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Determinants of Students' Choice of Engineering Disciplines in India

Hindistan'da Farklı Mühendislik Dallarını Seçen Öğrencilerin Seçimlerini Belirleyen Faktörler

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Özet

Hindistan'da mühendislik eğitimi son otuz yılda hızlı bir ivme kaydetmiştir. Bununla birlikte, mühendislik eğitiminin tüm dalları aynı hızda büyümemiştir. Makine, inşaat ve elektrik mühendisliği gibi geleneksel alanlar uzun zamandır pek rağbet görmemekte, ancak elektronik mühendisliği, bilgisayar bilimleri mühendisliği ve bilgi teknolojisi ile ilgili mühendislik alanları ise son yıllarda hızla gelişmektedir. Ortaokul mezunları ileride uzmanlaşacakları alanları seçme konusunda akılcı bir seçim yapmak zorundadır. Bu çalışma, Hindistan'daki dört farklı eyalette bulunan 40 mühendislik fakültesine kayıtlı yaklaşık 7.000 öğrencinin cevapladığı anketle toplanan verileri kullanarak, öğrencilerin 'geleneksel' ve 'modern' / 'bilgi teknolojileri ile ilgili' mühendislik dalları arasındaki seçimlerini açıklayan belirleyicileri probit regresyon denklemi yoluyla incelemeyi amaçlamıştır. Öğrencilerin bireysel ve hane halkı özellikleri, akademik geçmişi, mevcut eğitimin özellikleri, gelecekteki istihdam beklentileri ve eğitim hedefleri gibi bazı temel faktörler belirlenmiş, probit analizinde kullanılmış ve sonuçlar ayrıntılı olarak tartışılmıştır.

Anahtar sözcükler: Dal seçimleri, geleneksel alanlar, Hindistan, modern alanlar, mühendislik dalları, mühendislik eğitimi, öğrencinin seçimi, yükseköğretim.

Abstract

Engineering education has expanded fast in India during the last three decades. However, all branches of engineering education have not grown at the same pace. While standard traditional branches like mechanical, civil and electrical engineering have bad been popular for a long time, areas like electronics engineering, computer science engineering and information technology related engineering have evolved fast in the recent years. Senior secondary school graduates face a dilemma of making a rational choice in selecting the disciplines of their study. Using the data collected through a survey of about 7,000 students enrolled in 40 engineering institutions in four different states in India, an attempt has been made in this paper to examine the determinants that explain students' choice between 'traditional' and 'modern'/ 'information-technology-related' branches of engineering, by estimating a probit regression equation. A few sets of major factors – individual, household, academic background of the students, current education, future employment prospects and further educational aspirations etc., have been identified and used in the probit analysis and the results are discussed in detail.

Keywords: Disciplinary choices, engineering education, engineering disciplines, higher education, India, modern streams, student choice, traditional streams.

Higher education in India has expanded very fast since the early 1990s. Compared to 3.6 million students enrolled in 5,227 institutions of higher education in 1985–86 (University Grants Commission [UGC], 1987), the system has grown to nearly one thousand universities, 39 thousand colleges with nearly 37 million students in 2017–18 (Ministry of Human Resource Development [MHRD], 2018). Almost all branches of higher education have experienced high growth. Among the many branches, engineering education has grown relatively fast. In 1985–86, there were 180,000 enrolments in engineering and technology, constituting 3.4% of the total enrolments in higher education. By 2017–18, the student numbers increased to 4.8 million, and the number of students in engineering education increased more than four-fold, to 16% of the total (UGC, 2018). But all streams of engineering education have not grown fast. There are as many as 17 streams (or sub-streams) of engineering education being offered in Indian institutions. The top five sub-streams offered at first degree level in Indian institutes of engineering education in 2017–18 were mechanical engineering with 880,000 students, computer engineering with 830,000 students, electronics engineering with 650,000 students, civil engineering with 590,000

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students and electrical engineering with 420,000 students (MHRD, 2018). Other important ones include chemical engineering, automobile engineering, information technology, and telecommunication engineering. While branches like mechanical, civil and electrical engineering have enjoyed huge popularity for a long period, in recent years, areas like computer science and engineering, electronics and communication engineering, information technology (IT), and telecommunication engineering have gained more popularity. In fact, some of these popular ones have been introduced in Indian institutes of engineering education only during the last quarter century, coinciding with the revolution in information and communications technology. The job market in these evolving areas is also expanding fast, compared to the job market in standard traditional areas, where the market is either stagnant or growing at a very slow rate. Electronics-based products ranging from mobile phones, personal computers, digital televisions and radio to the internet with its complex network of satellites and state-of-the-art fibre optic communications play a vital role in our daily lives. As a result, computer technology, telecommunications and consumer electronics are rapidly evolving, and so expertise in these fields is in great demand. Among them, electronics engineering is becoming the most popular one. Probability of going abroad for further studies or for employment is also high in case of these IT-related disciplines. As per All India Council for Technical Education (AICTE) data,[1] around 70% of the total intake in undergraduate level is in these modern high-tech and evolving IT-related streams and the remaining 30% in traditional streams.

The Problem

Senior secondary school graduates interested in Bachelors' (or first or under-graduate) four-year degree studies in engineering education in India indeed face a choice problem. They need to choose the stream, unlike in some western universities, at the very time of applying for admission into the first year of the four-year degree programme in engineering studies. The dilemma for the students to choose a branch of engineering among as many as seventeen branches begins immediately after completing senior secondary school education. It appears a large number of students are not clear about what they want to choose; only a small section may have some clarity on what discipline or major they would like to pursue. But it is commonly perceived that the students with better academic record at school level and higher ranks in the competitive entrance examinations (held at national or state level and/or in a few cases at institutional level) wish, on a seemingly 'free choice/option' basis, to enrol in the streams such as computer science and engineering, electronics and communication engineering, information technology, or telecommunication engineering, which are perceived to carry high premium in the labour market -- higher probability of getting employment in the country or abroad and higher wages, and also in social status and prestige, as against the traditional streams such as civil engineering, mechanical engineering and electrical engineering. But choosing a major is indeed a complex process, as this choice is influenced by a variety of factors, such as the availability of the disciplines of study in the institutions, which is a major supply constraint, reputation of the institute, fees charged and other expenditure associated with different streams, peer effects, proximity of the institution where a given discipline is available, etc. In addition to students' aptitudes, attitudes and interests, the choice may also be influenced by individual cognitive factors, characteristics like gender and caste, household's socioeconomic and educational conditions, and many other factors. The choice might also get influenced by fair and unfair marketing strategies adopted by the engineering institutions, particularly the private colleges and universities in developing countries like India (Singh & Singh, 2015). The final selection is also guided, and rather almost decided, by the student counselling processes offered by public bodies at the time of admission. In short, students' choice of a particular stream of engineering studies (or for that matter any area of study – minor or major) cannot be adequately accounted for by any one single factor. It is influenced by a multitude of factors, which often interplay. In fact, students may not have a genuine 'free' choice, as there exist a severe supply constraint and market imperfections including asymmetry of information. As such, the question is: what are the factors that influence students' choice of disciplines in engineering studies at first degree (undergraduate) level in India? The paper is a modest attempt to answer this question.

Database

This paper examines the possible determinants of students' choice of engineering disciplines for enrolment in India, using the data collected from a survey of about 7,000 students studying in 40 engineering institutions in four major states in India, namely, (the National Capital Region of) Delhi, Maharashtra, Karnataka, and Tamil Nadu. The survey covered Indian Institutes of Technology, National Institutes of Technology (known earlier as Regional Colleges of Engineering), central and state universities, private universities, government colleges, and private colleges – government aided private, and private institutions that do not receive significant government support and thus rely mostly on student fee. The latter are familiarly

[1] Calculated from data available from AICTE website (www. aicte-inida.org/downloads…).

known as unaided private colleges. Thus the survey can be regarded as representative of the variety of engineering institutions in the country. The survey was conducted by the National University of Educational Planning and Administration in the context of a larger international comparative study of BRIC (Brazil, Russia, India and China) countries (Carnoy et al., 2013). Considerations of the scope of the larger study determined the choice of the states. Institutions were chosen based on purposive random sampling; also institutions were chosen based on the availability of major streams of engineering education at first degree level; and all the students in the final (fourth) year enrolled in those departments were surveyed. The reasons for selecting fourth year students as our respondents in the survey were their ability to give fairly reliable information about their studies, having completed more than three fourths of their undergraduate programme, ability to make good choices and to decide about their further careers -- further studies or employment, and likelihood of already securing job offers in on-campus recruitment. Based on the prevalence of major streams of engineering education in under graduate education in India, students enrolled in five major departments of engineering, viz., electrical engineering, mechanical engineering (if either of the two – mechanical or electrical engineering is not available in the institution, civil engineering), computer science and engineering, electronics and communication engineering, and information technology were chosen to constitute the main sample of the survey. These streams are broadly categorised into two groups, namely 'traditional' and 'modern' (or IT-related) streams of engineering. Traditional streams include electrical engineering, mechanical engineering, and civil engineering, whereas computer science and engineering, electronics and communication engineering, and information technology constitute the group of 'modern' or 'IT-related' streams.

How do students choose between the traditional and modern disciplines of engineering? Before this question is answered, let us quickly note a few salient features of the profile of the engineering students in India.

A Brief Profile of the Engineering Students in India

Drawing on the survey, a brief profile of students in engineering education classified under two groups of disciplines: traditional disciplines and modern disciplines, is given in Table 1. A few striking features of the profile may be noted as follows:

- According to our survey, nearly 70% of the students are enrolled in modern disciplines of engineering, while about 30% go to traditional disciplines. These figures coincide with the pattern of distribution at the national level, as given by the AICTE quoted earlier. Gender differences are minor in this respect, though they are marked in enrolments in engineering education as a whole *vis-a-vis* other (non-engineering) branches of higher education.
- Interestingly, we find no big difference in this pattern between different social groups, viz., scheduled castes (SCs), scheduled tribes (STs), other backward classes (OBCs) and general population.[2] While 60% of the students among scheduled tribes chose modern disciplines, in the general population the corresponding proportion is 70%.
- In every income bracket, a majority of the students opt for modern disciplines. So is the case for the students classified by parental occupation, or parents' education. In other words, whatever be the economic status of the household or the educational level of the parents or occupation of the parents, students' first preference seems to be modern disciplines over the traditional ones.
- Students migrate to other states more for admission in modern disciplines than in traditional disciplines of engineering.
- The majority of secondary school graduates from both public and private schools are enrolled in modern disciplines.
- While students with marginally better academic background (higher percentage of marks at senior secondary level) are enrolled in modern disciplines, the difference between traditional and modern disciplines is only marginal, i.e., students with nearly equally good academic background choose traditional disciplines.
- A majority of the students get admission in the discipline (or group of disciplines – modern or traditional) of their first choice.

Determinants of Students' Choice

What Does the Literature Suggest?

The student's choice for engineering education can be positioned in the literature in the broader theoretical framework of 'luck egalitarianism' discussed by Voigt (2007) in the context of the UK higher education system. Luck egalitarianism[3] uses the familiar distinction between 'choice' and 'circumstances' to draw a line between *just* and *unjust* inequalities: inequalities

[2] SCs and STs are considered as the most socially backward sections of the society and are eligible for fixed quotas (respectively 15% and 7.5%) in public education and employment as per the provisions made in a specific 'Schedule' of the Constitution of India in 1950. The quotas are decided based on the representation of the given group in the total population. In the caste hierarchy, the SCs and STs figure at the bottom. OBCs is another category added later in 1991 to the reserved categories (providing quotas to the extent of 27%), based on considerations of educational and social backwardness compared to upper castes.

[3] According to luck egalitarianism, distributions should reflect the choices that is reasonable to hold agents responsible for, while the differential effects of 'brute luck' must be compensated for. It is associated with the theorists such as Arneson (1989, 1990, 2000), Cohen (1989) and Dworkin (1981, 2002, 2003).

Table 1. Socio-economic and education profile of engineering students in India: Distribution by the type of discipline.

	Distribution by column			Distribution by row			
Gender	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Number**
Traditional	32.4	27.7	31.0	74.5	25.5	100.0	2056
Modern	67.6	72.3	69.0	70.0	30.0	100.0	4567
Total	100.0	100.0	100.0	71.4	28.6	100.0	6623
Number	4728	1895	6623				

	Distribution by column					Distribution by row				
Social category	**SC**	**ST**	**OBC**	**General**	**Total**	**SC**	**ST**	**OBC**	**General**	**Total**
Traditional	36.4	40.3	33.3	29.6	31.0	8.7	2.4	20.8	68.1	100
Modern	63.6	59.7	66.7	70.4	69.0	6.8	1.6	18.8	72.8	100
Total	100.0	100.0	100.0	100.0	100.0	7.4	1.9	19.4	71.3	100

	Distribution by column					Distribution by row				
Family income	**< Rs. 100,000**	**Rs. 100,000–500,000**	**Rs. 500,000–1 million**	**> Rs. 1 million**	**Total**	**< Rs. 100,000**	**Rs. 100,000–500,000**	**Rs. 500,000–1 million**	**> Rs. 1 million**	**Total**
Traditional	40.1	27.7	24.3	26.3	30.4	33.4	53.5	9.0	4.2	100
Modern	59.9	72.3	75.7	73.7	69.6	21.8	60.9	12.2	5.1	100
Total	100.0	100.0	100.0	100.0	100.0	25.3	58.6	11.2	4.8	100

	Distribution by column			Distribution by row		
Nativity	**Outsiders (Out-of-state)**	**Natives (Within the state)**	**Total**	**Outsiders (Out-of-state)**	**Natives (Within the state)**	**Total**
Traditional	26.0	36.4	32.5	27.0	70.4	100.0
Modern	74.0	63.6	67.5	40.6	59.4	100.0
Total	100.0	100.0	100.0	37.1	63.0	100.0

	Distribution by column						Distribution by row					
Parents' occupation	**Professional**	**Service**	**Unskilled**	**Businessman**	**Others**	**Total**	**Professional**	**Service**	**Unskilled**	**Businessman**	**Others**	**Total**
Father's occupation												
Traditional	28.4	37.4	44.1	29.1	30.4	30.2	55.5	9.9	7.9	19.6	7.1	100.0
Modern	71.6	62.6	55.9	71.0	69.6	69.8	60.7	7.2	4.3	20.7	7.1	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	59.1	8.0	3.4	20.4	7.1	100.0
Mother's occupation												
Traditional	28.3	30.9	47.5	15.3	28.1	27.8	22.4	8.4	2.2	20.0	47.0	100.0
Modern	71.7	69.1	52.5	84.7	71.9	72.3	25.9	10.5	3.7	3.7	56.2	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	26.1	9.2	1.7	4.9	58.1	100.0

	Distribution by column						Distribution by row					
Parents' education	**Illiterate**	**Primary**	**Secondary**	**Higher general**	**Professional**	**Total**	**Illiterate**	**Primary**	**Secondary**	**Higher general**	**Professional**	**Total**
Father's education												
Traditional	23.1	37.6	36.9	29.0	28.7	30.4	0.2	2.0	20.5	53.2	24.2	100.0
Modern	76.9	62.4	63.1	71.0	71.3	69.6	0.2	1.4	15.2	56.9	26.2	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	0.2	1.4	16.8	55.8	25.6	100.0
Mother's education												
Traditional	32.8	43.6	31.8	27.7	28.5	29.8	1.3	4.5	34.6	50.7	8.9	100.0
Modern	67.2	56.4	68.3	72.3	71.5	70.2	1.4	6.2	41.5	43.7	7.2	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	0.8	3.9	28.9	58.6	7.8	100.0

Table 1. *[Continued]* Socio-economic and education profile of engineering students in India: Distribution by the type of discipline of study.

Academic background of students													
	Type of school			Location of school			Medium of instruction			Board of examination			
	Government	Private	Total	Urban	Rural	Total	English	Non-English	Total	CBSE	ICSE	State board	Total
Distribution by column													
Traditional	34.3	28.6	30.2	28.9	44.2	30.6	27.7	42.4	29.8	26.1	27.5	32.6	30.4
Modern	65.7	71.5	69.8	71.2	55.8	69.4	72.3	57.6	70.2	73.9	72.5	67.5	69.6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Distribution by row													
Traditional	31.8	68.2	100	83.5	16.5	100	79.0	21.0	100	33.7	2.9	63.4	100
Modern	26.3	73.7	100	90.8	9.2	100	87.9	12.1	100	13.0	2.1	84.8	100
Total	28.0	72.0	100	88.6	11.4	100	85.2	14.8	100	32.5	4.4	63.1	100

	Academic performance: Average percentage of marks secured by the students in senior secondary examination			
	CBSE	ICSE	State boards	Total
Traditional	75.3	77.5	74.8	75.0
Modern	78.2	83.7	81.5	80.5
Total	77.5	82.0	79.4	78.8

	Students who took pre-admission coaching			Students who took Entrance examination		
	Took coaching	No coaching	Total	More than once only	Once only	Total
Distribution by column						
Traditional	30.0	32.8	31.4	35.2	30.2	30.5
Modern	70.1	67.2	68.6	64.8	69.8	69.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by row						
Traditional	45.2	54.8	100.0	7.2	92.8	100.0
Modern	48.4	51.6	100.0	5.8	94.2	100.0
Total	47.4	52.6	100.0	6.3	93.7	100.0

	Students who got admission in their first choice of discipline		
	in the 1st attempt	not in the 1st attempt	Total
Traditional	25.8	36.2	28.3
Modern	74.2	63.8	71.7
Total	100.0	100.0	100.0

	Discipline of first choice of the student										
	First choice										
Enrolled in	Civil	Computer	Electrical	Electrical & electronics	Tele - communication	Information & technology	Mechanical	Instrumentation	Management	Others	Total
Traditional	82.7	13.5	93.4	15.9	18.2	10.9	88.5	84.7	42.9	74.1	28.2
Modern	17.3	86.5	6.6	84.1	81.8	89.1	11.5	15.3	57.1	25.9	71.8
Total	100	100	100	100	100	100	100	100	100	100	100
Total (row distribution)	1.4	33.3	4.6	11.7	27.9	8.1	4.7	1.2	0.1	7.2	100.0

resulting from circumstances beyond an agent's control are unjust and must be rectified, while inequalities resulting from individuals' choices are justified. Accordingly, it can be argued that inequalities arising from self-selection of the disciplines (traditional or modern) is not morally problematic as it is based on individuals' choices. However, it is also argued that this impression is mistaken. Luck egalitarians might take seriously the idea that 'brute luck' affects the choices people make, and these effects are particularly obvious when we look at the decision-making process of engineering students of different socio-economic backgrounds. Qualitative research studies on this aspect reveal a significant impact of unequal background condi-

tions of students on the choice of different streams of study, making it less likely that 'economically weaker students' apply for admission in those disciplines, which are associated with high levels of fees and related expenditure. Hence, though the students' decision to enrol in different streams of study refer to their individual choices, these choices are not sufficient to legitimise further consequences from them.

There are quite a few studies on the students' choice of university/institution (*see* Tilak, 2019a), but not many can be found on the choice between disciplines. There are only a handful of studies, which are also on major branches of study. Hofstein, Ben-Zvi, Samuel and Kempa (1977) reported that the selection of physical science streams in Israel post-secondary education was significantly related to the socioeconomic background. Elchardus and Spruyt (2009) found that students' selection of academic disciplines and sociopolitical attitudes of students are related. The selection is highly influenced by socialization and sociopolitical attitudes. In a cross-country study on students' interest in science and technology studies, OECD (2006) found that students' choices of disciplines in higher education are mostly determined by their images of the professions associated with the studies, the content and curricula, and the quality of teaching. Goyette and Mullen (2006) found that gender and race explain the pattern of students' choice between vocational and arts and science courses in the universities of USA. It was further found that financial reward attached with a programme influences the choices of Asian Americans in their study programmes. In an interesting study, Rimfeld, Ayorech, Dale, Kovas and Plomin (2016) found that choice of subjects by students in the UK showed substantial genetic influence. Examining the students of the Southampton University, Maringe (2006) concluded that students seem to be adopting a consumerist approach in their decision making in higher education. The importance attached to labour market motives in terms of employment and career prospects significantly outweighs those related to pursuing higher education on the basis of subject interest and a love for the subject. Students consider programme and price related issues as more important than many other aspects. In a study on analysis of choice of youth in Indian higher education, Chakrabarti (2009) notes a significant influence of gender on the selection of disciplines: females have higher odds of selecting arts/humanities subjects compared to males; and gender bias against females is pronounced in case of science, commerce, medicine, engineering and other professional disciplines. According to Panda (2006), the three most important reasons behind selecting IT-related streams in engineering education as against standard disciplines of study by the female engineering students in Odisha are: (a) education level of the parents, (b) occupation of the parents, and (c) job market perspectives (*see* also Choudhury, 2012). Thus, we note from the literature review that a wide set of factors influences student choices of subjects in higher education; and that few studies exist that looked at students' choice between several engineering streams.

Method

Under this theoretical and empirical setting, the present study examines the factors determining students' choice of streams in engineering education in India. How do the students resolve the choice problem between traditional and modern disciplines of engineering? What are the factors that explain the choice of the students? What are the determinants of demand for various streams in engineering education? This paper uses a probit model in an attempt to answer these questions, which are relatively less examined in the literature, while demand for higher education in India in general, and to a lesser extent, the demand for engineering education has drawn the attention of many scholars.

The Model

Students' choice between traditional and modern streams of engineering studies is influenced by a variety of factors such as individual characteristics, household factors, academic background of the students, factors related to current education of the students, and factors relating to employment and intentions of the students to go for further higher education. It is indeed a complex process, involving mutually interacting factors. Determinants of students' choice of disciplines are analysed here using probit model, linking the choice of the discipline with a set of factors. The dependent variable in the model – the stream of study the student is enrolled in – is a binary variable and is defined as follows:

STREAM_STUDY = 1, if the student has enrolled in modern streams;

= 0, otherwise, i.e., if the student has enrolled in traditional streams.

The probit equation is estimated here as follows:

$$STREAM\_STUDY = \alpha + \beta_i X_i + \varepsilon$$

where

X_i are a set of explanatory variables, β_i are coefficients of the explanatory variables, α the constant, and ε the error term.

Explanatory Variables

The choice between traditional and modern streams of engineering studies is indeed a complex process, involving mutually interacting factors. It is influenced by a multitude of factors. A few important variables on individual characteristics, household background, student's academic background, student's current educational status, employment prospects, and educa-

tional aspirations of students -- are considered here as possible determinants. The selection of factors is partly constrained by the availability of data in the survey that formed the basis of the study. The rationale for the inclusion of different explanatory variables in the probit model is elucidated below.

Individual Characteristics

Gender: Gender is an important factor in determining participation in higher education and also in the choice of disciplines. It is commonly observed that female students prefer modern disciplines to traditional disciplines. This may be due to two important reasons: (a) traditional disciplines of study like mechanical and electrical engineering are highly laboratory intensive and hence are generally not liked by women; and more importantly, (b) graduates in traditional disciplines usually get jobs in labour-intensive activities like manufacturing or related organisations which may not be preferred by female graduates. Instead, women may like to take white-collar soft skill-oriented 'desk jobs', by graduating in modern disciplines such as computer science and engineering, electronics and communication engineering, and information technology. So gender, defined as a binary variable GENDER (1 for men, and 0 for women) was introduced to study the male-female differences on the choice of disciplines between modern and traditional ones.

Caste: The social category of the students (CASTE) may be an important individual characteristic feature in determining not only demand for higher education, but also the choice of disciplines in engineering education. Modern disciplines are nowadays associated with higher social status. Hence, one may view that the students belonging to general category have higher preference to enrol in modern engineering disciplines (over traditional areas) than the students from lower social background (e.g., SCs, STs and OBCs) who are more likely to prefer traditional disciplines. It may be due to the fact that modern disciplines like information technology and computer engineering require modern new skills like impressive communication skills, sophisticated knowledge of English, etc., which many students belonging to lower social background may not necessarily possess at the same level as general category students. Hence, it may become difficult for the socially backward category students to get admission in the IT-related departments like computer sciences and engineering, electronics and communication engineering, and information technology. It may also be due to lack of coaching and correspondingly their poor performance in the entrance examination. Thus caste of the students can be an important determinant in explaining demand for engineering education in modern *versus* traditional disciplines. Caste is used here in the form of four different dummy variables namely SC, ST, OBC and GENERAL. The regression coefficients of SC, ST and OBC are interpreted in relation to GENERAL which is used as the reference category.

Household Characteristics

Among the household characteristics, we have identified four factors that represent household economic status, education and occupation of the parents, and the residence of the household.

Household Income: Economic status of the households is widely recognised as an important factor in explaining demand for higher education (Tilak, 2015; Tilak & Choudhury, 2019). We feel that it might influence the choice of disciplines as well, as low income families may not be able to afford disciplines like modern information-technology related branches, as the fees and other related charges may be higher. So household income has been used in the regression equation to represent economic status of the households. Obviously parents with lower economic capacity choose the disciplines that fit to their budget and may not favour those streams which necessitate higher expenditure. Information on annual income of the family was collected in the survey in four income brackets: (i) less than Rs. 100,000, (ii) Rs. 100,000 to Rs. 500,000, (iii) Rs. 500,000 to Rs. one million,[4] and (iv) more than Rs. one million. In relatively terms, (i) may be considered as low income group, (ii) and (iii) as middle income group and (iv) as upper income group. Mid-values of each income bracket are taken and variable is measured in a continuous form, and for smoothness, the logarithmic value has been used in the probit model.

Parents' education and occupation may reflect parents' many characteristics including genetics. Parents' education and occupation might capture the effects of the family's non-financial resources, some kind of 'social capital', in addition to genetical factors.

Parents' Occupation: It is generally observed that students choose certain disciplines over others which may match with their parents' education and occupation. Students whose parents are IT-professionals may wish to enrol themselves in IT-related or similar disciplines instead of traditional or some other disciplines. Parents may also have similar preferences. Contrary to this, there may be another possibility that students opt for certain disciplines that are greatly in demand, irrespective of their parental occupation. Thus, parental occupation may have different effects upon the students' choice of disciplines. The experience of parents from a particular occupation may influence choice of disciplines of study of their wards. Therefore, *father's occupation* and *mother's occupation* are included in the equation here.

[4] At the current rate of exchange US$=Rs.70 (approx).

Information on occupation of the parents was collected in the survey on sixteen occupational categories, which are re-classified here into three groups: (a) professional or technical worker; (b) businessmen; and (c) others. Mainly due to small numbers of observations in many of the occupation categories such as clerical and related workers, service workers, farmers, fishermen and related workers, skilled workers (foreman, craftsman etc.), unskilled workers (ordinary labourer), retired, and workers not classified by occupation (athlete, actor, musician, unemployed, partially unemployed) -- they are included in the category of 'others'. The 'professional or technical workers' includes both junior and senior professional workers like doctors, professors, lawyers, architects, engineers, nurses, teachers, editors, photographers and bank employees. Information on the occupational level was collected both for father and mother of the student to know their differential effects on students' choice of disciplines. Housewives (home-makers) constitute about 23% of the total number of mothers in our sample, which was included in the 'others' category here.

Parents' Education: Similarly one can expect parents' education to have a significant effect on student's choice of disciplines, as students in many cases tend to choose the disciplines of study which may match with the educational level of their parents or with parents' interests. Parents with higher level of education can generally be considered better informed about the benefits associated with studying a particular discipline than the parents with lower level of education. Higher educated parents may be also more concerned about the quality of education and may be more aware of institutions and various disciplines and even sub-disciplines of study and hence they would advise their children to make a proper choice. Higher educated parents in India tend to send their children to IT-related disciplines compared to less or uneducated parents. This may be due to the fact that the educated parents might be knowing the employment potential of traditional and IT-related disciplines more clearly than un or less educated parents. The general impression is that IT-related/modern streams lead us to white-collar jobs, whereas traditional streams such as mechanical, civil and electrical engineering give blue-collar jobs. This is well understood by educated parents compared to un/less educated parents. Educated and better placed parents may also be aware of other advantages of studying particular disciplines, such as the higher salary packages, possibilities to get employment abroad etc., relatively more clearly than less educated parents who may not necessarily be aware of the differential labour market rewards associated with different disciplines; rather the latter may at best be concerned with the choice between the engineering and non-engineering branches of higher education and many not bother about choice within engineering. So parents' education is considered here to see its effect on students' choice. To analyse whether mother's education has more (or less) effect than father's education, the education of both are considered as two separate variables.

A measure of educational attainment used extensively in the literature is the highest level of education completed by the head of the household. Some have considered the education of every member of the household or total education of the entire household in such contexts.[5] Parents' education is classified here into three levels: (a) below secondary, (b) higher general and (c) higher professional. Higher general education includes the undergraduate and postgraduate programmes of study in the disciplines of arts, science and commerce, whereas higher professional education includes the undergraduate and postgraduate programmes in technical and professional disciplines of study. The illiterate parents and the parents with primary level of education, who constitute less than one per cent of the total sample were included in the below secondary category. This classification was used in the descriptive data analysis (▮▮ Table 1), whereas in the regression analysis the years of schooling is considered, converting the levels of education into corresponding years, which is considered as a better indicator, and which is also more extensively used in the literature than the level of education.

Nativity: Students go to far off places to get admission in the discipline of their choice, if admission in those disciplines are not available in institutions near their home or in their home state. Students who do not wish to go outside their state may end up joining those disciplines which are available within the state. As shown in ▮▮ Table 1, about 73% of students belonging to other states have taken admission in IT-related branches, while it is 63 percent for the students who are from the same given state where the institution is located. To examine whether nativity of a student has any effect on the choice of the discipline, we include a variable on nativity measured in a binary form – those belonging to the same state in which the current engineering institution is located versus those from other states – in the equation.[6] Students from almost all the states (including Union Territories of Chandigarh and Andaman and Nicobar Island) in India are represented in the sample.

Educational Background of the Students

Previous educational background of the students may considerably influence the students' preference for a discipline in higher education – specifically modern disciplines or tradition-

[5] But this is not considered here due to unavailability of data. Even if available, aggregation of education at household level may be subject to methodological problems and errors.
[6] In a few states in India, places in engineering institutions are reserved for natives (residents of the state) and a small proportion (around 15%) for outsiders (outside the state).

al disciplines. Students from different educational backgrounds get different exposure to build their future career. For example, at the very beginning of higher secondary education, i.e., in Grade XI itself in India, students' future education path is decided, as the students have to opt for humanities, arts and commerce versus sciences and mathematics; and within the latter group between biological sciences and physical sciences. Only those who take physical sciences at higher secondary level can proceed to higher studies in engineering and technology.[7] In some cases, institutions give weightage to the students' performance in their qualifying examination while giving admission in different streams. Students with good academic background have higher chances to perform well in the selection process and are able to secure admission in the branch of their choice. On the other hand, students from poor academic backgrounds may not perform well in the entrance examination which ultimately minimises their choice.

With respect to previous educational background of students, we identify six major dimensions, namely,

- academic achievement at school level, i.e., *percentage of marks* secured in the higher secondary school-end examination,
- *medium of instruction* followed in the classroom teaching at the higher secondary level (English or other languages),
- the *board of higher secondary examination* -- central board or state (provincial) board that the school was affiliated to,[8]
- the *type of management of higher secondary* school (government/ government-aided or private), and
- *location of the higher secondary school* (rural or urban).

Among the above, while the first one, namely percentage of marks, is considered here as a continuous variable, the other ones are binary variables. These aspects related to higher secondary schooling and related characteristics of the students should give a fairly good idea of the student's academic background and by including them in the probit equation, we examine its influence on the students' choice of disciplines of study.

Pre-Admission Coaching: As competition for admission in engineering studies is very tough, students take preparatory coaching for the entrance examination. Given that such coaching is very expensive, and that competition for modern disciplines is generally very high, students wishing to seek admission in these disciplines may necessarily take the preparatory coaching, though it is not essential. So we have also considered whether a student has taken pre-admission coaching to prepare for the entrance examination or not as a binary variable. It is hypothesized that students taking pre-admission coaching to secure a good rank in the entrance examination, and thereby get preferential treatment from institutions in granting admission in the streams of their choice may opt for modern disciplines.

Factors Relating to Current Education

Some of the factors relating to current education status of the students itself might influence the choice of disciplines. For example, students wishing to pursue studies in modern subjects might join private institutions, as more private institutions than public institutions offer more and more admissions in such disciplines. Or the cost of education might influence the choice of disciplines. These two dimensions are taken into consideration, and accordingly the following variables are chosen on current education: type of institution, cost of education, availability of scholarships, educational loans and opportunities for part-time work on campus as probable determinants of students' choice.

Type of Institution: The type of institution the students have enrolled themselves in may have a significant effect on their choice of IT-related versus traditional disciplines. This is mainly because there seems to exist a trade-off between the choice of institutions and disciplines of study in engineering education. More clearly, students preferring modern disciplines seek admission in private institutions, whereas students enrolled in government institutions might prefer taking a traditional discipline. This is primarily due to the fact that students may compromise on the discipline of study if they get admission in government institutions; and similarly they may compromise on the institutions if they are able to secure admission in modern disciplines (Tilak, 2019a). However, the students securing a good rank in the entrance examination need not compromise either on the type institution or the discipline of study, i.e., they may get admission in their preferred institution as well as in the discipline of their choice. It is also important to note that some public or private institutions are famous for certain disciplines, modern or traditional. After all, all the disciplines or subjects are not necessarily delivered at the same level even in a good university or a college. So students may get confused whether to opt for a good institution or a good discipline. Students preferring modern branches go to private insti-

[7] They are not eligible for admission in medicine, and related subjects though they can opt for general (arts, humanities, sciences etc.) subjects.

[8] Prominent boards are: Central Board of School Education (CBSE), and the Council for the Indian School Certificate Examination, a private body that conducts Indian Certificate of Secondary Education examination (ICSE) both of which conduct examination at all-India level, hence known as central boards and various state (provincial government) boards at state level. About 90% of students in our sample are from CBSE board and 8% from different state boards. As only 25 students (2% of the total students covered in the survey) had completed their senior secondary examination through ICSE board, which is also a central board, CBSE and ICSE are classified into one category as 'central board'. Due to small sample size of each of the state boards, it has not been attempted to analyse the impact on students' choice of institutions individually by state board, though we recognise that major differences exist between boards of different states.

tutions, as many private institutions offer such disciplines, compared to government institutions, whereas students preferring traditional branches may opt for government institutions. Rather the choice of discipline and the choice of type of institution seem to be closely related.

Household Cost of Education: The fee and other related costs of education associated with each discipline of study can be one of the most important factors determining students' choice of disciplines, as the high cost of a programme may discourage the students from low income families to opt for the same. Generally the fees and other expenditures are higher in modern highly demanded programmes compared to others. Total household expenditure on engineering education incurred by each student/parents is used as a proxy of household cost of education in the probit regression in logarithmic form. This includes the household expenditure on fees (library fees, examination fees, fees on games and sports), non-fee items (dormitory or housing, food, transport, textbooks and other class materials) and other related expenses (improving comunications in English, purchase of computers, internet, phones, entertainment and other necessay expenses). Household cost is used as a continuous variable in logarithmic form in the estimation of logistic regression.

Further, net household costs get considerably reduced by the availability of scholarships. Some costs can also be covered through student loans and engagement in part-time on-campus work. So it would have been more appropriate to take in our analysis the net household expenditure, i.e., the total household expenditure on engineering education minus the amount of scholarship or stipend or any other financial assistance received. However, we do not have required details on the amount of scholarship or financial assistance received by students during their programme of study. The HH_COST also does not include opportunity cost of education. So we considered three variables in addition to gross household costs, viz., scholarship, student loan, engagement in on-campus part-time work.

Scholarship: Availability of scholarship or any other financial assistance in an institution can be expected to play an important role in the students 'choices of disciplines, as more scholarships may be available in some disciplines and less in case of others. This may be very important particularly in case of students belonging to low and middle income strata, who may be interested in degree studies in engineering, but may not mind the stream of engineering. Students might choose in favour of those disciplines where they have higher chances to receive scholarships. Students were asked in the survey to report whether they have received any scholarship or not (but not the amount of scholarship) during their programme of study. This information has been used to generate a binary variable.

Educational Loans: Like scholarship, educational loans reduce the current financial burden of education on the households. Engineering education being a costlier discipline of the study, many students opt for educational loans to cover the costs of their education in India. But loans may not be evenly available across all disciplines. Banks might also discriminate formally or informally the students in different branches of engineering. While engineering students have higher chances of getting loans than say students in natural and physical sciences or humanities and social sciences, among the engineering students those who are enrolled in modern disciplines which are in high demand in labour market may have higher probability of getting loans than the students who join traditional departments. So the availability of loans may be expected to impact students' choices of various disciplines of study. Some institutions may also have formal arrangements with banks to provide loans to their students. The survey provides information on whether a student has received any educational loan for her/his studies from commercial banks during the programme of study, which is used as a binary variable in the equation.

Part-time Work Opportunity: Engineering students belonging to low and middle income groups and not receiving any financial support (scholarship or educational loans) may usually go for part-time jobs to continue their study. But the scope of doing such part-time jobs differs from department to department in an engineering institution. Availability of such opportunities obviously influences students' choice of departments or branches of engineering. Hence, the part-time work engagement of student is included as one of the explanatory variables in the probit analysis.

Employment Prospects and Educational Aspirations

What does the student want to do after bachelor's degree in engineering – employment or further studies -- also is an important factor that may influence one's selection of the disciplines at bachelor's level. So we identify two important factors in this regard: employment prospects and plans for further studies.

Employment Prospects: Generally, prospects of getting a good job is an obvious factor that influences students' choices regarding the discipline of the study.[9] Hence, labour market conditions such as probability of getting employment and good wages after graduation are important variables that need to be considered in any analysis of the present kind. But the survey does not cover information on employment or earnings

[9] Contrary evidence also exists: students do not only take expected economic returns into account when choosing a discipline, but also their chances of academic success. Rochat and Demeulemeester (2001) provide a detailed analysis on this aspect in the context of Belgium higher education.

of graduates. Employed engineering graduates did not form the respondents in the survey. However, we tried to capture employment potential of the programmes, by looking at placement profiles. On-campus recruitment of students, before they complete their studies is common in many engineering institutions of higher education in India. Prospective employers visit the institutions, conduct on-campus recruitment process and make offer of jobs to the suitable students, who will take up the employment after completion of their studies. It is important to note that employers visit only those institutions that have a high brand and/or proven record of producing quality graduates and recruit from only those disciplines that they are interested in and/or the institution is known for. So on-campus recruitment is also viewed as employer recognition of the programme and the institution. Securing a job offer on-campus recruitment is considered here as a dummy variable to reflect employment prospects associated with a given discipline.

Educational Aspirations: It is generally felt that some disciplines offer much scope for higher studies (master's and doctoral programmes) and hence those who wish to go for further studies for whatever may be the reason – e.g., to join academic and research jobs, or to further the chances of better employment – may opt for certain disciplines and not others. To test the impact of students' aspirations to go for further studies on their enrolment in traditional versus modern/IT-related branches of engineering, it is also included as a dummy variable in the probit model. It is a dummy variable and takes the value 1, if the student has expressed their desire or plan to go for further studies and 0, otherwise, i.e., if the student does not have willingness to go for further studies. Based on the current labour market conditions, one can hypothesise that the students intending to go for further studies after completion of their graduation might prefer enrolling themselves in traditional disciplines than the students who do not have a plan for further studies.

The Empirical Model

Thus, the empirical model estimated is as follows:

$$\begin{aligned}\text{STREAM\_STUDY} = {} & \alpha + \beta_1 \text{GENDER} + \beta_2 \text{SC} + \beta_3 \text{ST} \\ & + \beta_4 \text{OBC} + \beta_5 \text{lnHHY} + \beta_6 \text{FATHOCP\_PROF} \\ & + \beta_7 \text{FATHOCP\_BUS} + \beta_8 \text{MOTHOCP\_ PROF} \\ & + \beta_9 \text{MOTHOCP\_BUS} + \beta_{10} \text{FATHER\_ED} \\ & + \beta_{11} \text{MOTHER\_ED} + \beta_{12} \text{NATIVITY} + \beta_{13} \text{SEC\_MARKS} \\ & + \beta_{14} \text{SEC\_MEDIUM} + \beta_{15} \text{SEC\_BOARD} \\ & + \beta_{16} \text{SEC\_SCH\_TYPE} + \beta_{17} \text{SEC\_SCH\_LOCATION} \\ & + \beta_{18} \text{COACHING} + \beta_{19} \text{ENGG\_INST\_TYPE} \\ & + \beta_{20} \text{EMPLOYMENT} + \beta_{21} \text{lnHH\_COST} \\ & + \beta_{22} \text{SCHOLARSHIP} + \beta_{23} \text{ED\_LOAN} \\ & + \beta_{24} \text{PART\_TIME\_WORK} + \beta_{25} \text{ED\_ASP} + \varepsilon\end{aligned}$$

where

β_i coefficients of the explanatory variables, α the constant, and ε the error term.

As explained, some of the explanatory variables used in the analysis are continuous and some are used in the dummy form. Table 2 gives notation, definition and measurement of variables, and Table 3 a few summary statistics on these variables.

Results and Discussion

The results of the probit model are given in Table 4. The choice between traditional and IT-related branches of engineering is influenced by individual characteristics, household factors, academic background of the students and factors related to current education of the students.

Effect of Individual Characteristics

As expected, the individual characteristics of the students, viz., GENDER and CASTE have considerable impact on their choice between IT-related and traditional branches of engineering. As noted earlier (Table 1), among the total female students, 72% have taken admission in IT-related departments as against of 67% among male students (Table 1). The study by Panda (2006) reveals a similar pattern in case of Odisha; around 80% wished to join in the IT-related streams like instrumentation and electronics engineering, computer science engineering, whereas least preferred streams are mechanical and civil engineering. Gender turns out to be a statistically significant factor in the present analysis as well. Female students seem to prefer soft disciplines line electronics and other IT-related disciplines, compared to hard manual disciplines like mechanical and civil engineering. The results reported in Table 4 show that compared to male students, female students are more likely to study in modern branches, as expected. Women are 21% more likely than men to opt for modern disciplines as against traditional disciplines.

With respect to social background, is caste an important factor influencing the student choice of disciplines? More than 70% of the total students from general category have taken admission in IT-related streams compared to 59% of the students belonging to scheduled tribes and 63% of the scheduled castes (Table 1). But the probit results are not so robust. The econometric results in Table 4 do suggest, however, that the probability of seeking admission to IT-related departments was significantly higher for the students belonging to

Table 2. Definition and notation of the variables used in the probit analysis.

Individual characteristics	
Gender:	Gender of the student = 1 if female, 0 otherwise
Caste:	Caste of the student SC = 1 if SC, 0 otherwise ST = 1 if ST, 0 otherwise OBC = 1, if belonging to other backward classes, 0 otherwise GENERAL = 1, if general (non-reserved) category, = 0 otherwise (reference category)
Household factors	
HHY	Annual income of the household (in Rs.)
Parents' occupation	
Father's occupation	
	FATHOCP_PROF: = 1, if professional/technical worker, 0 otherwise FATHOCP_BUS: = 1, if businessman, 0 otherwise FATHOCP_OTHERS: = 1 if belonging to other occupations, 0 otherwise
Mother's occupation	
	MOTHOCP_PROF: 1, if professional/technical worker, 0 otherwise MOTHOCP_BUS: 1, if businesswoman, 0 otherwise MOTHOCP_OTHERS: 1 if belonging to other occupations, 0 otherwise
Parental education	
	FATHER_ED: actual years of schooling of father MOTHER_ED: actual years of schooling of mother NATIVITY = 1, if the student belongs to the state where the institution is located; = 0, otherwise
Student's academic background (at school level)	
SEC_MARKS:	% of marks secured in the board (school-end) examination
SEC_MEDIUM:	medium of instruction at the school = 1 if English, = 0 otherwise
SEC_BOARD:	Board under which secondary school studies were completed = 1, if the student has studied under state board; = 0, otherwise, i.e. if the student has studied under central board.
SEC_SCH_TYPE:	Management of the school in which the student studied = 1, if the student completed senior secondary schooling from a private school; = 0, otherwise,
SEC_SCH_LOCATION:	Location of the school, = 1 if located in rural areas, = 0 otherwise
COACHING:	= 1, if the student has attended any coaching classes in preparation for the entrance examination = 0, otherwise
Student's current education	
ENGG_INST_TYPE:	Type of institution the student is currently studying = 1, if the student is enrolled in a private institution; = 0, otherwise
STREAM_STUDY:	Stream of engineering discipline in which the student is enrolled = 1 if enrolled in modern/IT-related courses, = 0 otherwise
HH_COST:	Total household expenditure on engineering education of the student for the current academic year (Rs…)
SCHOLARSHIP:	Scholarship = 1, if received any scholarship, = 0 otherwise
ED_LOAN:	Education Loan = 1, if received education loan from any commercial bank, = 0 otherwise
PART_TIME_WORK:	= 1, if the student has done any part-time job during the programme of study; = 0, otherwise
Employment prospects and educational aspirations	
EMPLOYMENT:	Employment prospects = 1, if the student has not got any offer of employment in the on-campus recruitment; = 0, otherwise
ED_ASP:	Educational aspirations of the student = 1, if the student intends to go for further studies, = 0 otherwise

Table 3. Summary statistics of the variables used in the probit analysis.

Variables	*N*	Mean	Standard deviation	Min	Max
Individual characteristics					
GENDER	6623	0.29	0.45	0	1
Caste					
SC	6623	0.07	0.26	0	1
ST	6623	0.02	0.14	0	1
OBC	6623	0.19	0.40	0	1
GENERAL	6623	0.71	0.45	0	1
Household factors					
*ln*HHY	6076	12.33	0.96	10.82	14.04
FATHOCP_PROF	6121	0.20	0.40	0	1
FATHOCP_BUS	6121	0.20	0.40	0	1
FATHOCP_OTHERS	6121	0.60	0.49	0	1
MOTHOCP_PROF	4948	0.15	0.36	0	1
MOTHOCP_BUS	4948	0.08	0.28	0	1
MOTHOCP_OTHERS	4948	0.76	0.43	0	1
FATHER_ED	6550	14.57	3.91	0	17
MOTHER_ED	6516	12.94	4.74	0	17
NATIVITY	6033	0.63	0.48	0	1
Student's academic background					
SEC_MARKS	6141	78.89	11.19	30.29	100
SEC_MEDIUM	6079	0.15	0.35	0	1
SEC_BOARD	6306	0.66	0.48	0	1
SEC_SCH_TYPE	6014	0.72	0.45	0	1
SEC_SCH_LOCATION	4746	0.11	0.32	0	1
COACHING	5212	0.53	0.50	0	1
Student's current education status					
ENGG_INST_TYPE	6623	0.66	0.47	0	1
STREAM-STUDY	6623	0.69	0.46	0	1
*ln*HH_COST	5900	4.15	0.91	0.61	7.01
SCHOLARSHIP	6581	0.18	0.39	0	1
ED_LOAN	6033	0.10	0.30	0	1
PART_TIME_ WORK	6294	0.10	0.30	0	1
Employment prospects and education aspirations					
EMPLOYMENT	6438	0.74	0.44	0	1
ED_ASP	4017	0.59	0.49	0	1

general category than the students belonging to scheduled castes and tribes. More clearly, the estimates show that being a scheduled caste reduces the probability of admission in IT-related departments by one percentage point, and being scheduled tribe by three percentage points. Surprisingly, belonging to the OBC group increases the probability of attending IT-related subjects by five percentage points as compared to general category students. OBCs are, after all, not so backward as SCs and STs. Many of them are economically as advanced as middle and upper strata of the society. However, in the equation, out of these, only the coefficient associated with OBC is statistically significant at 10% level of significance.

Effect of Household Characteristics

Among the household factors, we expected household income to be a significant determinant of students' choice. As noted from Table 1, with increase in household income, the proportion of students attending modern branches increases. About three-fourth of the students from middle and higher income strata go for modern/IT-related disciplines, while the corresponding figure is less than 60% for the students belonging to low income families. Thus, one can expect a positive relationship between the economic capacity of the households and the probability of choosing modern streams. But household income turns out to be not statistically significant in the choice function estimated here. In every income group, modern branches attract larger numbers of students than traditional disciplines of study.

Occupation of the parents is expected to matter significantly in the students' choice between modern versus traditional disciplines of engineering. Probit estimates reveal that students whose fathers work as professionals or technical workers are more likely to enrol in IT-related disciplines than the students whose parents belong to 'other occupations' like clerical and related work, service work, farming, or are fishermen and related workers, and retired persons. Same is the case for students whose parents are involved in business activities. Probability of enrolment of students in IT-related disciplines increases by three percentage points if the occupational category of the father is professional or technical or business. Interestingly, however, mothers' occupation has an opposite effect: the coefficient associated with occupation of the mother is negative in value. Mothers who are professional workers, or businesswomen might prefer their children opting for standard traditional disciplines. This may be because of generally perceived relative stability in labour market conditions with respect to jobs for the graduates of traditional disciplines, compared to those jobs that are related to modern disciplines. Mothers may be more cautious in guiding their children in their choice of disciplines of study. They might feel that traditional disciplines offer more stable and secure jobs. The differential effects of parents' education, however, need further probing.

Similarly, the probit estimates show that parents' education has also a positive effect on increasing the probability of their children enrolling in modern branches, though the coefficients are small in value, and statistically not significant. Higher educated parents might view the modern disciplines to be highly promising in the near future and advise their children accordingly. There is no much difference between effect of the father's education and mother's education on student's choice.

The results reported in Table 4 show that among the household factors NATIVITY is statistically significant in determining the students' choice of the stream of engineering they wish to pursue. Students belonging to the state where the institution is located are less likely to take modern/IT-related streams than the students of other states. The marginal effect suggests that students belonging to the state where the institution is located are less likely by nine percentage points in taking admission in IT-related branches. After all, students

Table 4. Probit estimate of students' choice of disciplines of study in engineering education.

Variables	Coefficient	Standard error	Marginal effect *(dy/dx)**
Individual characteristics			
GENDER	0.215†	0.083	0.065
SC	-0.029	0.149	-0.009
ST	-0.106	0.280	-0.034
OBC	0.176‡	0.101	0.053
GENERAL	Reference category		
Household factors			
*ln*HHY	0.051	0.044	0.016
FATHOCP_PROF	0.085	0.089	0.026
FATHOCP_BUS	0.108	0.091	0.033
FATHOCP_OTHERS	Reference category		
MOTHOCP_PROF	-0.068	0.103	-0.022
MOTHOCP_BUS	-0.031	0.155	-0.010
MOTHOCP_OTHERS	Reference category		
FATHER_ED	0.009	0.013	0.003
MOTHER_ED	0.002	0.011	0.0006
NATIVITY	-0.293†	0.079	-0.090
Student's academic background (at secondary school level)			
SEC_MARKS	0.023†	0.004	0.007
SEC_MEDIUM	-0.025	0.106	-0.008
SEC_BOARD	-0.257†	0.084	-0.079
SEC_SCH_TYPE	-0.068	0.078	-0.021
SEC_SCH_LOCATION	-0.084	0.119	-0.027
COACHING	0.0009	0.070	0.002
Students' current education status			
ENGG_INST_TYPE	0.758†	0.086	0.260
*ln*HH_COST	-0.004	0.044	-0.001
SCHOLARSHIP	0.002	0.096	0.0006
ED_LOAN	0.091	0.109	0.028
PART_TIME_WORK	-0.001	0.11	-0.0003
Employment prospects and educational aspirations			
EMPLOYMENT	-0.166§	0.081	-0.051
ED_ASP	-0.039	0.071	-0.012
Constant	-2.088	0.629	
Log-likelihood	-890.356		
Pseudo R^2	0.097		
Number of observations	1706		

*Marginal effect, *dy/dx,* is for discrete change of dummy variable from 0 to 1. This shows the magnitude of impact of an explanatory variable on dependent variable. †statistically significant at 99% level of significance; ‡significant at 90% level; §significant at 95% level.

migrate to other states when they do not get admission in their own state in the discipline of their choice which is largely the IT-related branches in this case.

Effect of Educational Background of the Students

Earlier studies suggest that academic attainment is a very important factor in influencing demand for higher education. Students scoring well in the senior secondary examination have higher chances to perform better in the entrance examination and thus, are more likely to enrol in the disciplines of their choice, more commonly in the highly demanded disciplines like the modern disciplines. But it is important to note that more than the academic scores in the school-end examination, it is the rank in the competitive entrance examination that matters in securing admission in the discipline of one's choice. Examination scores in the school-end examination and the ranks in the common entrance examination are not necessarily always positively correlated. But we do not have data on the latter, and hence we use here examination scores only.[10] The results show that among the six factors considered on academic background of the students, the percentage of marks secured in the higher secondary examination turns out to be an important and statistically significant factor: the higher the percentage of marks scored in higher secondary examination, higher is the probability of taking admission in modern branches than traditional branches. One per cent increase in the marks in higher secondary end examination increases the probability of attending modern disciplines by seven percentage points. This is in conformity with the general belief that the students scoring high percentage of marks in their senior secondary examination may perform better in the entrance examination as well and would opt for IT-related branches of engineering.

Among the six factors on academic background, the other important one relates to the board of examination. The results reported in Table 4 show that students studied in schools affiliated to state (provincial) boards are less likely to enrol in IT-related streams than the students graduated from schools affiliated to a central board. All secondary schools in the country are necessarily affiliated to central (all-India) boards or to state (government) boards of examinations. Examinations are conducted at secondary and senior secondary level by the respective boards. Generally, CBSE curriculum is regarded to be of higher standard than others. Given the variations in quality in curriculum offered by different boards, students come out with varying capabilities, which will have an impact on their choices. The standard of curricula and quality of education are believed to be better in schools affiliated to central board and hence students graduating from central boards may tend to go for modern branches. The econometric results show the same: students graduating from state (provincial) board are 26% less likely to get admission in modern discipline than those who studied under central (government) board.

Classroom teaching in most of the private senior secondary schools takes place in English medium, whereas many government schools teach the students in the regional language(s) and some in English. The medium of instruction matters much, as the all-India common entrance examinations and the subsequent engineering degree programme are mostly conducted/offered in English (and to a lesser extent in Hindi). Hence students from English medium schools may have a higher marginal advantage in the entrance examination and they may get the stream of their choice. But medium of instruction, defined in a binary form – English or others, is found here to be not a statistically significant factor in influencing students' choices of disciplines, meaning that the students' choice is not much influenced by the medium of instruction at the school level, contrary to popular beliefs.

Other important variables relating to student academic background considered here include: type of school – public (central or State government/ government aided) or private, location of the school – rural or urban, and whether a student took coaching in preparation for entrance examinations.

An important factor that influences students' many decisions including their choices of higher education relates to the type of school they graduated from: public or private. It is expected that the students graduating from high quality private senior secondary schools would seek admission in disciplines of high demand or disciplines which are regarded as of high brand and status. But probit estimates show that students who had studied in private senior secondary schools were less likely to take admission in modern disciplines. This is contrary to the general, though unfounded, impression that private schools provide effective teaching environment with quality teachers, well developed curricula, and competitive student atmosphere which help them to be better prepared as well as informed about their options and might influence students to take admission in modern branches. But this is not the case: private schools might not necessarily provide that competitive advantage. However, the coefficient is statistically not significant.

[10] It is also complicated to use the data on ranks, if available, as entrance examinations are conducted and ranks are awarded by central organisations, and various state organisations, besides in some cases by institutions. Their standardization may involve adoption of arbitrary methods and values.

Rural-urban differences are generally very wide in case of most aspects of higher education. They may be believed to be influencing students' choice of stream of engineering as well. Students studying in urban schools have locational advantages in the form of better information, apart from better quality schooling. Hence, students graduated from urban schools may make better choices than those graduating from rural schools. The former may have higher chances to prefer modern disciplines than the students from rural schools. Thus one can expect that students' choice of disciplines differs with the location of the senior secondary school they have studied. The results confirm this. Students graduated from senior secondary schools located in rural areas have less probability of taking admission in modern departments than the students from rural senior secondary schools, as revealed by the probit estimates. Around 70% of the students who have completed their senior secondary schooling from urban areas have taken admission in IT-related departments; whereas the corresponding figure is 55% for the students graduated from rural senior secondary schools (Table 1).

Admission into engineering colleges has always been a tough proposition, with an increasing number of students seeking entry on the one hand, and limited availability of admissions in popular disciplines and disciplines of high status. Hence, preparatory coaching, which is also quite expensive, is widely perceived as one of the most essential pre-requisites for securing high ranks in entrance examination and then admission in engineering education institutions in India, though a good number of students who do not take such coaching, also obtain high ranks and admission as per their choice of disciplines and institutions. Since there is higher competition for modern disciplines like computer science and engineering, electronics and communication engineering, and information technology, students who have taken coaching, aspiring to get admission in such disciplines might more probably take pre-admission coaching than others. In our sample, approximately half of the students have gone for pre-admission coaching. The above stated general presumption is also confirmed by the probit results: those who go for coaching prefer IT-related modern disciplines, though the coefficient is statistically not significant and very small in value.

Effect of Factors Related to Current Education of the Students

Among different factors related to current education of the students included in this category, the type of institution the students have taken admission (ENGG_TYPE) has a significant effect, whereas other factors like, whether the students have received educational loan or not (ED_LOAN), whether the students have received scholarship or not (SCHOLARSHIP), facilities for part-time work (PART_TIME_WORK) and household cost of education (*ln*HH_COST) are statistically not significant.

Results of probit regression throw some light on the existing trade-off between type of institution and discipline of study. The results show that students studying in private institutions are 76% more likely to study in modern branches than the students studying in government institutions. This is largely because many private engineering institutions were established offering mainly IT-related streams. Offering of branches like mechanical and electrical engineering requires huge laboratories and investments, that the private institutions may not be interested to make. In contrast, most government institutions focus relatively more on providing strong traditional disciplines. The choices in case of a type of the institution and the discipline of study are closely and intricately related.

Contrary to normal expectations, cost does not seem to matter much. The household cost included as a continuous variable in logarithmic form in the estimation of logistic regression, turns out to be not as significant variable. The coefficient is, however, negative in value, suggesting that higher cost dissuades the student to opt for modern disciplines. Student preference for a discipline is not influenced by household expenditure. As per the survey data, the total household expenditure per student was Rs. 150,000 per year, which constitutes 47% of the annual average income of the family, which is high, but it appears the difference in household expenditure between the disciplines is not high (Tilak, 2019b).

Scholarship, educational loans and engagement in part-time work reduce the current financial burden of education on the households. They are also expected to influence the students' disciplinary choice. As per the estimated values of marginal effects in Table 4, variables on loans and scholarships, like total household expenditure, do have a positive effect on student's choices for IT-related disciplines, but the coefficients are not statistically significant. Part-time work opportunities have negative influence on students' preference for modern disciplines, though the coefficient is statistically not significant. As we have noted the number of students receiving scholarship or loan or engaged in part-time work constitutes a small proportion of the total number of students.

Effect of Employment Prospects and Educational Aspirations

In recent years, engineering graduates usually enter into the job market after completion of the under-graduate studies, and

hence very few of them go for higher studies, i.e., to pursue masters and Ph.D. level programmes.[11] But there are some who wish to go for further higher education either in engineering or in some areas of higher education. Particularly those who are interested in academic careers may prefer to go for further studies. Management programmes are very popular among the engineering graduates in India. But students may also go for masters (and research) programmes in engineering and technology. So depending upon their interests, students will chose those disciplines that offer better employment opportunities (in the country or outside), or those that facilitate progress to further higher studies.

Though the coefficient is not statistically significant, the results reported in Table 4 indicate that such a hypothesis is likely to be valid, and that students who desire to go for further study (to master and doctorate level) are less likely to enrol in IT-related departments than the students who are not interested in further studies. Two plausible reasons for this are: (a) the available scope to do higher studies might be higher in traditional departments of engineering education than in case of IT-related studies; and (b) the relatively easy availability of jobs for the graduates of IT-related studies, i.e., the students from IT-related disciplines possess higher opportunity cost of going for further studies than the students from traditional disciplines.

More importantly, as expected, the probability of getting employment after graduation (EMPLOYMENT) has a statistically significant influence on choice of a stream of study. It is found that job offer in on-campus recruitment is positively associated with increasing the probability of attending IT-related branches by two percentage points higher than a discipline with lower employment probabilities – the traditional disciplines. Students taking admission in IT-related branches have higher chances of getting jobs in the labour market than the students enrolled in traditional departments. Thus, students seem to consider on-campus recruitment records of various disciplines and institutions, while making a choice between admission in alternative disciplines and institutions. However, it is also argued that students do take into account not only expected economic returns when choosing a discipline, but also they consider their chances of academic success.

Summary of Findings

Engineering education has expanded fast in India during the last three decades. However, all branches of engineering education have not grown at the same pace. While standard traditional branches like mechanical, civil and electrical engineering have had been popular for a long time, areas like electronics engineering, computer science engineering and information technology related engineering have evolved fast in the recent years. Senior secondary school graduates face a dilemma of making an efficient choice in selecting the disciplines of their study. Using the data collected through a survey of about seven thousand students enrolled in forty engineering institutions in four different states in India, an attempt has been made in this paper to examine the factors that influence students in their decision making relating to choice of main streams in engineering education at undergraduate level, by estimating probit regression equation. We considered a few major factors – individual, household, academic background of the students, current educational practices, future employment prospects and educational aspirations etc., as possible determinants in this context and the results are discussed in detail in the previous pages. A few key signals are clear from the analysis:

- The probability of seeking admission in modern/IT-related departments is significantly higher among the students belonging to general category than the students belonging to SCs and STs. Surprisingly, belonging to the group of OBCs increases the probability of enrolling in IT-related disciplines as compared to general category students. Perhaps OBCs are as good as the general category, if not better, with respect to their socio-economic background. Similarly, the other individual characteristics that determine the probability of attending IT-related courses include gender. Compared to male students, female students are more likely to choose IT-related disciplines, though gender differences are not very marked.
- Native place of the students is found to be statistically significant in explaining the students' choice. Students migrate to other states to take admission in modern disciplines, while a majority of those who do not migrate get enrolled in traditional streams. However, many other household characteristics are found to be statistically not significant but the coefficients give expected results.
- In case of academic background of students, performance in the higher secondary examination turns out to be a statistically significant factor in the students' choice of disciplines. Higher the percentage of marks scored in higher secondary examination, higher is the probability of taking admission in IT-related departments than in traditional branches of engineering. This confirms the general belief that meritorious students score high percentage of marks in their senior secondary examination and also perform better in the competitive common entrance examination; and finally opt for IT-related departments. Similarly, students graduated from

[11] Compared to about 4.8 million students at first degree level, enrolments in master's programme were only 190,000 and in the Ph.D. programme 38 thousand in India in 2017–18 (MHRD, 2018). *See* also Banerjee and Muley (2009) for similar details.

schools affiliated to state (provincial) board are less likely to enrol in IT-related departments as against traditional departments. Generally the quality is believed to be better in schools affiliated to central boards and hence it can be concluded that better students seem to opt for modern disciplines.

- The results also show strong positive relationship between enrolment in modern disciplines and enrolment in private institutions. After all, many private engineering institutions offer admissions more in IT-related disciplines than in traditional areas, while many government institutions concentrate relatively more on traditional departments. Note that the traditional disciplines require higher investment in relatively more expensive laboratories and instruments, which many private institutions may be reluctant to make.
- As expected, employment potential and enrolment in disciplines are also related. Students taking admission in IT-related disciplines visualise higher chances of getting better or faster employment in the labour market than the students enrolled in other areas.

Some of the results are in conformity with general understanding and some not. The paper provides empirical evidence and unravels some of the issues involved in the students' choice.

An important limitation of the study is that we assume free choice for the students to select the discipline of their like. But this is not the case. There is a severe supply constraint, in addition to several kinds of market imperfections, including asymmetry of information that do not allow genuine free choice principle to operate. Secondly, what we define and measure here as 'choice' is not actually true 'choice'; it is not revealed choice; nor does it indicate revealed preference of the students. It only indicates enrolment, which can at best be described as 'experienced' choice. However, it is not far from choice, as students do have a choice to take it or to leave it. Thirdly, there may be several important factors that we could not consider in our quantitative analysis, constrained essentially by the survey data that formed the basis of this study. Many important related aspects could not be captured in the survey. For example, dowry, an important feature in Indian society, may have a very dominating effect on the students' choice of disciplines in engineering. Engineering graduates in IT-relates disciplines carry higher dowry. Women also tend to prefer such graduates for marriage. Further, scope for emigration to western world for higher studies or for employment also does influence students' choices. There may be several other quantifiable or intangible factors that could not be brought into this quantitative exercise here. So the results need to be interpreted with some degree of caution.

We found that almost everyone prefers to choose modern disciplines over traditional disciplines of engineering. Indian economy has begun experiencing a situation of a glut in the labour market with 'IT' engineers. The quality of these IT graduates is also on decline. Their labour market returns are experiencing a downward trend. But more importantly, engineering education scene is getting imbalanced with more and more low quality private institutions that too concentrating on modern disciplines at the cost of standard traditional disciplines. Due to asymmetry of information, students' preference for engineering education is still high, and more specifically the demand in favour of IT-related disciplines is growing. But traditional disciplines are also important for the rapidly growing economy. Low turnout of graduates from traditional departments in years to come may pose a serious bottleneck in the rapidly industrialising and fast modernising economy. Public attention may require on how to boost demand for standard disciplines of engineering in order to have a balanced development of all disciplines of engineering and how to check the growth and functioning of low quality private institutions which are actually fragmenting engineering education, by focusing on some disciplines at the cost of some basic and standard disciplines.

The trends observed here in case of engineering graduates in India, dominated by market forces, are not unique. Many other countries are experiencing similar trends. Higher education, and more particularly engineering/technical education is growing very fast in many developing and advanced countries like China, Brazil, and Russia, to mention a few. Quite a few countries are also experiencing unbalanced growth of several disciplines in engineering education of the kind noted here; and they are also experiencing frequent labour market imbalances. Hence, the analysis attempted and the results reached here could be of immense policy relevance for many other countries.

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