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Production, Education and Circulation of Engineers in India

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The bearers of scientific and technological innovations belong to two large groups of professionals, scientists on the one hand and engineers on the other, even if the boundary between these two groups is sometimes blurred. My talk will focus on the group of engineers and I will address three issues: first, the production of engineers, secondly, their international circulation, and thirdly, the quality of engineering education and the employability of graduate engineers.

1. The production of engineers in India.

Higher technical education, which is provided after class 12, which is equivalent to the final year of secondary school, in France (the classe terminale), is divided into two sectors : on the one hand, the engineering colleges which award Bachelors of Engineering or Bachelors of Technology (BTech) after 4 years of study ; and, on the other hand, the Polytechnics which award Engineering Diplomas in three years ; these diploma holders are also employed as engineers but at lower levels than the graduates' level. In my presentation, I consider exclusively the sector of engineering colleges.

The higher technical education that produces engineers has undergone profound structural changes since the late 1980s, that is, since the introduction of state policies whose aims were the deregulation of the Indian economy. These liberal policies have opened up to private investors areas of activities that had hitherto been preserved from the commercial sector, such as education. Furthermore, the transformations of the engineering education system must be linked to the emergence of the ICT sector.

As far as higher technical education is concerned, these changes can be documented on three levels: firstly, the number of engineering colleges, secondly their unequal

geographical distribution between states, and finally, a very unequal relationship between public and private colleges, which is reflected in the hierarchy of engineering colleges in terms of educational value, that is, the value of academic qualifications in the labor market.

Let me present 4 remarks.

a) The importance of engineering colleges in higher education.

Between 1985 and 2015, India has grown from about 240 engineering colleges to over 3300, which means a 14-fold increase in the number of colleges in three decades. Historically, no other country in the world has experienced such a large increase in technical education. What is the share of technical education in higher education as a whole? This growth represents a doubling of the share of technical institutions in higher education, from 4.5% to 8.3% of institutions. But in terms of enrolment in technical institutions, the share of engineering students has been multiplied by more than 5, rising from more than 3% to nearly 16% of students enrolled in engineering colleges.

The data available for 2020 suggest that the expansion of technical education has experienced a slight decline over the last 5 years (the number of engineering colleges is now around 3000).

I come to my second remark.

b) The engineering colleges are unevenly distributed, from a geographical point of view, among the states.

Here a parenthesis that anticipates my third remark. Two types of engineering colleges should be considered: on the one hand, those whose training ends at the bachelor degree, which is the vast majority of colleges, and, on the other hand, those which have a post-graduate program (MA, more rarely PhD). Thus, in mid-2010, about 50% (one college out of two) of all engineering colleges were located in the 4 southern states: Tamil Nadu, Andhra Pradesh, Karnataka, and Maharashtra, although these 4 states represent less than one third of the total population of India. But if we consider only engineering colleges at the undergraduate level, these 4 states account for about two thirds of the engineering colleges.

d) The field of engineering colleges is highly differentiated.

My third remark deals with the field of higher technical education that is a complex field unified by systems of competitive examinations organized, depending on the status of these colleges, either at the level of the Union of India, at the level of regional states, or at the level of individual colleges.

Two main factors structure this field of engineering colleges. On the one hand, their type of financing, public or private, in part or in whole. On the other hand, the curriculum offered, which opposes undergraduate colleges and postgraduate colleges.

Since the 1980s, there has been a privatization and commercialization of the education sector, particularly of technical education. The boom in engineering colleges is the result of the very high demand for technicians in the ICT sector that developed from the 1980s and 1990s. Public institutions, which were limited in number in the early 1980s, could not meet the labor demands of the ICT sector. Therefore, the government opened up technical education to the private sector. By 2015, more than 90% of engineering colleges were private institutions; but the majority of these institutions are under contract with the state (government-aided colleges). In other words, they must respect the quota policy in favor of disadvantaged groups (SC, ST, OBC).

Alongside these masses of engineering colleges, there is a minority of prestigious institutions that are still divided between the public and private sectors. For the public sector, the most famous engineering institutes are the Indian Institutes of Technology (IIT) and the National Institutes of Engineering (NIT) or old colleges such as the Guindy College of Engineering in Chennai.

But the private sector also has institutions of excellence such as the Birla Institute of Technology and Sciences, known as BITS, in Pilani, founded in 1964 by the Birla family, or the Sri Sivasubramaniya Nadar (SSN) Engineering College, established in 1996 by Shiv Nadar, the founder chairman of HCL, one of the leading ICT companies in India.

I come to my fourth and last remark.

e) How many engineers does India produce each year.

This is not as simple a question as it seems. But in 2015-2016, the All India Council for Technical Education (AICTE) gives the figure of 790,000 graduates for 3,300 institutions: (it should be noted that in 2019, these figures are slightly lower).

2. The circulation of Indian engineers.

The US has been the first destination for the migration of Indian engineers since the 1920s, particularly the Massachusetts Institute of Technology (MIT), which served as a model for the creation of IITs at the Independence.

To be schematic, we have to distinguish two types of migration in the US, which are very different in their purposes and social composition. A first group of migrants to the US, the largest in number, is made up of the mass of engineers in the ITC sector who found employment from the turn of the 20th century marked by Y2K imaginary bug.

Between 1990 and 2000, the number of Indians living in the US doubled from 450,000 to more than a million; and in the following decades the number doubled again: there are 2.7 million Indians in the USA in 2019 (but not all of them are engineers). This workforce of engineers and senior technicians was recruited in India, outside the colleges of excellence, by the major companies in the ITC sector, Tata Consultancy Service, Infosys, HCL, Wipro. Many of the employees were not even engineers in 2000, as the engineering college boom dates back to the later years.

A second group of migrant engineers in the US are postgraduate students who, after obtaining their bachelor's degree in India, go to US to continue their studies for a Master and then a PhD degree, or an MBA in a business school. These engineers, in the vast majority of cases, come from the pool of the best engineering colleges like IITs, NITs, BITs. It is estimated that about one-third of IIT graduates emigrate to the US. after obtaining their BTech degree.

Once the graduate studies in the US are completed, the question of return arises for these engineers. Researchers have shown that the chances of return decrease with the duration of the stay: if the return is not made within the first 3 years after the completion of the studies, the chances of a definitive return decrease.

I would like to mention two examples of engineers who, with a generation gap, went through the US and return to become important players in the ICT sector in India.

The first engineer is Faquir Chand Kohli, who just passed away in 2020 at the age of 96, he was born in 1924 in Peshawar. He completed his BSc in Electrical Engineering from Queen's University in Canada, and his Master degree from MIT. He worked for 3 years in US electrical companies in Canada returning to India in 1951. Then, he joined Tata Electrical Companies and 10 years later he took the leadership of Tata Consultancy Services (TCS).

The second example is S. Ramadorai, born 1945 in a Tamilian family, who succeeded F. C. Kohli at the head of TCS in 1996 and retired in 2009. Ramadorai is not an engineer but a scientist who holds a degree in electronics and communication from the Indian Institute of Sciences in Bangalore. He completed his education in the US with a MA in computer science and worked there as computer science graduate. But after his marriage, he returned to India, and was recruited by Kohli at TCS in1972.

These two types of migration are what researchers have called « brain drain » and « brain gain ». The alumni of the 5 historical IITs (today there are 23 IITs), who remained in the US where many of them became ICT entrepreneurs, formed, in the 1990s, a Pan-IIT Alumni Association called The Indus Entrepreneurs, TIE. The action of this association is oriented towards the defense and promotion of IIT Alumni both in the US and in India where these Indo-American entrepreneurs financially support their alma mater. In India, these entrepreneurs also invest in innovative start-ups in the ICT sector where they play the role of venture capitalists.

However, innovation is not always the work of IITians from the US. The IITs have developed structures that allow innovative companies to start up within the IITs before becoming independent. I conducted a study in a small start-up, with about a hundred employees, in 2013, specialized in the digital recognition sector, whose founders had chosen to develop their company in India, while expanding into the US. market.

3. The employability of Indian engineers.

The last point I would like to address is the quality of engineering education, which is reflected in terms of employability. This is a subject that is widely debated in all circles concerned (whether they are professionals, politics, citizens), on which as many studies have been carried out as there are proposed remedies.

The data that can be cited are those produced in particular by the consulting firm Aspiring Minds. This company has developed evaluation tests called AMCAT, an acronym that stands for Aspiring Minds Computer Adaptive Test. These tests are sold to large companies to be taken by job applicants. On the basis of these results, Aspiring Minds has been producing annual reports since 2010 in which the extension of these surveys outside India (in China in particular) is observed in order to assess the employability of Indian engineers in the global job market. It should be noted that Aspiring Minds is also a private company active in the training sector, which prepares students, at the end of their bachelor, for the tests it develops (the assessment market is segmented and does not only concern the engineering sector). The last reservation is that the assessments concern all engineering disciplines but are oriented towards the ICT sector, because the large companies in this sector recruit in all disciplines.

What does the last report consulted show for the year 2019 (the survey is based on a sample of 170,000 engineers from more than 250 engineering colleges). The conclusions are quite alarming: about 80% of graduate students (with a bachelor) are not fit for any job in the ICT sector. Less than 5% can code correctly, which is slightly higher than the Chinese engineers (2% only can code).

The results are detailed according to the different types of jobs (IT Toles, Engineering Roles, Non-Tech Roles, Soft-Skills), gender, tier cities, and tier engineering colleges. Unfortunately, there is no correlation with social groups, probably because the subject would be too controversial.

The results show that out of more than 3,000 engineering colleges, only 10%-15% maintain a satisfactory level of education: it is from this pool of 300-500 colleges that large companies recruit. The mass of graduate students is only qualified to work in the BPO (outsourcing) sector, a poorly paid job they are not prepared to do.

Before ending this presentation, I would like to mention a side question: the issue of caste in engineering education.

This issue is extremely complex, so it cannot be discussed in a few minutes. By caste, in this context, we mean the 3 major state caste groups that are subject to affirmative action, i.e. that benefit from quotas, in terms of seats in government and government-aided engineering colleges. To simplify, these are the SC (15%), the ST

(7.5%), and the OBC (27%), these 3 groups have a total of 49.5%. The remaining 50.5% constitute the General Category, which is open to all; (yet there are sub-categories like EWC, OBC-NCL, Other Minorities, which complicate this table). For the large mass of more than 3,000 colleges, the quota policy applies.

In fact, the issue of the unequal representation of SC, ST, and OBCs in higher technical education concerns mainly the schools of excellence that are the IITs. Quotas for SCs and STs were introduced in IITs in 1973, but due to their status of Institute of National Importance, quotas for OBCs were introduced relatively late, in 2008 only. The entry of the OBCs changed the social structure of the IITs' population, which was previously dominated by high castes. This is the reason for caste and class conflicts within IITs. The number of IITs has increased from 6 until 2000 to 23 today, but there are only about 10,000 seats for 1 million or more applicants (but it is a two-stage competition, and about 75% are eliminated in the first stage). Competition remains very intense to obtain a degree that is considered a guarantee for professional success (and quite often out of the technical sector, by the way).