Estimating Mincerian Earning Function for Engineering Trainings in Pakistan

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Abstract

Mincerian Earning Function (MEF), with its standard assumptions, is a dominant model to estimate earning returns to education through its earning-schooling relationship in labor markets. This study explores empirical evidence to estimate the MEF for different years of engineering training in Pakistan. The theoretical model of MEF is used to specify the main determinants of general education, experience, engineering training, and other variables to show a snapshot of technical training and earning relationships in Pakistan. The instrumental variable two stages least square (IV2SLS) technique gives estimates of MEF for the selected sample size of 371 qualified respondents in the fields of engineering education and training in this study. The two-stage random sampling technique is used to collect cross-sectional data, and the results are statistically significant for general education and engineering training in the case of Pakistan. General education, experience, engineering training, and the provinces associations for the respondents likely influence the log earnings of the respondents. The results put forth insightful policy implications for national and provincial public policy processes for human capital formation in the fields of science and technology.

Keywords: Human Capital, Mincerian Earning Function, Engineering Training, Education.

Introduction

The introduction part of this study consists of three parts. The first part explores the literary context of the study. The second part covers the research gap and objectives of the study. The last part of this introductory section covers the scheme of the study.

Literary Context

The studies of Griffen (2024) and Freeman and Soete (2009) are of the view that the development of science and technology has many current and futuristic perspectives, from early human life till today, for the overall development of societies across the globe. The global economy has changed manifolds by the advent of sciences and technology over the last 150 years. The economies have flourished in progressive manners on the sides of productivity in all the known economic sectors. The studies of Martine (1995) and Kostoff and Schaller (2001) give the foresight and roadmaps, respectively, of science and technology to progress well ahead. These studies have explored the experience of the world's top advanced countries and developing countries as well in science and

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technology and showed phenomenal benefits of the advancements of science and technology both for overall economic and social benefits. The innovations and inventions of scientific knowledge through engineering, information and the, computer technologies, and biological sciences paved the way for the development of prosperity accrued to people across the globe. Specifically, the development of engineering education and training is shown to penetrate most of the economic sectors to increase productivity and livelihood-earning benefits in the labor markets of these advanced economies of the world.

The literature on human capital theory has established the relationships between education, scientific development, human resource development, and individual productivity in economic ways of thinking after the scientific development of knowledge generation (Almendarez, 2011; Hartog & Van, 2007). The development of science and technology gives no direct relationship between earnings and other aspects of development, but through human capital, theoretical connections, the impacts of scientific development on marginal productivities of individuals are theorized by human capital theory and its alternate models (Bozeman et al., 2001).

The human capital theory of Becker (1992) illustrated the importance of education, skills development, science and technology, and other forms of schooling to enhance and theoretically link the marginal productivity of individuals with educational acquisitions of individuals and became a dominant and proven study model to show and justify the relationships among any aspect of education and marginal productivity (Gillies, 2015; Sweetland, 1996; Wuttaphan, 2017).

To follow the literary context of the topic concerned, one of the studies of Becker (1994) illustrates the Chicago school of thought on the human capital theory of Becker (1062) in the context of a half-century work on the marginal productivity of labor, that is, returns to education. Becker (1994) distinguishes between capital and human capital, and he argues that human capital yields return to individuals exactly in the same manner as capital yields return to income capital. However, the income capital is deposited in banks, and human capital gives returns through marginal productivity in the production models through labour wage determinations.

The labour market returns to all forms of education, training, and experience of individuals are theoretically underpinned by Jacob Mincer in 1958 through his groundbreaking work to show the relationships between training and earnings empirically. Later, this model was termed the earning-schooling model under the title of Mincer Earning Function (MEF) in the literature concerned (Becker, 2009; Mincer, 1974; Heckman et al., 2003).

The empirical applications of MEF to estimate the earning-schooling and earning-skilling relationships became a decent convention in the fields of economics, labour economics, the economics of education, and many other fields of socioeconomic development. The MEF has different variants across different economic, educational, social, political, investment, and labour market outcomes in the shapes of model specifications for all types of cross-sectional, time-series, and panel data estimates. The MEF is modelled for different household, labour market, and social and economic data to give both rigorous theoretical insights and policy implications for the designs, policies, and development pertaining to investment in education, science and technology, and skills development across the globe (Ahmed, 2019; Heckman et al., 2006).

The usefulness of standard MEF for estimating the earning-schooling relationships is widely recognized to be extended in many fields of education and training acquisitions for policy interventions to opt for investment in human resource development across the globe (Bjorklund & Kjellstrom, 2002). In the case of Pakistan, no study has been found to give a snapshot of empirically estimating the MEF very specifically to show the economic importance of engineering

training in different technologies across different universities and technical training centers in the country.

In support of the claim in the last sentence, the studies of Shabbir and Khan (1991) are one of the early studies on MEF in the case of Pakistan, and they lack a specification of the estimates of MEF exclusively for engineering education and training. Another study of Shabbir (1994) is also important to cite here in support of the claim and it also implies specifically education sector-wise empirics of MEF for Pakistan.

Similarly, the studies of Abbas and Foreman (2008), Ahmed (2019), and Nasir and Nazli (2010) are implications to suggest further research on estimating MEF for different sectors of education, science and technology, and other training skills that map overall human capital development model of Pakistan. The MEF to be estimated for engineering training is necessary to educational policy implications for higher education of Pakistan and skills development programs of both the provinces and federation of Pakistan to optimally allocate adequate investment funds for human resource development as per the targets of Pakistan Vision-2025, sub-targets of sustainable development goals (SDGs), and labour market demands for technological and industrial sectors of the economy of Pakistan (Pakistan Vision-2025, 2017; UNDP, 2015).

Literature Gap and Study Objectives
The provinces and government of Pakistan have been allocating billions of funds in Pakistan currency every year for the function and development of engineering education and training in Pakistan. There are more than 150 universities across the country that disseminate engineering training in different study programs in all the provinces of Pakistan. At the national level, the National Vocational and Technical Training Commission (NAVTTC) and Technical and Vocational Training Authorities (TEVTAs) are working in all the provinces of Pakistan for the purpose of disseminating technical and vocational education and training (TVET). The overall TVET programs are aimed at providing both technical and vocational skills in different trades to train youth and unskilled labour for the economic and labour market demands in the country. The TVET sectors across the educational disciplines and educational segregation are not discussed to categorize the true needs of earning and employment prospects of unemployed youth and industrial labour market demands. It is necessary to estimate the proven model of MEF applied for estimating the rates of returns to engineering training for relevant policy insights and interventions to justify the funding of investment in the fields of engineering education to universities, NAVTTC, and provincial TVETs. However, the empirics of earnings estimates for engineering diplomas and certificates are known only to get insight into proper skills development policy processes in the country (Ahmed et al., 2021; Mahmood 2007).

Similarly, the dominant supply-side focus on skills dissemination has created demand and supply gaps of relevant skills in the country's labour markets. There is evidence that the relevant skills shortages are present despite huge investments in training the youth across the country (Ahmed & Shah, 2022). This study also implies the provision of relevant skills and training to the youth to ensure the targets of employment and decent levels of earnings for the skilled unemployed youth of the country. In light of the above literature gaps on the part of training in Pakistan, this study aims to estimate the MEF for different engineering skills and training across the country.

Scheme of the Study
The study employs the theoretical model of MEF, model specification, and data collection in the next section of the research methodology. The third section of the study will discuss the important

results of MEF for engineering training in Pakistan. The last section of the study concludes the study with policy implications for the development of skills in Pakistan.

Methodology
This section of the study starts from elaborating the theoretical model of MEF, model specification for statistical analysis, estimation technique, and data collection methods of the research methodology adopted in this important empirical work in case of Pakistan.

Theoretical Model of MEF
The theoretical version of MEF for estimating the earning and schooling relation of Mincer (1974) is used, given, and elaborated below as model (1).

$$y_i = a_0 + a_1 edu_i + a_2 exp_i + a_3 (exp_i)^2 + e_i \ldots\ldots\ldots\ldots (1)$$

The above MEF (1) indicates that, y_i is earning of an individual "i" who acquired engineering training from an engineering university and a technical training institute, edu_i is general education in number of years of schooling completed, exp_i is the labor market job experience, and $(exp_i)^2$ is square of the experience terms to capture concavity of the model (1) of an individual, and e_i is the error term.

The standard assumptions of the model (1) are intact as per the statistical conventions described for model (1) to measure the earning and schooling relationships. This model (1) is prescribed for capturing many variants of earning and trainings relationships based on 50 years of MEF in the literature (Heckman et al, 2003).

Model Specification of MEF for Engineering Trainings
The model (1) of Mincer (1974) is specified in the following for including the necessary determinants of earnings, including the number of years of engineering trainings completed by individuals, for individuals in case of Pakistan as model (2).

Following the conventions and to capture the determinants of earning in broader perspectives in addition to general education and experience of individuals, the engineering trainings and other socioeconomic determinants are incorporated in statistical model specification for the purpose of this study.

$$y_i = a_0 + a_1 edu_i + a_2 exp_i + a_3 (exp_i)^2 + a_4 eng_i + a_5 rural_i + a_6 public_i + a_7 prov_i + a_8 gen_i + e_i \ldots\ldots\ldots\ldots (2)$$

The above specified MEF (2) indicates that, y_i is earning of an individual "i" who acquired engineering training from an engineering university and a technical training institute, edu_i is general education in number of years of schooling completed, exp_i is the job experience of individuals in labor labors, and $(exp_i)^2$ is square of the experience terms to capture concavity in model (2) of an individual, eng_i is engineering trainings/education in number of years in technical trade, $rural_i$ is two category dummy variable if an individual belongs to rural area, $public_i$ is engineering institute located in rural area, $prov_i$ is a province a four category dummy variable and shows if individual belongs to provinces other than Balochistan, gen_i is two category dummy variable of gender if an individual is male by gender, and e_i is the error term.

As per the empirical estimates of model (2), it is expected that the signs of a_0, a_1, a_2, a_4, a_6, a_7, and a_8 are positive and the rest coefficients are negative by signs (Heckman et al, 2003; Mincer, 1974, Shabbir & Khan, 1991; Becker, 1994).

Estimation Technique
The two stages instrumental variable least square (IV2SLS) technique is used for estimating the earnings returns of model (2) for engineering training of the respondents by following the studies of Ahmed (2019), Mincer (1974), Hickman et al. (2003), Gillies (2015), and Sweetland (1996) for this study. The studies of Ahmed (2019) and Hickman et al. (2003) have also estimated MEF models via the IV2SLS technique along with the benchmark estimation techniques of ordinary least square (OLS), but they also recommend that the OLS estimates of MEF lack meaningful interpretations and have less meaning in the presence of superior approaches like IV2SLS methods and other statistical approaches. Thus, the convention of the concerned literature is here followed, and the OLS estimates of model (2) are not incorporated in the results. The discussion on the estimates is based on parameters estimates of model (2) in this study.
For the IV2SLS technique to apply to the data of model (2), the instrument for the education variable is needed, and the average years of mother and father education are used as instrumental variables in the second stage of the estimation technique (Heckman et al., 2003, 2006).

Variables and Data Collection
It is field survey research and covers multiple factors of research conventions like different engineering training levels, gender aspects, provincial association of the respondents and earning profiles in four provinces of Pakistan. It is a cross-sectional study of a sample size of 371 skilled respondents who got training in selected engineering universities and technical training institutes in the country. The physical location of the universities and training institutions encompasses the four provinces of Pakistan. The data is collected with the help of a full pledged questionnaire adopted and modified for the study from the unpublished thesis of Ahmed (2019) as a data collection tool. A field survey is conducted from March 2020 to May 2020 to get relevant data. A total of 400 respondents were consulted for data collection. However, the data of only 371 were completed and made ready for estimating the model (2). The sampling technique of two stages of random sampling is used based on four categories of engineering training in the first stage of sampling and the gender factor as the second stage of sampling technique in data collection. The data is limited to only the respondents of technically trained individuals in the fields of engineering degrees of Bachelor, Master, and Post-graduate qualified from universities and qualified respondents with three years of Associate Engineering Diplomas/certificates from technical centers affiliated with universities, colleges, NAVTTC or provincial TEVTs across the country (Ahmed & Shah, 2022).

Results and Discussion
The descriptive analysis of all the dependent and independent variables of model (2) is first reported and discussed. Later, the parameters estimate of model (2) through IV2SLS techniques are reported and discussed in this study.

Descriptive Results and Discussion
The descriptive results show that a total of 371 respondents are distributed on many parameters of model (2) specified for this study. The total number of observations is distributed, and 165 respondents are qualified with three years of associate engineering certificates and diplomas from affiliated technical institutes in Pakistan. The respondents with proper degrees, such as Bachelor of Science, are 139 reported in this study. The number of respondents with a Master of Science or

M.Phil. in the fields of engineering is 54, and highly qualified with PhD degrees engineers only 13 covered in this study for data collection across the country (table 1).

The data also showed that the average earnings of Associate Engineering Diplomas are reported around PKR: 27,218, BS (Engineering) PKR: 56,245, MS (Engineering) PKR: 113,207, and highly qualified PhD (Engineering) 225,175, respectively in the respective labour markets of Pakistan. The general levels of education are distributed as 12, 16, 18, and a minimum of 21 years for three years of engineering training, four years of engineering training, seven years of engineering training, and a minimum of 11 years of engineering training, respectively. The job experience of all four groups of qualified engineers is in the range between 4.5 to 6.7 years of job experience in Pakistan's labour markets (table 1).

In rural areas, a total of 244 respondents got training in different engineering levels and urban areas, the numbers of qualified respondents are 127 reported in this study. Provincial distribution is important, as most of the engineering training is disseminated to the population of Punjab, as the least is disseminated to the least populous province of Balochistan in Pakistan. The gender segregation indicates that the provision of engineering education and training is skewed to more males as compared to the female segments of Pakistani society (table 1).

The data in table (1) shows that engineering training is provided mostly to male segments of the population, in rural area respondents, mostly in 3 and 4 years of engineering qualification levels, and Punjab-centric due to many social, demographic, population-based, investment in engineering fields, and the availability of public sector skills development frameworks in Pakistan.

The results also implied a positive relationship between general education and earnings. This relationship is empirically shown in the same line as per the support of the literature concerned, Ahmed (2019), Heckman et al. (2003, 2006) and in the support of Mincer (1974), and other studies in the fields of education and labour economics.

The results of table (1) imply that there are many social, economic, and educational benefits that the engineering system of Pakistan accrue to the general population for human capital. Formation targets envisioned in the Pakistan Vision-2025 document and achieving the sustainable development goals of SDGs (Pakistan Vision-2025, 2017).

Table 1: Descriptive statistics of Engineering trainings in Pakistan

Parameters	Associate	Bachelor	Master	Post-graduate	Total
Observations	165	139	54	13	371
Earnings	27,218.94	56,245.21	113,207.02	225,175.54	-
Education	12 years	16 years	18 years	=>21 years	-
Experience	6.7 years	5.1 years	4.5 years	4.9 years	-
Eng Skills in Years	3	4	7	11	-
Rural	112	95	31	6	244
Urban	53	44	23	7	127
Public	103	95	36	-	-
Private	62	44	18	-	-
Balochistan	16	11	9	2	38
Punjab	85	72	21	6	184
Sindh	41	31	13	3	88
Pakhtunkhwa	23	25	11	2	61
Male	117	93	39	9	285
Female	48	46	15	4	113

Source: Authors' calculations for the collected data.

IV2SLS Results and Discussion

The results of IV2SLS are shown below in table (2) and briefly discussed onwards to show the empirical relationships between engineering training and earnings for selected individuals in the case of Pakistan. The IV2SLS results are based on model (2) of this study, and it does not cover the complete aspects of the overall engineering programs of the Higher Education Commission and all the NAVTTC and provincial TEVTAs frameworks in Pakistan's labour markets. The results are a snapshot of empirically estimating the MEF for engineering training in the case of Pakistan, and further studies on MEF on the same line may be covered by the nationally representative databases of Labor Force Surveys and other surveys of the Statistics Division of Pakistan and other organizations. Shedding light on the limitations of data and suggesting further empirics for specific programs of training in the preceding sentences, the results of IV2SLS are presented below in table (2) and discussed simultaneously.

The estimated parameters of model (2) through IV2SLS in stage two reveal that model (2) is statistically significant at Wald chi (2) = 41201.12 at P-value = 0.000 and showed the power of model specification for empirically estimating the MEF for engineering training in case of Pakistan. The results of the coefficients show that many factors likely influence the earnings of qualified respondents through engineering training in Pakistan. The influence of general education on earnings shows that one year of extra general education likely increases around 12% in the earning profiles of respondents in Pakistan. The results are mostly in line with the empirics of both the national and international labour markets for the relationships between general education and schooling in the context of MEF (Chiswick, 2003; Heckman et al., 2003; Shabbir & Khan, 1991). The experience parameter is likely to increase the earnings of around 4% of the technically trained respondents in Pakistan's labour markets. The experience returns to earnings are shown less in this study as compared to the studies of Mincer (1994) for most of the countries and that of Ahmed (2009) in the context of Pakistan. The reason for the lower reporting of experience of the empirical results shown in table (2) might be the specification of an individual field of engineering training in the case of Pakistan. The statistical significance of experience-squared is also significant, and the minus sign with the coefficient of the experienced squared is also in line with the relevant literature (Chiswick, 2003).

The influence of engineering training on the log earnings of respondents shows that each year of extra engineering training likely increases earnings by around 13% in the case of Pakistan. The results of engineering training are significant at 5% confidence intervals, and most of the studies in the literature confirm these results (Patrinos, 2016).

In the case of respondents hailing either from rural or urban areas and its influence over their earnings, the results show a statistically significant parameter of extra earnings of around 21% for respondents belonging to rural areas as compared to urban areas of Pakistan. The results are in contrast with most of the literature concerned, and the reason might be that the question is asked in the questionnaire respondent to indicate their local/domicile certificate of origin during the data collection of this study.

The results of engineering acquisitions either from public or private skills institutes and the training acquisitions from public sector institutes are reported as insignificant results in table (2) through IV2SLS estimation techniques for a limited sample size of 371 in this study.

In the case of provincial associations of the respondents of this study, respondents from all the provinces of Pakistan are likely earning more earnings based on the same levels of engineering skills as compared to the respondents belonging to the least developed province of Balochistan. The results are significant for the respondents of Punjab and Sindh and insignificant statistically

for the respondents of Pakhtunkhwa. The significant results of the respondents of Punjab and Sindh indicate that being a domicile holder of Punjab earns 16% and that of Sindh earns 10% extra earnings as compared to the same level of qualified respondents holding the local of Balochistan. However, the extra earnings of Pakhtunkhwa domicile holders in comparison with Balochistan local certificate holder respondents are not statistically significant in the estimated results of Model (2). The results are in line with Abbas and Foreman (2008), Nasir and Nazli (2010), and Shabbir and Khan (1991) in the case of Pakistan. The reasons are described well by the preceding cited studies.

The last results of gender-based influence on the earnings of the respondents in the case of engineering training are not statistically significant. The reason might be a limited sample size, highly skewed towards male qualified respondents, and the disproportionate nature of data collected in the field of engineering education and training for Pakistan.

Table 2: Mincerian earnings estimates of Engineering trainings in Pakistan (Only for 371 Cross-sectional observations)

(Dependent Variable is Log Earning) (2nd Stage Results of IV2SLS)		
	Coefficients	P-values
General Education	0.1182***	0.0001
Experience	0.0351**	0.0091
Experience-squared	-0.0021*	0.0534
Engineering Trainings	0.1319**	0.0127
Urban (Base)		
Rural	-0.2101	0.3407
Private Institutes (Base)		
Public Institutes	0.3201*	0.0562
Balochistan (Base)		
Punjab	0.1601*	0.0501
Sindh	0.1045**	0.0102
Pakhtunkhwa	0.9287	0.7207
Female (Base)		
Male	0.1209*	0.0578
Wald chi (2) = 41201.12; Prob>chi2 = 0.000; R-squared = .8915; Root SME = .21871		
Source: Stata calculations by authors		

Conclusion and Policy Implications

This study is the first-ever study, though constrained in spheres of limited data, to estimate MEF for engineering training of four categories in Pakistan. The associate engineering diplomas and certificates, the bachelor's, the master's, and the post-graduate degree holders are the focus of this study to capture the earnings estimates of their qualifications in the case of Pakistan. The standard MEF and its model specification for the study revealed beneficial policy insights for the development of engineering education in Pakistan. The cross-sectional study of 371 respondents through the estimation technique of the IV2SLS approach showed some statistically significant relationships between general education and earnings and between engineering training and earnings in the case of Pakistan, as theorized generally by the standard studies of human capital frameworks. There are positive relationships empirically shown between engineering training and earnings for qualified engineers and technically expert individuals in Pakistan's labour markets. The results and discussion may imply the following policy implications.

1. The government must ensure adequate fund allocations for the development of science and technology, particularly in the fields of engineering education, to develop human capital formation as per the demands of Pakistan's industrial and labour markets.
2. Rural and female-specific engineering education programs must be prioritized to train huge and less fortunate segments of Pakistani society. The policy parameters must consider gender and rural contexts in prioritizing social sector development plans.
3. The dormant and dysfunctional training exercises of NAVTTC and provincial TEVTAs must be made active and functional in rural areas of Pakistan generally and particularly in marginal areas like Balochistan.
4. The associate engineering diplomas must be extended to more demanding skills trades as per the demands in rural areas, labour markets, industrial needs, and day-to-day technical needs of common people by the existing universities and technical training centers across the country.
5. There must be strong linkages between NAVTTC, TEVTAs, TVET allied departs, and engineering universities to develop a comprehensive and inclusive skills development framework for human capital formation in Pakistan.

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