RESEARCH ARTICLE

Estimating returns to education: The control function approach

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Abstract

This study aims to evaluate the effect of schooling years on wage level in Turkey by using the Mincer wage equation. This function is used as the baseline for the investigation of earnings determinants. For this purpose, the relationship between wage and education level of people is estimated by using a semiparametric regression model considering the control function approach. Various variables such as education level, experience, gender and marital status are estimated separately in the wage model by utilizing the Household Budget Statistics micro data set of 2017 in Turkey obtained by the Turkish Statistical Institute. The parametric model does not clarify the model clearly when functional form of relation is not known. To overcome this drawback, semiparametric regression model, which contains parametric and nonparametric variables, can be successfully applied. This model is extended by adding the 1997 education reform as a control variable. The achieved semiparametric test results from this study showed that there is a positive relationship between schooling years and wage level. On the other hand, control function approach results indicate the existence of fluctuant progress for the effect of schooling years on the wage level along the period.

Keywords: Labor Markets, Mincer Wage Equation, Education, Semiparametric Regression Model, Control Function Approach, Endogeneity

JEL Codes: I0, C0, J01

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1. INTRODUCTION

Education is essential for human beings and a key factor in the process of development. At the same time, it is an important determinant of wage level. Some empirical studies reveal that educational wage differentials increased in the past decades. Mincer (1974), one of the pioneers who analysed relations between human capital accumulation and earnings in labor markets, reveals that education levels and experience are determinants for wage levels. According to the Mincerian wage equation, more educated and more experienced workers earn more than others who are less eligible. In other words, wage level is a function of education and experience.

Mincer indicates that wage in logarithmic form is linear in schooling and quadratic in experience in function, some reported studies showed the same empirical results as well (Martins and Pereira 2004; Tansel and Bodur 2012). On the other hand, some of the research results conclude the different functional type of Mincerian wage equation (Murphy and Welch 1990; Seltzer and Frank 2007). There is no exact agreement about the functional form of the wage model in recent studies. The investigation of this assumption entails an estimate of whether the Mincerian wage function is in a certain form empirically or not. Although parametric regression models are assumed to be the best models which explain relations between variables, these models may not perform this assumption (Lee 1990). Assumption requirements and exact orders in the validity of parametric regression models lead to the design and development of new approaches and methods, which provide flexibility in the validity of assumptions. Nonparametric and semiparametric regression methods which ensure this flexibility in models are used for this purpose (Gibbons 1976). Mincerian wage equation contains nonparametric and parametric variables in the model. Thus, the semiparametric regression model is appropriate for this approach.

In this study, the relationship between schooling years and wage level based on the Mincerian wage equation is investigated by using semiparametric methods that consider the endogeneity problem. The data set is obtained from the 2017 Household Budget Statistics micro data set for Turkey provided from the Turkish Statistical Institute (TUIK). This semiparametric regression model involves the nonparametric components of years of education and years of experience along with parametric components of other variables in the Mincer function to clarify the log of wages. Schooling may be endogenous because of the omission of some factors, which affect the wage level in the Mincer equation. The existence of a correlation between these unobserved factors and schooling causes inconsistent and biased estimate results. The instrumental variable method is used to overcome this endogeneity issue. This issue is solved by the control function approach.

1997 education reform was politically motivated and unexpected. The reform extended compulsory education from five years to eight years. This reform is used as a natural policy experiment in the analyses and is viewed as an ideal instrument in literature (Patrinos et al. 2021). The education reform is used as an instrumental variable in the control function approach in this study.

The rest of the paper is structured as follows: Section 2 involves a definition of the Mincerian wage equation and literature. Section 3 presents the methodology, Section 4 includes data and Section 5 provides the achieved results. Finally, the conclusion is provided in the last section.

2. MINCERIAN WAGE EQUATION AND LITERATURE

The Mincerian wage equation involves determinants of individual wages and has been interested in many economists for decades. The logarithmic form of wage level is organized as a function of years of schooling and years of potential experience in the Mincerian earning model (Mincer 1974). Standard Mincerian semi-logarithmic wage function is formulated as:

$$lnW_i = \alpha + \beta ED_i + \zeta_1 EX_i + \zeta_2 EX_i^2 + \varepsilon_i \tag{1}$$

where lnW_i is log of gross hourly wages, is years of schooling, ED is experience which EX is obtained as age minus schooling years minus school starting age and is error term. Mincerian wage equation postulates a linear relationship with years of schooling and a quadratic relationship with years of experience. The functional form of these variables is derived from human capital theory, which refers that people accumulate human capital in the

labor market and school. According to this theory, earnings are assumed to depend on years of schooling and potential experience referred to as on the job training in the human capital literature.

Generally, years of schooling's coefficient is assumed as the rate of returns to schooling in regression of log earnings level on years of schooling. Other variables such as gender, marital status, occupation, region, firm size can be used in this regression model. Earnings, years of schooling and years of experience are three key regressors in the Mincerian wage model while other regressors are added to the model (Güriş and Çağlayan 2012: 1409).

A number of empirical studies on the estimates of the rate of returns to education using Mincerian wage (earnings) equation were reported in the literature. Various econometric models and approaches were used to estimate the results of the wage distribution and returns to education. Heckman et al. (2008) examined the internal rate of return to schooling using the U.S. decennial censuses between 1940 and 2000 based on Mincerian earning model. The results indicate that high school graduation provides larger returns than graduation from college. Black et al. (2011) predicted the return to schooling across local labor markets in the United States in 1980, 1990 and 2000. According to the results, returns to education is relatively low in expensive high-opportunity cities. Bhuller et al. (2017) investigated the causal relationship between schooling and earnings over the life cycle using Norwegian data from 1967 to 2014. In their study, the obtained results exhibited that additional schooling gives higher lifetime earnings. Gautam (2020) studied the relationship between wage and education in 2017 in Nepal. It was found that the rate of return to schooling in Nepal is lower than the South Asian average and varies across demographics.

Studies concerning the Turkish case also investigated the impact of years of schooling on earnings using Mincerian wage equation. Tansel (1994) estimated earnings function using Turkish data and found that university graduation has more influence on women's wage earner than men wage earners. Bircan and Tansel (2006) investigated the returns to education using the data from 1994 and 2002 in Turkey. The findings revealed that returns to education declined on average in the related period. Vural and Gürcan (2008) examined the private returns to education using 1994 and 2004 data for Turkey. The achieved findings demonstrated that returns to education change across the different sectors and there exists an important heterogeneity in returns to different schooling levels. Güriş and Çağlayan (2012) analysed differences in returns to education in the years 2003 and 2006 in Turkey. The findings concluded that schooling has an impact on wages for both male and female workers.

Nonparametric and semiparametric regression models were also estimated using the Mincerian wage model in empirical studies. Ulrick (2007) applied a nonparametric model to measure returns to education for year 1999 using U.S. data. The obtained results indicated that nonparametric model estimates the returns as double compared to the standard Mincer formulation. Henderson et al. (2011) estimated homogeneous rates of return to schooling by using nonparametric regression in the period between 1940 and 2000 decennial data in the U.S. In their study, the results indicated that contrary to previously reported studies. The average gap in the rate of return between black and white employees is larger. However, this gap between immigrants and natives is smaller.

On the other hand, Turkish case studies using semiparametric approach are quite restricted in literature. For example, Akay and Uyar (2017) successfully applied the semiparametric regression model to investigate the relationship between wage and other control variables by utilizing 2013 data in Turkey. The achieved results confirmed that the effect of schooling on female workers is more than on male workers; also this effect on workers in the private sector is more than in the public sector. Baskaya and Hulagu (2011) used semiparametric technique to estimate the wage gap between formal and informal employees using data between 2005 and 2009 in Turkey. The achieved findings concluded that an increase in years of education affects being a formal worker positively.

There is a variety of studies that examined the Mincer wage equation using semiparametric regression with an instrumental variable approach. Kharbanda (2014) investigated the marginal rate of return of education on wages using data from 1980 and 2000 in India. According to the findings, the existence of instrumental variables in the model affects the marginal rate of returns to education after a high school degree especially. Gabbriellini (2015) also estimated the rate of returns to education using semiparametric regression with an instrumental variable approach. In this study, the obtained findings supported that returns to education is important for earnings.

3. METHODOLOGY

Semiparametric specification is used to investigate the relationship between wage level and years of education. There is a parametric form between dependent and independent variables in the parametric model. Because parametric functions might be misspecified and restrictive, a semiparametric approach is applied in this study:

$$y_i = f_1(x_1) + \ldots + f_j(x_j) + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon \tag{2}$$

where where $\beta_1 x_1 + \ldots + \beta_k x_k$ represents the parametric component and $f_1(x_1) + \ldots + f_j(x_j)$ the nonparametric component. Parametric variables are estimated by using ordinary least squares (OLS) and nonparametric variables are estimated using splines. The backfitting algorithm is used in the presence of the relation between parametric and nonparametric variables and provides opportunity of consideration this relation. Partial residuals of each independent variable are obtained in the process of backfitting algorithm. Partial residuals of nonparametric variables are smoothed and the partial residuals, which belong to parametric variables, are used to construct a regression of these variables. The regression model estimation is applied by using the OLS method. Nonparametric regression estimation is obtained by applying backfitting algorithm.

The nonexistence of correlation between explanatory variables and the error term is an essential hypothesis in regression model. If there is a correlation, estimators are no valid in function. In such case, the OLS method is no valid and an instrumental variable approach is necessary to apply. The instrumental variables should be selected in a way that they are correlated with the explanatory variables strongly but not correlated with error components in the function. The problem of endogeneity may occur in the nonparametric function and the control function approach, enhanced by Newey et al. (1999) can be used to overcome this issue. This approach considers a triangular nonparametric system where:

$$Y = f(X, Z_1) + \varepsilon$$
$$X = \mu(Z) + U, E[\varepsilon|U,Z] = E[\varepsilon|U], E[U|Z] = 0 \tag{3}$$

X is d_x x 1 vector of endogenous variables, Z is a d_x x 1 vector of instrumental variables and Z_1 is included as $d_{11}x1$ subvector. $\mu(Z)$ is d_x x 1 vector of functions which belong to instruments Z and U is d_x x 1 vector of error terms.

Newey et al. (1999) focus on the identification of *f(.,.)*. They aimed to reduce the curse of dimensionality problem and implemented a procedure of three-step estimation for an additively separable nonparametric structural function for this purpose. To obtain consistent estimates of residuals, the first stage includes separate regressions for each endogenous regressor on the exogenous regressors. In the second stage regression, obtained residuals are employed. Single regression of the response variable is applied to each endogenous regressor and each residual is calculated from the first-stage regressions. Finally, in the third stage includes, the backfitting algorithm is used to estimate additive components or *f(.)* functions (Ozabaci et al. 2014).

In this study, the years of schooling is a possible endogenous variable because of adverse causality with wage level. The endogeneity problem is considered for the Mincerian earning function in a nonparametric form. The exogenous variable for years of schooling is selected as 1997 educational reform, which is taken from the literature.

4. DATA

In this study, the relationship between schooling years and wage level based on the Mincerian wage equation is investigated by using semiparametric methods that consider the endogeneity problem. For this purpose, data were obtained by Household Budget Statistics micro data set in 2017 for Turkey provided from the TUIK. The employees ages from 15 to 65 were considered.

The natural logarithm of annual wages (WG) is considered as the function of education (EDU), years of experience (EXP), marital status (MS), gender (GN) and educational reform of 1997 (ER). Education is defined as completed years of schooling in the study. There are various changes in the years of schooling number based on educational reforms in the Turkish educational system. Compulsory level primary school degree was 5 years until 1997. Middle school degree was 3 years and high school degree was also 3 years till the educational reform started in 1997. After this reform, the completion necessity of basic education was 8 years; evaluated as 5 years of primary education and 3 years of middle school. High school degree was 3 years and extended to 4 years in 2005. Another educational reform was implemented in 2012. Primary school degree was decreased from 5 years to 4 years after this reform. Middle school requirement was also extended to 4 years and high school degree remained as 4 years. This current system is named as 4+4+4 system since 2012. As a result, the compulsory level of schooling was evaluated as 12 years including the high school level as well. The people who did not complete any school degree are assigned as 2 years of schooling in the study. There are 2 years of college education, 4 years and 6 years of bachelor's degree as well. A post-graduate degree is also separated in the questionnaire. Additional 2 years is approved if the person is graduated from master degree of schooling, 4 years is assumed if the individual completed the doctorate degree.

Experience is estimated as equal to "age- completed years of schooling-6", where 6 is approved as the school start age in literature. Marital status, gender and people that were affected by the 1997 educational reform are defined as dummy variables in the study. Dummy variables are equal to one for male employees, married employees and the employees for which the 1997 educational reform had an impact on. People who were born in 1986 or later were assumed to be affected by the 1997 reform.

Table 1. Descriptive Statistics of the Variables

Variables	WG	ED	EXP
Mean	4.1	9.3	21
Maximum	5.8	20	57
Minimum	1.6	2	0
Std. Dev.	0.5	4.05	13.1
Num. of Obs.	11447	11447	11447

Table 1 shows the descriptive statistics for the variables in the study. For the employees, an average level of logarithmic wage is 4.1. The maximum wage level is approximately 6, the minimum level is higher than 1.5. Average years of education is 9.3. The maximum years of schooling is 20 years, equal to a doctorate completion year. The minimum years of schooling is 2 years, which represents the noncompletion of any schooling degree. Mean years of experience is calculated as 21 years and the maximum years of experience is 57 years in the findings. Minimum years of experience is defined as 0 which means that there are employees who didn't complete one year of experience in labor markets.

5. RESULTS

The effect of years of education on the wage level is investigated by a semiparametric regression model with a control function approach. In this section, the standard Mincerian wage model, Mincerian wage function with semiparametric regression model and Mincerian wage equation obtained by semiparametric regression model with control function approach were investigated separately. Firstly, partial F test and likelihood ratio (LR) test were implemented. The partial F test investigates if the effect of each variable on the independent variable is significant or not. LR test is calculated to represent which model's explanatory power is better (Keele 2008).

Table 2 shows the results of the partial F test and LR test. Findings in section (a) conclude that *EXP* and *EDU* nonparametric variables should take part in the model. Test results in section (b) state that *EXP* and *EDU* variables should be considered as nonparametrically in the model. According to the LR test results, acceptance of the model as nonparametrically is statistically significant.

Table 2. Results of the Partial F and LR Tests

Partial F Test Results				
	(a)		(b)	
	EXP	EDU	EXP	EDU
F Test Statistics	318.8	590.67	352.5	51.7
Prob.	0.000	0.000	0.000	0.000
LR Test Results				
Chi-Square Test		1586.2		
Prob.		0.000		

The three regression models which estimate the effect of schooling years on the wage level are represented in Table 3. Firstly, the standard Mincerian wage equation is estimated by using OLS. Secondly, the semiparametric regression model which doesn't make any restrictive assumptions about the relations of variables is applied. Thirdly, a semiparametric regression model with the control function approach, which is used to prevent endogeneity problem in the nonparametric case, is estimated. While quantitative variables are added into the model nonparametrically, qualitative variables are added parametrically. The coefficients of these dummy variables are interpreted by using the approach developed by Halvorsen and Palmquist (1980).

Table 3. Results of the Model Estimations

Variables	OLS	Semiparametric Regression	Control Function Approach
Intercept	6.6	8.9	8.9
	(0.04)	(0.02)	(0.02)
	(t-test: 155.3)	(t-test:398.1)	(t-test:397.6)
	(Prb:0.000)	(Prb:0.000)	(Prb:0.000)
EDU	0.14	(See Fig 1 (a))	(See Fig 2(a))
	(0.003)	(F-test: 595.7)	(F-test: 270.9)
	(t-test: 54.3)	(prob:0.000)	(prob:0.000)
	(prb:0.000)		
EXP	0.1	(See Fig 1(b))	(See Fig 2(b))
	(0.003)	(F-test: 207.1)	(F-test: 183.3)
	(t-test: 36.7)	(prob:0.000)	(prob:0.000)
	(prb:0.000)		
$(EXP)^2$	-0.001		
	(0.0001)		
	(t-test: -32.5)		
	(prob:0.000)		
MS	0.21	0.17	0.16
	(0.025)	(0.02)	(0.1)
	(t-test: 8.44)	(t-test: 6.8)	(t-test: 6.61)
	(prob:0.000)	(Prob:0.000)	(Prob:0.000)
GN	0.5	0.5	0.5
	(0.02)	(0.02)	(0.02)
	(t-test: 26.36)	(t-test: 28.73)	(t-test: 29.1)
	(prob:0.000)	(prob:0.000)	(prob:0.000)
ER			-1.7
			(0.2)
			(t-test:-11.4)
			(prob: 0.000)

According to the standard Mincerian wage equation; an increase in the years of education level and years of experience is associated with an approximate 14% and 10% increase in wages, respectively. The effect of marital status on wages is 23%, in other words, married employees earn 23% more than unmarried employees. Test results also indicate that male workers earn 64% more than female workers. Findings of semiparametric estimation and semiparametric estimation with the control function are almost the same in marital status. Married employees earn 18% and 17% more than unmarried employees respectively. Results of the two regression models indicate that male employees earn 64% more than female employees. According to the control function test statistics result of the dummy variable which represents individuals affected by the 1997 educational reform, control function is significant. In other words, the control function can be used as an exogenous variable for years of education endogenous variable.

Nonparametric regressions are examined through graphical representation. Curves indicate the estimation of *f(.)* functions for the variables. There are confidence intervals including upper and lower 95% grey layers on the side of the main curve. Figure 1 and Figure 2 compare estimation results of *EDU* and *EXP* nonparametric variables. Figure 1 shows results of the relation that do not consider endogeneity, estimation results of Figure 2 consider endogeneity though.

Figure 1. Estimation Results of Semiparametric Regression w/o Considering Endogeneity

(a) EDU (b) EXP
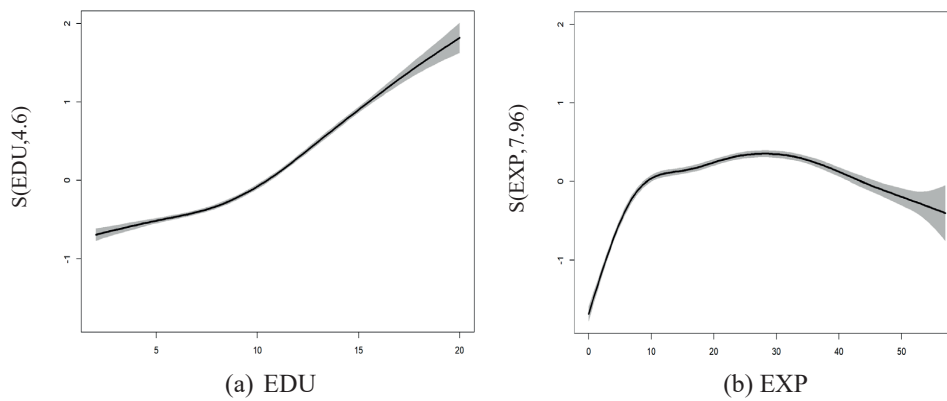
Graph (a) represents the effect of years of schooling on wages in Figure 1. According to the curve, a raise in years of education affects the wages positively. This rate of this impact less in the first eight years than other years in the period. After eight years, the rate of effect of years of schooling increases and remain in the process. Graph (b) shows the impact of years of experience on wage level. According to the result, the rate of this impact is quite high in the first ten years, an increase in years of experience raises the wages at a high rate in this period. In the period from ten to thirty years, the rate of positive impact declines and affects lower in the process. After the 30th year, the impact of experience on wage level is negative. In other words, the experience causes a decrease on in the wage level after 30 years.

Figure 2. Estimation Results of Semiparametric Regression Considering Endogeneity

(a) EDU (b) EXP
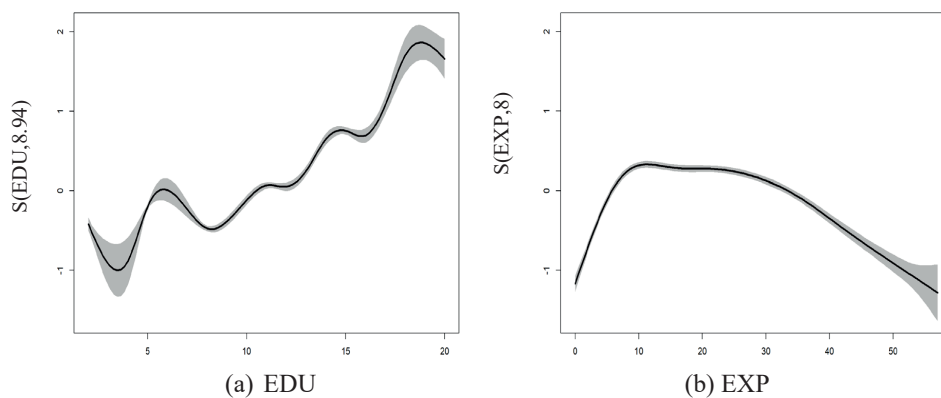
Graph (a) shows the effect of years of education on wages considering endogeneity in Figure 2. In general, an increase in the years of education affects wage level positively. This effect is negative in the first three years, between the sixth and eighth years and after the eighteenth years mainly. Education levels of individuals who did not complete any educational degree, graduated from primary school and completed doctorate degree affect wage levels negatively. According to the results, university graduation particularly has an important impact on wages, the rate of increase in wages is fairly high in this period. Results of Graph (b) indicate a positive impact of experience on wages at a high rate in first ten years. After this period, the effect of experience on wage level is negative in general.

6. CONCLUSION

This study investigates the impact of years of education on wage level using the Mincerian wage equation for 2017 data in Turkey. The Mincerian model is estimated by using some control variables (i.e. schooling and experience) which are determinants for this model. The model is estimated by applying a semiparametric regression model which provides flexibility of functional form. The endogeneity problem is considered and the control function approach, enhanced by Newey et al. (1999), is used to overcome this problem. 1997 education reform is applied as a control function to deal with the endogeneity of schooling and this exogenous variable is significant according to the results. The estimation results of "the semiparametric Regression without considering endogeneity" and "semiparametric regression considering endogeneity" are compared. Both of these two regressions' findings indicate that the effect of years of schooling on wage is positive in general. Semiparametric regression results without considering the endogeneity confirm that each schooling year has a positive effect on the wages in the related period. The rate of this effect tends to rise in the eighth year and continues at this rate in the period.

On the other hand, the achieved findings of the semiparametric regression considering the endogeneity problem reveal that impact of the schooling years on the wage level changes by years of education. Especially individuals who are literate without a degree, completed middle school level and doctorate degree respectively have a negative impact on earning level. Completing primary education level affects the wages positively and the rate of rising is quite high in this schooling level particularly. The same impact occurs in the university and master's degree completion level-where the curve has a quite high leap in the related period. As a result, the impact of the 1997 educational reform on wages is quite high for individuals who graduated from primary school and master's degrees respectively.

The effect of the 1997 education reform on years of experience differs after ten years compared to the findings of semiparametric regression without considering endogeneity. The negative impact of years of experience on wages after the related term is more than the effect of semiparametric regression. The results also indicated that the effects of gender on the wages are the same using these three methods. The impact of marital status on wages varies according to the obtained results using these methods. Semiparametric test results considering endogeneity and without considering endogeneity are almost the same. However, the result of the OLS method indicates that the positive impact of being married on wages is higher than the results of other regression models. Education reform instrumental variable has no significant impact on the effect of gender and marital status on wage level compared to the semiparametric regression results without considering endogeneity.

The findings of the study considering the instrumental variable show that there is also a positive relationship between educational attainment and wage level. The aim of the 1997 education reform is to extend the years of compulsory education. The success of the reform especially reflects to the wage level among people who graduated from primary school and university. These policy implications related to increase educational attainment can be exceeded to provide workers to have more schooling levels, thus having more wage levels in the future.

Policy implications for the educational process related to the results can be implemented successfully. According to the test results, university graduation has an important impact on wages. This study suggests that educational reforms and implementations based on university education can be exceeded quality. At the same time increasing employment opportunities for university graduated people is essential to rise the willingness of people about prosecution the education level after a high school degree. Preschool education investments also should be enhanced to ensure people to realize the importance of education from childhood. In general, supportive policies at all levels of education are necessary for economic growth and development.

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