Returns to schooling in Palestine: a Bayesian approach

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Abstract: This paper presents an empirical method to find more efficient estimates of returns to schooling using Bayesian linear regression instead of OLS method. The private returns to schooling in Palestine using the Palestinian labour force survey (PLFS) for the year 2017 have been estimated, where on average, males earn 40.7% more than females. Separate regressions have been performed for males and females, in which the returns to schooling for females are found higher than their males' counterparts. Bayesian inference has also been applied into Heckman two-step procedure with *logit* and *probit* models to correct self-selection bias for females' sample. It is found that *logit* Heckman correction yields positive and higher coefficient of years of schooling than *probit* and OLS. The wage disparities in Palestine have been found influenced by various factors like age, sex, and occupational groups. These findings are useful for policymakers to plan for future investment in higher education.

Keywords: Bayesian linear regression; wages; returns to schooling.

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1 Introduction

Human capital theory theorises that there are intrinsic economic effects of education on both economic levels, i.e., micro and macro levels, which consider the expenditure on education as a human capital investment. Education is one of the major factors that affect earrings and wages for workers. Education may affect individual's life, participation in many economic activities, productivity of the workers, and the overall economy in several ways. Individuals who do not have basic education levels have difficulty to communicate to others. Since education is undeniably a major way to human capital accumulation, the economic returns to education has been one of central topics in labour economics and economics of education. Basic theoretical model for human capital has been studied by Mincer (1974), Backer (1964) and Schultz (1961). Accordingly, one can identify earnings derived from education as the return on an investment. Therefore, the rate of return to education is also known as the average increase in wages associated with one year increase in education.

The human capital theory can be used to derive and estimate a number of indicators, such as the private rate of return to schooling and the social rate of return to schooling, where the return to schooling is not confined to the educated himself. The private rate of return to education can be used to estimate the increase in wages of educated persons by increasing the worker's productivity. The social rate of return to education indicates the changes in average wages in certain regions, depending on the changes in average schooling levels in those regions (Acemoglu and Angrist, 1999).

Many researchers have estimated Mincer human capital equation using various statistical inference methods. Unlike classical linear regression methods like OLS and ML which produce inefficient estimation of parameters, the Bayesian inference methods can provide solutions to many problems in classical inference methods; and may fit out the aforementioned methods. Furthermore, model comparison using the Bayes factor produces more efficient results than other methods (R-squared, AIC, etc.). OLS and Bayesian estimation suffer from three problems, which are self-selection bias (Heckman, 1979), ability bias (Altonji and Dunn, 1996) and endogeneity problems (Angrist and Kruger, 1991). Heckman (1976) has shown that least square estimator is biased due to self-selection, especially for the groups that have low participation rate in the labour force, particularly women. Daoud (2005) corrected the self-selection bias using two-step procedure by Heckman (1976), where he found that education increases labour force participation because years of schooling dummy coefficient is significant and positive. Moreover, in investigating endogeneity problems, Heckman and Vytlacil (1998) and Card (2001) estimated the return to education using instrumental variable methods, which yielded an unbiased estimation. However, normality assumption of errors was restricted since the wage distribution was skewed. Instead of the usual regression methods such as OLS, GLS, and ML, Bayesian inference methods can help to avoid some problems of estimation that exist in usual inference methods, and may fit out them.

In this study, the aim was to estimate the rate of return to schooling in Palestine using data of Palestinian labour force survey (PLFS) provided by Palestinian Central Bureau of Statistics (PCBS) for the year 2017. Bayesian inference has been mainly used to identify the relationship between education (schooling) and wage controlling for other variables that may affect relationships like gender, experience or age, educational levels, and place of residence, whose results have been compared with OLS and Bayesian estimations. Bayesian estimation method has been found more efficient than OLS estimation method since the standard error of the mean for Bayesian method is lower than those found using OLS method. Finally, return to schooling estimated by Bayes and OLS methods have been found suffering from self-selection bias. Bayesian inference has also been applied into Heckman two-step procedure with *logit* and *probit* models to correct for self-selection bias. Bayesian estimation with *logit* Heckman correction has been found different from and greater than those by Bayesian estimation with *probit* Heckman correction and Bayesian estimation without Heckman correction. This finding is useful for policymakers to plan for future investment in higher education.

The outline of the paper is as follows: Section 2 summarises the literature review, Section 3 describes the data and methodology, Section 4 presents the interpretation of results, and the last section is the conclusion.

2 Literature review

The expenditure on education appears to be an interesting investment in human capital. Based on this, the private return to schooling has been interpreted as the average increase of wage from the increase of years of education by one year. Mincer (1974), Backer (1964) and Schultz (1961) pioneered the basic theoretical model for the human capital that defines education as a human capital; and in this model, earnings depend on the years of schooling, age (or experience), and the square of age (or experience), to be concentrated on the convex of wage distribution.

Several scholars have aimed to investigate the effect of education or schooling on worker's wages using Mincerian human capital equation for various countries. The flexibility of this equation allows researchers to add additional variables to the model, which provides precise modelling approach to study the dynamics of the relationship between wages and schooling (Patrinos, 2016).

While ordinary least square (OLS) estimation often leads to biased estimation due to correlation between education and errors, instrumental variable method is an unbiased estimation (Heckman and Vytlacil, 1998; Card, 2001). However, normality assumption of errors is a major constraint due to skewness of wages distribution. Meanwhile, Bayesian inference can smoothen normality assumption and provide more efficient estimation. Yu et al. (2005) applied Bayesian inference on a quantile regression model of wages. They found that Bayesian inference was more effective in determining the wage structure of males in Britain over the period 1991–2001. Lubrano and Ndoye (2012) developed Bayesian inference for an unconditional quantile regression model, and found that this approach provided better estimation of the upper tail of the wage distribution. Block et al. (2012) applied Bayesian inference using family background variables as instruments for education. They found different results by relaxing the strict exclusion restriction on the family background variables, and the width of the 95% posterior interval was larger than the size of bias for the education coefficient in the IV model.

Different empirical studies have been attempted to estimate the return to schooling across different countries. Card (1995) compared OLS and instrumental variable estimates, by considering the distance to college as an instrument for schooling, which was related to higher level of education of men who take about four years of study in college. He found that the return to education was 13.2% using instrumental variable compared to those found in OLS, with 7%. Psacharopoulos and Patrinos (2004) reviewed different research papers that had estimated the return to education. They concluded that the returns to education were high in Sub-Saharan Africa, with percentages of 37.6%, 24.6%, and 27.8% for primary, secondary, and higher, respectively.

Ammermüller and Weber (2005) estimated the returns to schooling in Germany using Mincer (1974) equation. OLSs were applied separately by gender and region in Germany, by utilising data from German micro-census (Mikrozensus) data and the German Socio-Economic Panel Study (GSOEP) covering the period from 1985 to 2002. They found that the return to schooling was about 8–10% and about 7–8% in West and East regions, respectively. Their findings also exhibited that females in West region had higher returns to schooling than males in 2002 only, while in East region, the returns to schooling for females were greater than those for males counterpart in the whole period. The problem of self-selection bias did not exist and the results of Heckman correction in 2002 revealed that no selection had existed. Meanwhile, Arshad and Ghani (2015) applied OLS regression approach to investigate the returns to education in Malaysia, based on household income survey in 2009. Education levels as well as some demographic variables had been added to Mincer human capital equation. They showed that the educational levels of upper secondary and university were high and have significant positive impact on earnings. However, they could not correct for selection bias due to data limitation, since they used education levels instead of years of schooling.

In case of Palestine, only some studies have been done on returns to schooling, especially those that use Bayesian inference. Angrist (1995, 1996, 1997) used data from Israeli official statistics to estimate the private rate of return to education in Palestine during the period 1981–1991, but his studies were restricted on males only. His main finding was that the direction of the private return to education is decreasing with time. He attributed this result to the increase in the number of college graduate students in 1980s of the last century. Sayre (2001) used the same data used by Angrist, and found that the average wages for workers with high school were less than for those who had university education by 47% in 1981; further, this difference decreased approximately by 15% in 2001.

Least square estimators are biased due to self-selection bias, especially for groups that have low participation in the labour force, particularly women (Heckman, 1976). Daoud (2005) used data from PCBS of the years 1999 and 2001. He applied Mincernian equation for males and females separately. He showed that the return to schooling was smaller for males, and during 2001, the gap in returns to schooling was diminished. Moreover, he concluded that the return to schooling is low compared with the other countries in the Middle East (i.e., 2.8% in 1999). Also, the private rate of return to education for men (2.8%) was lower than for women (6%); as the model for estimating the return to schooling was a nonlinear model in terms of level of schooling. He tried to correct for self-selection bias using two-step procedure introduced by Heckman (1976) and he found that education increased the labour force participation, as shown by years of schooling dummy coefficient which was significant and positive. He justified that Heckman's two-step procedure is useful since *z-test* of $\rho \neq 0$ is strongly significant and the term of the self-selection is also significant. He showed that OLS overestimated the return to schooling. However, he obtained a negative coefficient of years of schooling for *probit* Heckman correction, which was then, was solved by defining dummy variables for educational levels. One of the contributions of this paper is that it finds that *logit* Heckman correction yield positive and higher coefficient of years of schooling than OLS.

Tansel and Daoud (2011) compared the private returns to schooling in Palestine and Turkey. They indicated that the gap in return to schooling between men and women in Palestine is greater than those in Turkey. Additionally, they found that the return to schooling increases with the increase of level of education, which means that the wage curve, with respect to the number of years of schooling, is convex and not linear, which has also been found in other studies.

Daoud and Sadeq (2012) used quarterly Palestinian labour force data of the period 1996–2010. They estimated the private rate of return to schooling and its determinants, by applying OLS and Hekman's correction to Mincer's equation for males and females separately. They found that the private returns to schooling were 1.8%–2.8% for males and 6%–12% for females, without using Heckman correction, and the fluctuation increased for this return with Heckman's correction. Moreover, they used educational levels instead of years of schooling for both males and females. They found that the average difference in daily wages for females increased significantly for secondary or associate diploma holders, compared to illiterates. However, the average difference in daily wages for males increased notably for bachelor and master and PhD holders compared to illiterates. They found that the difference between OLS and Heckman correction for females was high since their participation in labour force is low, while for males, the difference was negligible between them.

3 Methodology and data

Mincernian earning function is commonly used to estimate the returns to schooling, which was developed by Mincer (1974). Among studies that have been tackled in Palestine have implemented the model are by Daoud (2005), Tansel and Daoud (2011) and Daoud and Sadeq (2012). The estimation model can be written as:

$$\ln(w_i) = \beta_0 + \beta_1 S_i + \beta_2 S_i^2 + \beta_3 Age_i + \beta_4 Age_i^2 + \sum_{i=5}^{n} \beta_i X_i + e_i \quad (1)$$

where w_i is the daily wage for an individual i, S_i represents a measure of their years of schooling, Age_i is the age of individuals, and X_i is a vector of controlling variables such as sex, marital status, place of work, locality type and occupation. In this study, equation (1) has been used to estimate for the whole sample and for males and females separately.

The private returns to schooling can be estimated by differentiating equation (1) with respect to years of schooling, which is the marginal slope of this equation.

$$\frac{\partial \ln(w_i)}{\partial S_i} = \beta_1 + 2\beta_2 S_i \quad (1.1)$$

The value of S_i will be substituted by the average years of schooling. Variable of age was used in this study instead of potential experience, since Daoud (2005) had shown that age is better for prediction of daily wages than potential experience. Some control variables like locality type, place of work and occupation are qualitative variables, thus dummy variables that represent each category for each variable needed to be defined beforehand. For example, locality type variables have three categories (urban, rural, and camp), so a dummy variable can be defined and keyed in to represent who would reside in camp and take a value of 1 or 0 otherwise. By this way, this dummy variable could be interpreted as the average difference of daily wage between camp residence and non-camp residence.

Moreover, the variable years of schooling in equation (1) can been replaced by dummy variables that represent the educational levels for each individual, thus the model becomes:

$$\ln(w_i) = \beta_0 + \sum_{i=1}^{7} \gamma_i Educ_i + \beta_1 Age_i + \beta_2 Age_i^2 + \sum_{i=3}^{n} \beta_i X_i + u_i \quad (2)$$

where $Educ_i$ represents educational levels with preparatory as a reference category. The interpretation of the coefficients of education dummies will be compared with preparatory for the reference category. For example, the secondary dummy will be interpreted as the average difference of daily wages between secondary and preparatory levels.

In this study, Bayesian linear regression has been integrated into Mincernian equation, which is an alternative way of all statistical inferences such as least square, ML, etc. The major challenges in order to make a Bayesian inference about parameter θ, is an appropriate prior $P(\theta)$ has to be chosen for θ with the likelihood function $f(x \mid \theta)$ and an approximate calculation for the posterior $P(\theta \mid x)$. Accordingly, before seeing the data, the prior summarises what we know about the parameter and shows suggested information before any new evidence is exposed, thus they can take any form. It is common to select certain classes of priors that are easy to interpret to make the calculations easier. For this study, informative natural conjugate prior has been chosen, which is a distribution, and when combined with the likelihood function, yields a posterior that is in the same distributions family. Basically, the functional form of the conjugate priors is the same as the likelihood function. In the Bayesian approach, the posterior distribution for the parameter can be obtained by combining the prior information with the likelihood function (i.e., the observed knowledge). The mean of the posterior distribution is usually used to determine the best estimate of the parameter (Koop, 2003). Additionally, the Mincernian equation had been estimated using OLS regression for purposes of comparison.

OLS and Bayesian estimations suffer from three problems, which are self-selection bias (Heckman, 1976), ability bias (Altonji and Dunn, 1996) and endogeneity problems (Angrist and Kruger, 1991). This study was conducted with aim to attempt correcting the problem of self-selection bias, by applying Bayesian inference to Heckman's (1979) two-step procedure, using *logit* and *probit* models. A dummy variable that takes a value of 1 for wage employed individuals and 0 for unemployed and out of labour force had been defined beforehand, before addition of some variables like marital status and place of residence to *logit* and *probit* models, but occupation status was dropped. This dummy was regressed on years of schooling, squared years of schooling, age, squared age, marital status, place of work and camp residence variables. Furthermore, to find out which model best fits and able to predict daily wages, Heckman's *logit* model had been compared with Heckman's *probit* model using Bayes factor. The estimated model using Bayesian inference without Heckman's correction was not included in model comparison since it suffers from selectivity bias.

The following explains Heckman's (1979) two-step procedure: individuals have tendency to participate in the labour force if the market wage (w) exceeds the reservation wage (w^*). In this case, w is observed if $w > w^*$, and if otherwise, it will not be observed. Accordingly, a dummy variable (P) is defined, which takes a value of 1 for employed individuals and 0 otherwise, as:

$$P_i = K_i\alpha + u_{i1} > 0 \tag{3}$$

And

$$W_i = X\beta + \delta u_{i2} \tag{4}$$

where P_i is observed only if $w > w^*$. This equation is named by participation equation, which links the participation with set of variables (K) that affect individual's decision to work like number of children and marital status. Equation (3) is used to estimate simultaneously with equation (4) to obtain the inverse Mills ratio (λ), which is the ratio of the probability density function over the cumulative distribution function of a distribution. Then, some independent variables that exist in equation (3) are multiplied by their coefficients, and inverse Mills ratio, λ will be added into equation (1). Applying Heckman correction on equation (1), it becomes:

$$\ln W_i = \beta_0 + \beta X_i + \lambda K_i\alpha + d_i \tag{5}$$

where $\lambda = \rho\delta_{u_2}$ is the inverse Mills ratio, δ_u indicates the standard error of equation (4), ρ indicates the coefficient of correlation of residuals in equation (3) and residuals in equation (4). X represents the set of independent variables mentioned in equation (1) and K represents some variables that will affect individual's participation in the labour force, like marital status and locality type, i.e., camp (Daoud, 1999; Daoud and Sadeq, 2012).

Therefore, the return to schooling can be estimated by differentiating equation (5) with respect to years of schooling:

$$\frac{\partial \ln(w_i)}{\partial S_i} = \beta_1 + 2\beta_2 S_i + \lambda(\alpha_1 + 2\alpha_2 S_i) \tag{5.1}$$

For this study, the PLFS 2017, has been referred to, provided by the PCBS. Only individuals with age of 15 years and more had been selected for this study, compared to PLFS which includes individuals with age of ten years old and more. It also contains individual's information about the daily wages, education qualification and some demographic variables such as sex, locality type, place of work, and marital status.

Some descriptive statistics utilised in this study are mean, standard deviation, minimum and maximum. Table 1 presents the average daily wages in (NIS) of the workers according to education levels. The highest average daily wage is for workers who have PhD degree, while the lowest is for workers who have associate diploma. On average, higher level of education of workers promises higher average daily wages. The test statistic (F = 41.36, p = 0.0) of one-way ANOVA indicates that there is a significant difference of daily wages according to the educational attainment. The free education system in Palestine comprises of compulsory basic education from grades 1 to 10; which is divided into elementary education from grades 1 to 4 and preparatory education from grades 5 to 10. This is followed by two years of optional secondary education, either academic or vocational, as grades 11 and 12, and at the end of the two years, they will take public examination called Tawjihi. Passing the secondary level will allow students to enrol in high education institutes to complete post-secondary education, such as two-year diploma, bachelor, higher diploma, master's and PhD studies. Pre-school education that is offered for children aged 4 to 5 years is not a compulsory stage in the system of education in Palestine (World Bank, 2006).

Table 1 Distribution of daily wages by education levels and gender (in NIS*)

Statistics	*PhD*	*Master's*	*Higher diploma*	*Bachelor (BA/BSc)*	*Associate diploma*	*Secondary*
Mean	250.18	163.21	110.92	109.24	103.14	107.75
Std. dev.	105.05	88.20	35.89	61.83	66.89	82.97
Min	20.53	16.67	30.77	3.46	3.85	3.85
Max	468.2	780.35	192.31	540.25	400.00	540.25
N	69	360	33	2,991	1,083	2,041
Statistics	*Preparatory*	*Elementary*	*Illiterate and can read and write*			
Mean	110.82	111.60	105.53			
Std. dev.	89.69	84.58	92.21			
Min	3.33	5.00	2.31			
Max	500.00	500.00	500.00			
N	4,990	1,875	619			

Note: *New Israeli Shekels.

Source: Authors' own calculation based on PLFS, 2017 data

Wage difference according to sex is shown in Table 2, which exhibits that men have average daily wage of 116.20 NIS, which is higher than for women, which is 84.90 NIS. Moreover, the independent sample t-test at one per cent level of significance reveals a statistically significant (t = 16.501, P = 0.00) gender wage gap. Female category was used as a reference category for the purpose of estimation.

Table 2 Distribution of daily wages by sex (in NIS)

Statistics	*Overall sample*	*Males*	*Females*
Mean	111.34	116.20	84.90
Std. dev.	82.26	86.14	48.82
Min	2.31	2.31	3.46
Max	780.35	780.35	431.32
N	14,061	11,878	2,183

Source: Authors' own calculation based on PLFS, 2017 data

In terms of wage disparities by marital status, Table 3 presents the distribution of daily wages by marital status. Married workers have average daily wages more than other workers who are not married. At 1% level of significance, the independent sample test exhibits that the wage disparities by marital status is statistically significant (t = 30.55, P = 0.00). The reference category for marital status covered all categories other than married for the purpose of estimation.

Table 3 Distribution of daily wages by marital status (in NIS)

Statistics	*Married*	*Others**
Mean	116.20	84.90
Std. dev.	86.14	48.82
Min	2.31	3.46
Max	780.35	431.32
N	11,878	2,183

Note: *Never married, engaged, divorced, widowed and separated.

Source: Authors' own calculation based on PLFS, 2017 data

The distribution of daily wages according to region is shown in Table 4. Workers from West Bank have average daily wage of 132.51 NIS, higher than those in Gaza Strip counterpart, who earn about 60.45 NIS. This wage difference is statistically significant at 1% level of significance after conducting independent sample t-test (t = 51.603, p = 0.00). Gaza Strip was used as a reference category for the purpose of estimation.

Locality type is also commonly considered as a factor that influences the daily wages of workers in Palestine. Table 5 illustrates the distribution of daily wages by locality type, which indicates that workers lives in rural areas have mean daily wages higher than those live in both urban and camp areas counterparts. This is probably because a large proportion of them depend on the Israeli labour market where wages are higher (see Daoud, 2005). Additionally, the average daily wages of workers who live in camp areas are less than those who lives in urban areas. The results of one-way ANOVA at 1% level of significance reveal that the disparities in wages are statistically significant (F = 219.655, p = 0.00). The dummy variable camp was defined by the value of 1 for camp and 0, for both urban and rural localities for the purpose of estimation.

Table 4 Distribution of daily wages by region (in NIS)

Statistics	*West Bank*	*Gaza Strip*
Mean	132.51	60.45
Std. dev.	83.80	49.84
Min	3.85	2.31
Max	780.35	621.85
N	9,930	4,131

Source: Authors' own calculation based on PLFS, 2017 data

Table 5 Distribution of daily wages by locality type (in NIS)

Statistics	*Urban*	*Rural*	*Camp*
Mean	108.21	135.01	84.17
Std. dev.	83.20	83.55	58.64
Min	3.33	8.33	2.31
Max	780.35	540.25	500.00
N	9,562	2,994	1,505

Source: Authors' own calculation based on PLFS, 2017 data

Another important factor that plays an important role in shaping wage differentials in Palestine is the place of work. Table 6 illustrates the distribution of daily wages by place of work, which exhibits that workers who work in Israel have highest mean daily wages, about 2.2 times the average daily wage of those who work in West Bank, and about 3.6 times the average daily wage for those who work in Gaza Strip. There is a high statistically significant differences of mean daily wages by place of work according to the results of one-way ANOVA (F = 6,095.979, p = 0.00). The average daily wage for workers who work in West Bank is higher than those who work in Gaza Strip. Accordingly, West Bank and Gaza Strip had been used as a reference category in the estimation of equations (1) and (2).

Table 6 Distribution of daily wages by place of work (in NIS)

Statistics	*West Bank*	*Gaza Strip*	*Israel and settlements*
Mean	99.13	60.42	220.10
Std. dev.	51.88	49.86	88.25
Min	3.85	2.31	24.00
Max	780.35	621.85	500.00
N	7,195	4,126	2,740

Source: Authors' own calculation based on PLFS, 2017 data

Table 7 Distribution of daily wages by occupation (in NIS)

Statistics	*Legislators and senior …*	*Professionals and clerks*	*Service, shop and market workers*	*Skilled agricultural and fishery workers*	*Craft and related trade workers*	*Plant and machine operators and assemblers*	*Elementary occupation*
Mean	171.68	107.08	74.03	84.91	168.72	94.64	96.50
Std. dev.	81.29	57.21	53.92	58.43	114.40	71.51	73.40
Min	20.00	3.46	3.85	5.00	2.31	8.33	3.33
Max	621.85	780.35	400.00	250.00	500.00	540.25	500.00
N	372	4,173	1,853	74	2,512	1,254	3,823

Source: Authors' own calculation based on PLFS, 2017 data

Table 7 show the distribution of daily wages by occupation groups. It had been initially expected that occupation groups have effects on wage differentials in Palestine. The mean daily wage for legislators and senior workers is high with value of 171.68 NIS, while the lowest is for services, shop and market workers with value of 74.03 NIS. The results of one-way ANOVA indicates that the mean wage difference by occupation groups is highly significant ($F = 388.244$, $P = 0.00$). Elementary occupation was used as a reference category in the estimation of equations (1) and (2).

4 Results

The estimation results of OLS and Bayesian posterior estimates of the coefficients, with their respective standard errors based on equation (1) are shown in Table 8. Model Ia consists of estimation for the whole sample, which includes 14,061 observations. Based on OLS estimation method, R-squared exhibited that this model explains 64.2% of wage disparities in Palestine. Estimations of male wage equation is shown in model IIa based on 11,878 observations, whose R-squared value of 68.9%, while estimations of female wage equation is shown in model IIIa, which consists of 2,183 observations with R-squared value of 45.76%. Since the models are in log-linear form, the below explanation is interpreted based on the exponentiated coefficient of estimates, because it is the inverse of the logarithmic function.[1]

As shown in Table 8, the results indicate that OLS and Bayesian regression methods estimates of the mean are almost the same, but the standard error estimate of the mean using Bayesian method is less than the standard error estimate of the mean using OLS method. Therefore, it can be concluded that Bayesian regression method is more efficient than OLS method. Our findings fit the results obtained by Block et al. (2012) and Mettle et al. (2016) which state that the posterior and OLS means are almost the same, while the posterior standard error is less than OLS standard error.

The coefficient of squared age is negative and significant in the three models for each of the two methods employed, which means that the relationship between daily wages and age is concave. There is also direct relationship between age and daily wages, in which males receive lower wages at advance stages of age since the coefficient of age squared is negative, while for females, it does not matter and the relationship between age and wages is linear. Moreover, the squared years of schooling is significant and positive, which means that the returns to schooling rise as the years of schooling increase. The estimated returns to schooling value for the overall sample in Table 8 based on equation (1.1) is 3.77%. It is also found that the return to schooling value for females is 8.3%, which is higher than those for their males counterparts (i.e., 3.04%). This result fits the results obtained by Tansel and Daoud (2011) and Daoud and Sadeq (2012).

According to the gender wage gap, holding other things constant, the results show that males, on average, earn 40.7% more than their females counterparts. Meanwhile, according to the region (West Bank and Gaza Strip) as a place of residence, the wage difference is high. That is, on average, daily wages for individuals living in West Bank are 108.1% higher than those who live in Gaza Strip. For both models of IIa and IIIa, the factor of region is also significant, thus there is wage difference between males who lives in West Bank and Gaza Strip as well as between females counterparts.

Table 8 OLS and Bayes parameter estimates of equation (1)

	Model Ia Overall sample		*Model IIa Male*		*Model IIIa Female*	
	OLS	*Bayes posterior*	*OLS*	*Bayes posterior*	*OLS*	*Bayes posterior*
Years of schooling	–0.0326*** (0.0059)	–0.033*** (0.000195)	–0.0333*** (0.0064)	–0.0331*** (0.00022)	–0.0278* (0.0168)	–0.0282*** (0.000556)
Squared years of schooling	0.0029*** (0.0003)	0.0030*** (0.000008)	0.0028*** (0.0003)	0.0028*** (0.000011)	0.0039*** (0.0007)	0.0039*** (0.000026)
Age	0.0350*** (0.0026)	0.0353*** (0.000061)	0.0382*** (0.0028)	0.0383*** (0.000084)	0.0553*** (0.0079)	0.0559*** (0.000191)
Age^2	–0.0003*** (0.00003)	–0.00032*** (0.0000009)	–0.0004*** (0.00001)	–0.0004* (0.0000012)	–0.0004* (0.0001)	–0.0004* (0.000003)
Sex	0.3415*** (0.0139)	0.3418*** (0.00053)	---	---	---	---
Marry	0.1395*** (0.0130)	0.1358*** (0.0009)	0.1116*** (0.0141)	0.1104* (0.000365)	0.2109*** (0.0286)	0.2066*** (0.00193)
Region	0.7320*** (0.0107)	0.7330*** (0.00042)	0.7963*** (0.0108)	0.7950* (0.000864)	0.4363*** (0.0314)	0.4339*** (0.000663)
Camp (locality)	–0.0569*** (0.0136)	–0.0552*** (0.0003)	–0.0807*** (0.0136)	–0.0839*** (0.001037)	0.0181 (0.0431)	0.0149 (0.0093)
Place of work (Israel)	0.8565*** (0.0104)	0.851*** (0.0006)	0.8383* (0.0104)	0.8382*** (0.000622)	0.8016*** (0.0612)	0.7968*** (0.000979)
Legislators and senior	0.5560*** (0.0291)	0.5618*** (0.00133)	0.5760*** (0.0318)	0.5727*** (0.00169)	0.2822*** (0.0733)	0.2907*** (0.001456)
Professionals and clerks	0.3144*** (0.0137)	0.3135*** (0.0003)	0.3233*** (0.0141)	0.3237*** (0.000156)	0.1145*** (0.0488)	0.1106** (0.002427)
Service, shop and market workers	0.0134 (0.0137)	0.0130*** (0.0003)	0.0623*** (0.0142)	0.0623*** (0.000319)	–0.2429*** (0.0505)	–0.2522*** (0.002691)
Skilled agricultural and fishery workers	–0.150*** (0.0557)	–0.150*** (0.0006)	–0.1314*** (0.0575)	–0.1321*** (0.000397)	–0.3077** (0.1482)	–0.3095*** (0.000374)
Craft and related trade workers	0.2313*** (0.0116)	0.2351*** (0.0003)	0.2450*** (0.0115)	0.2437*** (0.000348)	–0.1517 (0.0947)	–0.1473 (0.0803)
Plant and machine operators and assemblers	0.0313** (0.0143)	0.0320*** (0.0003)	0.0570*** (0.0146)	0.0543*** (0.000739)	–0.0534 (0.0483)	–0.0526 (0.03251)
Constant	2.381**** (0.0588)	2.384*** (0.0004)	2.6715*** (0.0587)	2.6707*** (0.000463)	1.8591*** (0.1833)	1.8635*** (0.000683)

Notes: ***Significant at 1%, **significant at 5% and *significant at 10%.

Source: Authors' own calculation based on PLFS, 2017 data

With ceteris paribus condition, the average daily wages for married workers are 14.5% higher than their unmarried counterparts (i.e., never married, divorced, widowed and separated). Married male workers, on average, receive daily wages higher than other workers by 11.7%, as indicated from the results of model IIa, while the average daily wages for married females workers are 22.9% higher than those unmarried females counterparts, as shown by model IIIa results in Table 8.

Further, the average daily wages for workers who live in refugee camps are less than those who live in rural and urban locality areas. This effect is significant for the whole sample estimated in model Ia by –0.054, which means that workers in refugee camp locality earn 5.4% less than workers living in rural and urban localities. Moreover, this wage gap is significant and negative for males' sample as estimated in model IIa, that is, male workers living in refugee camps have daily wages less than those living in rural and urban areas by 8.0%. However, as indicated in model IIIa, there is no significant wage difference between females who live in refugee camps and those who living in rural and urban localities. These results may be explained by the finding by Daoud and Shanti (2012) that showed that the likelihood of male refugees to choose to work in national and private sectors is about 3 to 5% less than those male non-refugees.

The relationship between daily wages and place of work is shown by the categorical variables of Israel and West Bank and Gaza Strip as a reference category; holding other variables constant. The results reveal that there is a high, positive and significant wage difference between individuals who work in Israel and West Bank and Gaza Strip, that is, the daily wages for workers who work in Israel are 134.2% higher than workers who work in West Bank and Gaza Strip. These results are supported by descriptive statistics as shown in Table 6. The wage differences for males sample in model IIa and for females sample in model IIIa also exhibit that males and females who work in Israel earn 131.2% and 121.8%, respectively, higher than those working in West Bank and Gaza Strip. Our results support the findings by Daoud (2005) and Daoud and Sadeq (2012). They showed that the wage difference for those who work in Israel is high, and had increased over the period 1996–2010 for males, but they did not find significant difference for females.

Disparities in wages by occupation had also been explored, by defining the categorical variables (legislators and senior, professionals and clerks, service, shop and market workers, skilled agricultural and fishery workers, craft and related trade workers and plant and machine operators and assemblers), and the reference category is the elementary occupation. As shown in Table 8, OLS results revealed that there is a significant wage differences between all occupation groups, except service, shop and market workers occupation compared with elementary occupation in model Ia. Meanwhile, Bayes estimates showed that these differences are significant for all categories. This allowed us to compare daily wages for all occupations with elementary occupation. In model Ia, the legislators and senior category has high wage difference compared to elementary occupation, which reached 75.4%. This category is followed by the categories of professionals and clerks, craft and related trade, plant and machine operators and assemblers and service, shop and market workers, where the differences in daily wages reach 36.8%, 26.5%, 3.3% and 1.3%, respectively higher than elementary occupation. However, the category of skilled agricultural and fishery workers has daily wages 13.9% less than workers in elementary occupation, ceteris paribus.

Meanwhile, model IIa based on males sample showed that the wage gap is wider for the category of legislators and senior workers, where they receive daily wages 77.3%

higher than those in elementary category. This is followed by the categories of professionals and clerks, craft and related trade, service, shop and market workers, and plant and machine operators and assemblers, with daily wages of 38.2%, 27.6%, 6.4% and 5.6% higher than elementary category. Meanwhile, skilled agricultural and fishery workers receive daily wages 12.4% less than those in elementary occupations, ceteris paribus.

However, model IIIa based on females' sample exhibits that there is significant difference in daily wages for female workers in legislators and senior and professionals and clerks with daily wages 33.7% and 11.7%, respectively, higher than those in elementary occupation, ceteris paribus. However, those working in service, shop and market and skilled agricultural and fishery earns daily wages earn 22.3% and 26.6%, respectively, less than those workers in elementary occupation. The remaining categories are not significant, which exhibits that there is no wage difference for these categories compared with elementary occupation. This is because the females' sample contains a small number of female workers in other than elementary occupation, and the sample size of paid female workers is small.

Table 9 shows the estimates of equation (2) for males and females separately, which consider educational levels instead of years of schooling in order to know at which educational level the daily wage is high. As shown in Table 9, model IIb represents the results for males while model IIIb represents the results of females sample. 69.0% of male's wage disparities are explained by model IIb while 42.4% of female's wage disparities are explained by model IIIb as indicated by the values of their respective R-squared values.

According to wage disparities by education levels, the results reveal that the private returns to schooling become higher with higher level of education for both males and females in Palestine in the year 2017, as shown in Table 10. The results also indicate that females have higher rate of return than males. These results are consistent with the results of recent studies in Palestine by Tansel and Daoud (2011) and Daoud and Sadeq (2012). Moreover, the descriptive analysis on daily wages by schooling levels supports our finding.

For males sample, the highest average daily wage is for PhD degree holders, which is 1.84 times more than those who have a preparatory level of education. In other words, the return to schooling for PhD degree holders is about 184% compared with holders of a preparatory level. This is followed by master's degree, higher diploma, and bachelor degree with average daily wages of 67.8%, 43.2%, 24.7%, respectively, higher than those with preparatory counterpart, while the lowest is for associate diploma and secondary, which are 6.3% and 6.6%, respectively, higher than those who have preparatory level, as indicated in Table 10. However, there is no significant wage difference between those who have elementary and preparatory levels of education, as shown in Table 9.

For females sample, the highest average daily wage is for PhD degree holders, which is 198% higher than those who have preparatory level of education. This is followed by Master's degree, higher diploma, bachelor degree, and associate diploma, with average daily wages of 135%, 109%, 64.8%, and 46.4%, respectively, higher than those with preparatory counterparts, as shown in Table 10. However, there is no significant wage difference between those who have elementary and secondary and preparatory levels of education, as shown in Table 9.

Table 9 OLS and Bayes parameter estimates of equation (2)

	Model IIb Male		*Model IIIb Female*	
	OLS	*Bayes posterior*	*OLS*	*Bayes posterior*
Age	0.0403*** (0.003)	0.0405*** (0.0001)	0.0540*** (0.008)	0.055* (0.0021)
Age^2	–0.0004*** (0.00003)	–0.0004*** (0.000002)	–0.0004*** (0.00009)	–0.0004* (0.000003)
Elementary	–0.0157 (0.012)	–0.0156 (0.009)	–0.0234 (0.047)	–0.0212 (0.013)
Secondary	0.0677*** (0.012)	0.0636*** (0.0005)	0.0334 (0.0580)	0.0373 (0.0240)
Associate diploma	0.0594*** (0.017)	0.0609*** (0.0002)	0.3854*** (0.061)	0.3810*** (0.0025)
BA\BSc	0.2206*** (0.015)	0.2210*** (0.0006)	0.5073*** (0.057)	0.4995*** (0.0022)
Higher diploma	0.3556*** (0.088)	0.3592*** (0.0012)	0.7462*** (0.109)	0.7381**** (0.0027)
Master degree	0.5217*** (0.038)	0.5174*** (0.0005)	0.8579*** (0.0684)	0.8536*** (0.0026)
PhD	1.0492*** (0.078)	1.0421*** (0.0013)	1.0858*** (0.135)	1.0933*** (0.0013)
Marry	0.1024*** (0.014)	0.0996*** (0.0009)	0.2036* (0.028)	0.2079*** (0.0012)
Region	0.7963*** (0.011)	0.7966*** (0.0014)	0.4206*** (0.0310)	0.4285*** (0.0022)
Camp (locality)	–0.0818*** (0.014)	–0.0806*** (0.0007)	0.0130 (0.0420)	0.0222 (0.0230)
Place of work (Israel)	0.8388*** (0.010)	0.8426*** (0.0016)	0.7961*** (0.062)	0.8013*** (0.0055)
Legislators and senior	0.5756*** (0.032)	0.5727*** (0.0004)	0.2354*** (0.085)	0.2446*** (0.0026)
Professionals and clerks	0.3479*** (0.014)	0.3476*** (0.0014)	0.0850*** (0.056)	0.0919*** (0.0183)
Service, shop and market workers	0.0744*** (0.014)	0.0719*** (0.0004)	–0.2120*** (0.050)	–0.2019*** (0.0018)
Skilled agricultural and fishery workers	–0.1348*** (0.058)	–0.1464*** (0.0014)	–0.3604*** (0.050)	–0.3476*** (0.0028)
Craft and related trade workers	0.2487*** (0.011)	0.2461*** (0.0004)	–0.1398 (0.096)	–0.1409 (0.027)
Plant and machine operators and assemblers	0.0612*** (0.014)	0.0600*** (0.0009)	–0.0557 (0.049)	–0.0501 (0.029)
Constant	2.600*** (0.046)	2.600*** (0.0005)	2.0151*** (0.162)	1.993**** (0.0036)

Notes: ***Significant at 1%, **significant at 5% and *significant at 10%.

Source: Authors' own calculation based on PLFS, 2017 data

Table 10 Average estimated returns to schooling by gender from estimated models IIa, IIIa, IIb, and IIIb

	Males	*Females*
Years of schooling	0.0304	0.083
Education dummies*		
Elementary	–0.015	–0.021
Secondary	0.066	0.038
Associate diploma	0.063	0.464
BA\BSc degree	0.247	0.648
Higher diploma	0.432	1.09
Master's degree	0.678	1.35
PhD degree	1.84	1.98

Note: *Reference category is preparatory level.

Source: Authors' own calculation from Bayesian estimation of equations (1) and (2) based on PLFS, 2017 data

Table 11 Joint posterior estimation of natural log of daily wages and participation equation for females

	Probit	*Ln(w_i)*	*Logit*	*Ln(w_i)*
Years of schooling	–0.084*** (0.00035)	–0.0023*** (0.00012)	–0.1380*** (0.00023)	0.0560*** (0.00175)
Squared years of schooling	0.0075*** (0.00001)	0.0043*** (0.00002)	0.0270*** (0.00008)	–0.0017*** (0.00005)
Age	0.1832*** (0.00135)	0.0131*** (0.00023)	0.1297*** (0.00028)	0.0227*** (0.00019)
Age^2	–0.0023*** (0.000002)	–0.00018*** (0.000003)	–0.0040*** (0.000003)	–0.0001*** (0.000001)
Marry	0.3233*** (0.0076)	0.2234*** (0.0002)	0.3051*** (0.0052)	0.1490*** (0.0003)
Region	----	–0.1205*** (0.0126)	----	0.4523*** (0.00015)
Camp (locality)	–0.0265 (0.0196)	–0.0823 (0.0752)	–0.0657 (0.327)	–0.0505 (0.0363)
Place of work (Israel)	2.136* (0.156)	0.5146*** (0.0025)	2.578*** (0.2351)	0.4320*** (0.00316)
Constant	–2.425* (0.00341)	4.448*** (0.00325)	–3.625*** (0.0015)	5.0271*** (0.0024)
λ	----	–0.0095*** (0.00125)	----	0.256*** (0.003)

Notes: ***Significant at 1%, **significant at 5% and *significant at 10%.

Source: Authors' own calculation based on PLFS, 2017 data

Estimation results by Heckman correction using *logit* model indicate that the estimated coefficient of years of schooling is greater than those obtained using Bayesian and OLS estimation, and it is positive; that is, by using equation (5.1), the private return to schooling for females is 15.3%. However, estimation results of Heckman correction using *probit* model indicate that the coefficient of years of schooling slightly differs from those obtained using Bayesian and OLS estimation, which is negative. The estimated private rate of return is 11.7%. Table 11 shows the estimation results of Heckman correction using *probit* and *logit* models, respectively. Daoud and Sadeq (2012) found that Heckman correction did not vary from OLS estimates of return to schooling for males. However, they found that the difference in estimates of the return to schooling for females using Heckman correction is higher compared to OLS estimates, by which they justified this high difference by lower participation rate in the labour force for females. According to the PCBS labour force survey report 2017, females' labour force participation rate is at 19.2%.

Table 12 presents model comparison using Bayes factor between Bayesian estimation with *logit* Heckman correction and *probit* Heckman correction. In this study, it has been found that applying *logit* Heckman correction using Bayesian inference is the best model to predict individual's wages and estimates of return to education. Hence, *logit* Heckman correction using Bayesian inference has done a good job of estimation, and it is more suitable than *probit* Heckman correction and Bayesian inference without Heckman correction.

Table 12 Bayes factor values for *logit* and *probit* Heckman corrections model comparison

Bayes factor	*Logit*	*Probit*
Logit	1.00	2.325×10^{19}
Probit	4.301×10^{-20}	1.00

Source: Authors' own calculation based on PLFS, 2017 data

In sum, wage inequality in Palestine is influenced by various factors like age, educational attainment, sex, region, marital status, locality type, place of work, and occupational groups. The return to schooling is significantly high and positive, and increases with the higher level of education and years of schooling.

5 Conclusions

This paper has presented the estimation of the private rate of return to schooling using OLS and Bayesian linear regression using PLFS data in 2017. From results, it can be concluded that Bayesian inference method produces more efficient estimation than OLS inference method. The posterior standard error using Bayesian inference is less than the standard error of the mean using OLS. Furthermore, estimation results of daily wages equation indicate that the wage equation is convex with respect to years of schooling, which means that the private rate of return to schooling increases with higher level of education.

Moreover, in order to correct for self-selection bias, *logit* Heckman correction has been applied using Bayesian inference, which has done a good job of estimation. It is found more effective than *probit* Heckman correction and Bayesian inference without Heckman correction.

In sum, the wage disparities in Palestine are influenced by various factors like age, educational attainment, sex, region, marital status, locality type, place of work, and occupational groups. The return to schooling is significantly high and positive, and increases with higher level of education and years of schooling, especially highest at tertiary levels. Therefore, our results suggest that in order to reduce the gender pay gap in Palestine, government and policymakers should pay more attention to invest in higher education sector by extending support to education sector, which shall lead to more educated individuals with higher wages and lower rates of unemployment and poverty. However, this should not come at detriment of basic education, since it is provided as a fundamental human service, and access to basic and secondary education is a prerequisite for admission into university. In particular, it is important to support higher education for females since education expansion will positively affect their participation decision in the labour force, in addition to their returns to schooling being higher than their males counterparts. Additionally, in order to have equitable society in Palestine, policymakers should encourage employers to provide both sexes with equal opportunities in employment.

Furthermore, since workers in Israel and settlements earn higher wages than those in the domestic labour market, government should put more efforts to reduce the dependence on employment in Israel and settlements through investment in education.

Of course, the results cannot directly tell about gender discrimination. But discrimination can be one possible reason by observing the background of Palestine. Additionally, OLS and Bayesian linear regression models of wages suffer from endogeneity and ability bias; therefore we recommend further research on Bayesian methods to solve these problems. For future research consideration, the return to schooling can be more effectively estimated using panel data of the PLFS for the period of 1996–2017. Furthermore, two-level hierarchical models can be utilised to estimate the social return to education.

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Notes

1 The estimated regression coefficients form the log-linear models can be exponentiated using the following formula: $(e^{\beta} - 1) \times 100\%$. For small values of the estimated coefficients, approximately $e^{\beta} \cong \beta$.