Education and Labour Productivity in Papua New Guinea's Tuna Processing Industry

H.F. Campbell
School of Economics
University of Queensland

Abstract

Wage and personal characteristics data from a sample of 205 tuna cannery workers in Madang, Papua New Guinea are used to investigate the contribution of education to labour productivity. A Probit model is used to test the hypothesis that more highly educated workers are more likely to be appointed to skilled positions and the results are used to estimate the value of an additional year of schooling. Regression models are used to estimate the effects of levels of education on the earnings of skilled and unskilled workers respectively. These models are also used to test for sex discrimination. One conclusion is that an additional year of schooling raises labour productivity by at least 5%.

1. Introduction

This paper presents the results of an analysis of data obtained from a sample of tuna cannery workers in Madang, Papua New Guinea (PNG). The analysis examines some aspects of the contribution of higher levels of education to increased labour productivity. One possible contribution to increased labour productivity lies in more highly educated people being more likely to be able to move from the informal sector of the economy to the formal sector, but the analysis is unable to measure this effect since the sample is drawn from workers in the formal sector only. Two other possible effects, which can be measured by the analysis, are that, of those workers who do move into the formal sector, the more highly educated workers are more likely to be appointed to more productive (or skilled) positions, and that more highly educated workers will be more productive in whatever position, skilled or unskilled, they attain.

The gross wage measures the value of the marginal product of labour if the employer is competitive in both the product and labour markets. While the canned tuna market is highly competitive, a tuna cannery is a very significant employer in the local labour market and may enjoy some monopsony power. If this power is exercised the gross wage will understate the productivity of all categories of labour: the value of the marginal product of any type of labour will be measured by the gross wage multiplied by $(1 + 1/e)$ where e is the elasticity of supply of that type of labour. If the company faces a lower supply elasticity of skilled than of unskilled labour, and if it exercises monopsony power, differences in gross wages between skilled and unskilled labour will understate differences in productivity, and hence understate the contribution of education to increasing productivity.

Part 2 of the paper provides a brief description of the local labour market, the tuna cannery, its labour force, and the sample of workers. In Part 3 a Probit model is used to estimate the effect of higher levels of education on the probability of being hired to a skilled as opposed to an unskilled position. Part 4 examines the effects of higher levels of education on the wages of skilled and unskilled workers respectively, and tests for the existence of sex discrimination, and Part 5 summarizes the conclusions of the analysis.

2. The Cannery and its Labour Force

The tuna cannery on which the study is based is located in Madang, PNG and has a rated annual capacity of 24,000 mt of tuna. In the 2000 Census Madang Province's population was recorded at 248,000 persons aged 10 years and over. Of these 155,000 were classified as being in the labour force, with 151,000 employed. The definition of employment used in the Census includes those working in the non-monetary sector and the low rate of unemployment (2.91%) reported by the Census masks a considerable amount of under-employment. In the rural sector of the province 65% of male employment and 80% of female employment consists of subsistence activity. Gumoi (2005) provides further information about the labour market.

At the time of the labor force survey the cannery employed 2530 local workers in three shifts, 1939 female and 591 male workers. Most employees were engaged in occupations requiring low skill levels. These occupations are categorized as “crew” – a factory floor worker – or “loiner” – a fish filleter. People employed in these positions are classified to as “unskilled”, although, strictly speaking, this description refers to the occupation rather than the characteristics of the employee. All other positions in the cannery are classified as “skilled”. On the basis of this classification 549 employees are skilled and 1981 unskilled. Using this classification of skilled and unskilled positions, the distribution of the labor force between skilled and unskilled positions and male and female workers is reported in Table 1.

Table 1 about here

Random samples were selected from each category of worker reported in Table 1 to generate a stratified sample of 205 workers. The number of sampled workers in each category, and the percentage of sampled workers of the total number in that category are reported in Table 2. Each member of the sample was asked a set of 24 questions in the course of a half-hour

Table 2 about here

interview. The survey questionnaire and the detailed responses to the questions are summarized and reported in Campbell (2006).

The skilled workers in the sample work an average of 117.4 hours per fortnight for a wage of 172.5 Kina. For the unskilled workers the figures are 120.6 hours of work for a wage of 92.4 Kina. The average earnings, years of schooling and proportion of tertiary qualifications are reported in Table 3 for the four categories of workers. The results of the sample suggest

Table 3 about here

that while the hours of work are similar, the wages of skilled workers are, on average, almost twice that of unskilled workers, and that skilled workers are more highly educated than unskilled workers. Among skilled workers females are more highly educated than males but the reverse is true for unskilled workers.

The expected value of the wage, W_i, earned by worker i can be expressed as:

$$E(W_i) = E(W_i/S_i).P(S_i/H_i).P(H_i)$$

where $E(W_i/S_i)$ is the expected wage conditional on the skill level, S_i, of the position held (skilled or unskilled), $P(S_i/H_i)$ is the probability of being appointed to that type of position, conditional on being hired, and $P(H_i)$ is the probability of being hired. It can be hypothesized that the level of education affects each of these three variables – the wage of a worker in a skilled or unskilled position, the probability of getting a skilled position if hired, and the probability of being hired in the first place. Since the sample is of employees it can provide information about the first two variables only. The probability of a worker being allocated to a skilled position, given that they are hired, is determined by their level of education and other characteristics; this relationship can be estimated using a Probit model. The wage they earn, given that they have been hired to either a skilled or unskilled position, may also be determined by their level of education and this effect can be estimated by regression analysis. It would inappropriate to collapse these two processes into a single earnings function because the skilled/unskilled position independent variable in that model would be a function of the worker characteristics variables which would also appear as independent variables in the regression model.

The next section of the paper examines the extent to which a higher level of education contributes to a worker being hired to a skilled as opposed to an unskilled position ($P(S_i/H_i)$), and the following section investigates the extent to which higher levels of education are associated with higher wages within the skilled and unskilled groups respectively ($P(W_i/S_i)$).

3. The Probit Model

The dependent variable in the Probit model is a dummy variable which takes on the value 1 when the worker is employed in a skilled position and zero otherwise. The skilled position dummy is regressed against a set of worker characteristics such as experience, education attainment and sex to generate an index of productivity. Experience is measured as age less years of schooling, education attainment is represented by two variables – years of schooling and whether or not the worker has a tertiary qualification. The productivity index is converted to standard normal form and the resulting normal cumulative distribution function is used to calculate the probability of each worker being assigned to a skilled or unskilled position: for values of the CDF equal to, or less than 0.5 (which correspond to index values less than or equal to zero) an unskilled position is predicted, and for the other values a skilled position is predicted. The index is estimated by the Maximum Likelihood technique which chooses the parameters of the index so as to maximize the joint probability of the outcomes observed in the sample. One measure of the performance of the model is the proportion of correct predictions it yields.

The results of the Probit analysis are reported in Table 4. The negative value of

Table 4 about here

the constant term reflects the fact that, with 80 skilled positions and 125 unskilled positions in the sample, an observation selected at random is more likely to be in an unskilled position. The coefficient on the sex dummy is not significantly different from zero, suggesting that there is no sex discrimination in allocating workers to skilled or unskilled positions. The coefficients on the other variables are significantly different from zero at at least the 97.5% level, suggesting that experience, years of schooling and tertiary qualifications are significant in determining whether a job applicant is allocated to a skilled or unskilled position.

The effect of an additional year of schooling on the probability of an applicant obtaining a skilled position, if hired, can be calculated from the Probit model. This effect varies from individual to individual and will be calculated here for the average individual in the sample. At sample means the productivity index takes a value of -0.3340 which translates to a probability of 0.3707 of obtaining a skilled position. There is a less than even chance of a skilled position for the average employee in the sample because 61% of the sample workers are in unskilled positions. The increased probability of the average worker obtaining a skilled position as a result of obtaining one extra year of schooling is calculated by adding one unit to the mean years of schooling and re-evaluating the productivity index and the corresponding probability of a skilled position. The revised probability is 0.4641, an increase of 0.0934. Interpreting this value as the increased probability of earning the mean wage of skilled as opposed to unskilled workers (172.5 kina per fortnight as opposed to 92.41 kina), the expected value of the extra year's schooling is 7.48 Kina per fortnight, or, based on a 24 fortnight year, 179.53 Kina per annum, which 6.8% of the sample average wage. This figure measures the contribution to productivity of an additional year's schooling for the average member of the sample to the extent that it improves the chances of getting a skilled as opposed to an unskilled job.

Schooling probably also contributes to the worker's chance of getting a job in the first place - moving from the formal to the informal sector - but this contribution is not measured by the model.

A similar calculation can be performed to estimate the impact of a tertiary qualification on the probability of being hired to a skilled position and the consequent effect on the expected wage. The productivity index is evaluated at T=1 (0.08714) and T=0 (-0.44254) and the corresponding probabilities of a skilled job calculated as 0.5319 and 0.3300 respectively. Interpreting the difference in probabilities (0.2019) as the increased probability of earning the mean wage of skilled as opposed to unskilled workers, the expected value of the tertiary qualification is 16.17 Kina per fortnight, or, based on a 24 fortnight year, 388.08 Kina per annum, which is 14.73% of the sample average wage.

4. Distribution of Benefits Amongst Workers

The difference between the average wages of skilled and unskilled workers was used in the previous part of the paper to calculate the productivity benefit of an additional year of schooling. In this section the distribution of the benefits of education among skilled and unskilled workers, and between males and females is considered. Since the average benefit of an extra year of schooling in leading to skilled as opposed to unskilled employment has already been measured, the effect calculated in this part of the paper must not be counted as an additional productivity benefit. Rather it demonstrates the extent to which a higher level of education can increase the productivity or wages of a skilled or an unskilled worker, and measures part of the benefit from an individual point of view of additional education. Productivity is measured by the gross wage whereas individual benefits are measured by take-home pay. Since there is little difference between the two values, as tax, superannuation and deductions for work-related expenses are relatively small, varying from 5.34% of gross wage for unskilled female workers to 12.07% for skilled male workers (Campbell (2006)), the analysis will be conducted in terms of the gross wage only.

As noted above, once appointed to either a skilled or unskilled position, a worker's level of education may still have an influence on their productivity as measured by the gross wage, and on their take home pay. Of course the number of hours worked during the pay period will also be important, and other factors such as years of experience and sex may also have an influence. The effect of the level of education on wages can be estimated by fitting earnings functions for each of the four categories of employees:

$$W_i = \alpha_0 + \alpha_1 E_i + \alpha_2 L_i + \alpha_3 T_i + \alpha_4 H_i + u_i$$

where W = fortnightly earnings of worker i
E = years of experience
L = years of schooling
T = tertiary qualification (1=yes, 0=no)

H = hours worked per fortnight

The results presented in Table 5, based on gross wage as the dependent variable, are very

Table 5 about here

similar to those obtained from using take-home pay as the dependent variable and the latter are not presented here.

It can be seen from the results presented in Table 5 that years of schooling is a highly significant determinant (97.5% or higher) of earnings for all groups except skilled males, for whom the significance level is around 90% Conversely, it is only for the skilled males group that there is any evidence of tertiary qualifications having a significant influence on earnings. Experience is marginally significant for all groups except unskilled females. Hours worked is a highly significant variable for unskilled workers, but of marginal significance for skilled workers.

It can be seen from Table 3 that there is a substantial difference between the average wages of male and female skilled workers, whereas for unskilled workers the gap is much less. The relative importance of the earnings function variables in determining the difference between the mean earnings of male and female skilled and unskilled workers respectively can now be determined. The observations on males and females in each skill category are pooled and an earnings function incorporating a set of intercept and slope coefficient dummy variables is estimated:

$$W_i = \beta_0 + \beta_1 D_i + \beta_2 D_i E_i + \beta_3 D_i L_i + \beta_4 D_i T_i + \beta_5 D_i H_i + \beta_6 E_i + \beta_7 L_i + \beta_8 T_i + \beta_9 H_i + u_i$$

where D_i=1 for male, 0 for female. From this equation the difference between the mean wages of males and females in each category can be expressed as:

$$\overline{W_m} - \overline{W_f} = \left\lfloor \beta_1 + \beta_2 \overline{E_m} + \beta_3 \overline{L_m} + \beta_4 \overline{T_m} + \beta_5 \overline{H_m} \right\rfloor + \left\lfloor \beta_7 (\overline{L_m} - \overline{L_f}) + \beta_8 (\overline{T_m} - \overline{T_f}) \right\rfloor$$
$$+ \beta_6 \left[\overline{E_m} - \overline{E_f} \right] + \beta_9 \left[\overline{H_m} - \overline{H_f} \right]$$

where the terms in square brackets represent differences between the means due to sex, level of education, years of experience and hours worked respectively. The values of these terms, together with their standard errors, are reported in Table 6.

Following the general approach pioneered by Oaxaca (1973), the differences between male and female mean wages attributable to differences in education levels, experience and hours worked are evaluated using the regression coefficients applicable to the female sub-sample. For the skilled sub-sample, it can be seen that, leaving aside the difference in sex, mean male and female wages are expected to be similar, with higher expected male earnings due to greater experience and longer working hours being offset by lower expected earnings due to lower education levels. However there is a significant difference between mean wages, amounting to 57.02 kina per fortnight, which cannot be explained by differences in skill level, experience and hours worked, and which is attributed to the difference in sex. For the unskilled sub-sample the difference between mean male and female wages is much lower and is mainly attributable to longer hours of work by males. There is no evidence that the difference in sex contributes in any way to the difference between mean wages of male and female unskilled workers.

It seems unlikely that the significance of sex in contributing to the substantial difference between the mean wages of male and female workers is the result of sex discrimination in the workplace. There is no evidence of discrimination in the results of the Probit model of the process of allocating workers to skilled and unskilled positions, and no evidence that sex is a determinant of the difference between the mean wages of male and female workers in the unskilled sub-sample. Rather the explanation for the difference appears to lie in the different jobs profile of the male and female skilled workforce. Table 7 reports the numbers of male and female employees in each of 11

Table 7 about here

categories of skilled positions in the skilled workforce. It can be seen males are more heavily represented in equipment operation, trades and sales and purchases, whereas females tend to be in production line positions involving some level of skill or leadership qualities or engaged in record keeping functions. The market conditions determining the wages of these different types of jobs may be very different, leading to wage differences which explain the apparent importance of sex in explaining the difference between male and female wages. In principle the hypothesis that there is no significant difference between mean male and female wages could be tested using sub-samples of workers in each of the job categories reported in Table 7. However the sub-sample sizes are not large enough to generate sufficient observations on wages to conduct this test.

Even if there is no sex discrimination in the workplace differences in sex may play a role in individuals' skill acquisition preferences or in the likelihood of them being able to realize their career goals.

5. Conclusions

The results of the Probit analysis suggest that more education is associated with an increased probability of getting a skilled position and earning a higher wage if hired. The expected value of the higher wage as a result of an extra year of schooling is 179.53 kina per annum which is 6.8% of the sample average wage, and as a result of a tertiary qualification is 388.08 kina per annum which is 14.73% of the sample average wage. The earnings functions estimates suggested that extra schooling also places the skilled worker higher in the wage distribution of skilled workers, but has no effect on unskilled worker's wages. The pooled earnings functions indicated that the difference between the mean wages of skilled male and female workers was mainly attributable to the sex difference and differences in education levels. However the differences in earnings attributable to sex were not thought to be the result of sex discrimination in the workplace but rather to more general economic and social conditions.

Acknowledgements

I would like to thank Modowa Gumoi (UPNG) for help in designing and carrying out the labour force survey, Jerome Tioti, National Fisheries Authority (NFA) Papua New Guinea for supervising the conduct of the survey, the interviewers Marylouise Avu, Rodney Kirarock and Christa Lulu, the RD Company for facilitating the survey, and particularly Kirsten Decrepito of RD who was very helpful in providing information about the workforce, Stephanie Seales who transcribed the survey responses, and Phil Bodman for comments on an earlier draft of the paper. The School of Economics, University of Queensland and The Centre for Economics and Management of Aquatic Resources (CEMARE), University of Portsmouth, provided research support, and The Australian Center for International Agricultural Research (ACIAR) provided funding under Project ASEM/2004/011.

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Tables

Table 1: Composition of the Cannery's Domestic Labor Force

	(% of total) Male	Female
Skilled	11.5	10.2
Unskilled	11.7	66.6

Table 2: Composition of the Labor Force Sample

	Number of Respondents *(% of category)*	
	Male	Female
Skilled	25 *(8.5)*	55 *(20.4)*
Unskilled	40 *(13.5)*	85 *(5.1)*

Table 3: Average Levels of Education and Earnings

	Skilled Workers			Unskilled Workers		
	Males	Females	Total	Males	Females	Total
Average Schooling (years)	8.4	9.2	8.9	6.9	6.3	6.5
Tertiary Qualification (%)	28	40	36	13	9	10
Earnings (Kina/fortnight)	211.1	155.0	172.5	99.2	89.2	92.4

Table 4: Results of the Probit Analysis

Variable	Estimated Coefficient	Standard Error	t-Ratio
Years of Schooling	0.2421	0.04792	5.0518
Tertiary (1=Yes)	0.52955	0.25104	2.1094
Sex (1=male)	-0.0241	0.20543	-0.11732
Experience	0.03086	0.013906	2.2192
Constant	-2.8396	0.56494	-5.0265

Dependent variable is the skilled position dummy, Skilled=1, Unskilled=0
Likelihood Ratio Test Statistic: Chi^2 (df=4) = 49.5285
Standard errors and t-values are asymptotic
Percentage of correct predictions: 76.59

Table 5: Effects of Education and Personal Characteristics on Take-Home Pay

(a) Unskilled Male Workers

Variable	Estimated Coefficient	Standard Error	t-Ratio 35 df	p-Value
Experience	1.29	0.75	1.7217	0.0940
Years of Schooling	9.20	3.31	2.7803	0.0087
Tertiary (1=yes)	8.60	26.34	0.3264	0.7461
Hours Worked per Fortnight	0.55	0.18	3.0308	0.0046
Constant	-67.70	46.49	-1.4563	0.1542

n=40, R^2=0.24

(b) Unskilled Female Workers

Variable	Estimated Coefficient	Standard Error	t-Ratio 80 df	p-Value
Experience	0.14	0.25	0.5711	0.5696
Years of Schooling	2.41	1.13	2.1340	0.0359
Tertiary (1=yes)	-5.31	7.07	-0.7510	0.4549
Hours Worked per Fortnight	0.31	0.08	3.8465	0.0002
Constant	36.76	13.84	2.6559	0.0095

n=85, R^2=0.21

(c) Skilled Male Workers

Variable	Estimated Coefficient	Standard Error	t-Ratio 20 df	p-Value
Experience	6.23	3.16	1.9695	0.0629
Years of Schooling	12.84	7.34	1.7494	0.0956
Tertiary (1=yes)	70.74	41.27	1.7070	0.1033
Hours Worked per Fortnight	1.55	0.91	1.6937	0.1058
Constant	-61.120	69.025	-0.88547	0.3788

n=25, R^2=0.33

(d) Skilled Female Workers

Variable	Estimated Coefficient	Standard Error	t-Ratio 50 df	p-Value
Experience	2.41	1.49	1.6917	0.1116
Years of Schooling	18.08	5.25	3.4405	0.0012
Tertiary (1=yes)	7.28	24.13	0.3015	0.7643
Hours Worked per Fortnight	0.45	0.32	1.3959	0.1689
Constant	-107.76	71.52	-1.5066	0.1382

n=55, Adjusted R^2=0.27

Notes: the dependent variable is earnings per fortnight. All equations are estimated by OLS using the Heteroskedastic-Consistent Covariance Matrix to correct for possible heteroskedasticity.

Table 6: Determinants of Differences between Male and Female Mean Wages

(a) Skilled Workers

	Difference (Male-Female)	Standard Error	t-Statistic (df=70)	p-Value
Difference in Sex	57.017	18.758	3.0396	0.0033
Difference in Education	-15.734	3.099	-5.0770	0.0000
Difference in Experience	4.0618	2.5078	1.6197	0.1098
Difference in Hours Worked	10.732	7.6889	1.3959	0.1672
Total (Male – Female)	56.08			

(b) Unskilled Workers

	Difference (Male-Female)	Standard Error	t-Statistic (df=115)	p-Value
Difference in Sex	10.908	10.747	1.0150	0.3122
Difference in Education	-1.3489	0.9757	-1.3825	0.1695
Difference in Experience	0.9014	0.6217	1.4498	0.1498
Difference in Hours Worked	7.3815	1.9190	3.8465	0.0002
Total (Male – Female)	9.96			

Note: Equations estimated by OLS using the Heteroskedastic-Consistent Covariance Matrix to correct for possible heteroskedasticity. Standard errors and related statistics obtained from the Test command in Shazam.

Table 7: Jobs Profile of Skilled Male and Female Cannery Workers

Job Category	Males	Females	Total
Management/Supervisor/Inspector	16	13	29
Personnel/Accounts/Payroll	7	7	14
Sales/Purchases	20	3	23
Clerk	4	13	17
Technician	14	8	22
Tradesperson	24	1	25
Mobile Equipment Operator	38	0	38
Fixed Equipment Operator	69	17	86
Recorder/Monitor/Timekeeper	23	46	69
Production Line Team Leader	35	58	93
Skilled Production Line Worker	40	93	133
Total	290	259	549