

Chapter 7

The Impact of the Expansion of Higher Education on the Rate of Return to Higher Education in Taiwan



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On April 10, 1994, 200 civic groups including over 30,000 people marched in the streets of Taipei, and in October of the same year, the “League for Educational Reform 4/10” was established. The protesters submitted petitions outlining four main demands: smaller schools and classes, the establishment of more high schools and universities, modernization of the education system, and the formulation of a new body of law pertaining to education. These efforts led to a dramatic increase in the number of higher education institutions, which grew in number from 60 in 1994 to 144 in 2017.¹ During the same period, however, the rate of unemployment among college graduates rose from 2.52% in 1994 to 5.19% in 2017.²

Afzal (2011) found evidence that education is the main factor determining an individual’s economic status and social achievements, and further confirmed that education is the key to the development of human capital. Education can improve the productivity and efficiency of workers and can cultivate the human resources required for continued societal development and growth. The rate of return to education is defined as the economic benefits resulting from a specific educational investment. Mincer’s wage equation based on the ordinary least squares (OLS) method is the most common technique used to calculate rates of return to education. The OLS method uses linear minimum mean-square error estimation to determine

¹Source: Department of Statistics, Taiwan Ministry of Education, http://stats.moe.gov.tw/files/important/OVERVIEW_U03.pdf.

²Source: Directorate General of Budget, Accounting and Statistics, Executive Yuan http://win.dgbas.gov.tw/dgbas04/bc4/manpower/year/year_t1-t24.asp?table=21&ym=1&yearb=82&yeare=106&out=1.

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the degree to which one additional year of education affects an individual's average wage. However, this means that OLS cannot be used to compare the rates of return to education at differing income levels. Quantile regression has also been used to estimate the rates of return to education in different quantiles pertaining to the conditional distribution of wages. This approach provides a more comprehensive picture of return-education dynamics.

Quantile regression has been applied in a variety of disciplines. In education, this method has been used to examine rates of return. Buchinsky (2001) used quantile regression to measure the rate of return to education among women in the United States. Martins and Pereira (2004) explored the relationship between education level and wage inequality, concluding that there is a positive correlation between the two. Ning (2010) examined whether the expansion of education has improved wage equality in mainland China, and argued that the effects of education are less pronounced in lower income groups. Quantile regression can be used to overcome the limitations of OLS, and may be able to shed light on the differences in the rates of return to education at various wage levels.

In this study, we used quantile regression to determine whether the expansion of higher education in Taiwan since 1994 has impacted the overall rate of return to undergraduate education. We also examined the different return rates in various fields of study such as science, engineering, and agriculture.

7.1 Quantile Regression Model

Quantile regression enables us to focus on the effects of explanatory variables on the conditional distribution of the dependent variable. The estimation is based on the principle of minimizing an asymmetrically weighted sum of absolute errors, which can be defined as follows:

$$y_i = x_i' \beta_\theta + \varepsilon_{i\theta} \quad i = 1, 2, \dots, n$$

where y_i is the dependent variable selected at random from sample Y_i ; x_i is the dependent variable; θ is a vector of values between 0 and 1; β_θ is a parameter vector; and $\varepsilon_{i\theta}$ is a vector of residuals. Assuming a linear relationship, $\text{Quant}_\theta(y_i|x_i)$ given x_i , the θ th conditional quantile of y_i , can be defined as

$$\text{Quant}_\theta(y_i|x_i) = X_i' \beta_\theta, \quad i = 1, 2, \dots, n$$

where β_θ is the vector of parameters to be estimated ($0 < \theta < 1$). For a linear model, the estimator of the regression coefficient β_θ is

$$\hat{\beta}_\theta = \min \left\{ \sum_{i=y_i \geq x_i' \beta} \theta |y_i - x_i' \beta| + \sum_{i=y_i < x_i' \beta} (1-\theta) |y_i - x_i' \beta| \right\}$$

In this model, various weights can be assigned to absolute values of positive and negative residuals to derive the quantile regression estimator, where β_θ indicates that the θ quantile of y_i increases by β_θ for every unit increase in x_i . When $\theta = 0.5$, we obtain the estimator of the least absolute deviation by multiplying the above estimator by 2, as follows:

$$\widehat{\beta_{0.5}} = \sum_{i=1}^n |y_i - x_i' \beta|$$

In the case where $\theta = 0.5$, quantile regression can also be referred to as median regression (*i.e.*, a special case of quantile regression). The general form of the estimator is written as follows:

$$\hat{\beta}_\theta = \min \left[\frac{1}{n} \sum_{i=1}^n \rho_\theta(y_i - x_i' \beta) \right] = \min \left[\frac{1}{n} \sum_{i=1}^n \rho_\theta(\varepsilon_{i\theta}) \right]$$

ρ_θ serves as a check function, which assigns various weights to positive and negative residuals. It is defined as follows:

$$\begin{aligned} \rho_\theta(\varepsilon) &= \theta_\varepsilon & \text{if } \varepsilon \geq 0 \\ \rho_\theta(\varepsilon) &= (\theta - 1)\varepsilon & \text{if } \varepsilon < 0 \end{aligned}$$

Therefore, $\hat{\beta}_\theta$ is the θ quantile of y_i .

7.2 Quantile Regression Results for the Rate of Return for Higher Education

Our data sources included educational statistics from the Taiwan Ministry of Education, the Human Resources Survey Database, and the Survey Research Data Archive (SRDA). The data covered the period between 1994 and 2016. The subjects were employees ranging in age from 22 (the average age of new college graduates in Taiwan) to 65.

Based on the human capital model proposed by Mincer (1974),³ quantile regression was used to derive the rates of return to higher education between 1994 and 2016 as well as the distribution, trends, and determinants during the period. The basic model used gender, city, marital status, education level, company size, work experience, and the square of work experience for preliminary analysis. The square of work experience served as a correction term.

³Mincer's human capital model: $\ln Y = a + b_1 S + b_2 E + b_3 E^2 + \varepsilon$

Table 7.1 Quantile regression results for rate of return to higher education (1994–2016)

Vector θ	0.05		0.25		0.5		0.75		0.95	
Year	β	SD	β	SD	β	SD	β	SD	β	SD
1994	0.187	0.073	0.143	0.028	0.171	0.021	0.159	0.025	0.137	0.070
1995	0.309	0.027	0.208	0.026	0.168	0.021	0.180	0.024	0.233	0.014
1996	0.180	0.109	0.210	0.030	0.227	0.029	0.225	0.024	0.251	0.076
1997	0.081	0.099	0.168	0.028	0.203	0.026	0.241	0.017	0.216	0.071
1998	0.092	0.065	0.170	0.025	0.203	0.032	0.263	0.028	0.190	0.025
1999	0.160	0.016	0.185	0.018	0.200	0.016	0.237	0.039	0.285	0.035
2000	0.056	0.088	0.184	0.021	0.211	0.029	0.288	0.036	0.301	0.027
2001	0.027	0.024	0.165	0.018	0.233	0.033	0.260	0.037	0.275	0.044
2002	0.060	0.098	0.209	0.020	0.221	0.024	0.251	0.015	0.265	0.028
2003	0.153	0.050	0.193	0.024	0.215	0.022	0.209	0.022	0.162	0.022
2004	0.103	0.119	0.189	0.024	0.214	0.018	0.212	0.021	0.239	0.064
2005	0.153	0.041	0.165	0.019	0.191	0.017	0.188	0.024	0.234	0.087
2006	0.023	0.140	0.140	0.020	0.155	0.015	0.218	0.021	0.181	0.020
2007	0.008	0.131	0.163	0.020	0.202	0.018	0.218	0.020	0.212	0.024
2008	0.024	0.060	0.114	0.020	0.189	0.018	0.215	0.020	0.267	0.042
2009	0.166	0.017	0.189	0.007	0.202	0.006	0.224	0.007	0.231	0.017
2010	0.153	0.036	0.199	0.022	0.222	0.036	0.197	0.037	0.126	0.091
2011	−0.030	0.195	0.093	0.038	0.110	0.031	0.136	0.019	0.166	0.060
2012	0.053	0.053	0.105	0.017	0.129	0.017	0.139	0.019	0.235	0.032
2013	0.048	0.103	0.100	0.037	0.108	0.043	0.158	0.040	0.139	0.023
2014	0.153	0.086	0.076	0.034	0.135	0.042	0.185	0.040	0.227	0.039
2015	−0.240	0.438	0.036	0.040	0.144	0.049	0.219	0.055	0.216	0.115
2016	−0.655	0.172	0.003	0.034	0.099	0.029	0.149	0.028	0.118	0.082

Note: β refers to quantile regression coefficients, SD refers to standard deviation

Table 7.1 presents a summary of the quantile regression results for the rate of return for higher education from 1994 to 2016. The quantile regression coefficients were estimated at five θ levels: the 5th, 25th, 50th, 75th, and 95th quantiles.

The results in Table 7.1 can be used to visualize the distribution of the rate of return to higher education (Fig. 7.1), where the X-axis indicates the year and the Y-axis indicates the coefficient of the rate of return to higher education. Based on the estimates for the 0.5 quantile, the rate of return to higher education indicated a gradual decline during this timeframe.

Table 7.2 summarizes the quantile regression results for 2016. Taking education level as an example, the positive coefficient indicates that employees with an undergraduate degree received higher wages than those without one. There were also significant relationships between work experience/wages and gender/wages, suggesting that male employees and those with more work experience earn more. The coefficient for marital status is negative but not significant, which indicates that there is no significant difference in wages between married and unmarried individuals. The coefficient of the square of work experience was negative, suggesting a

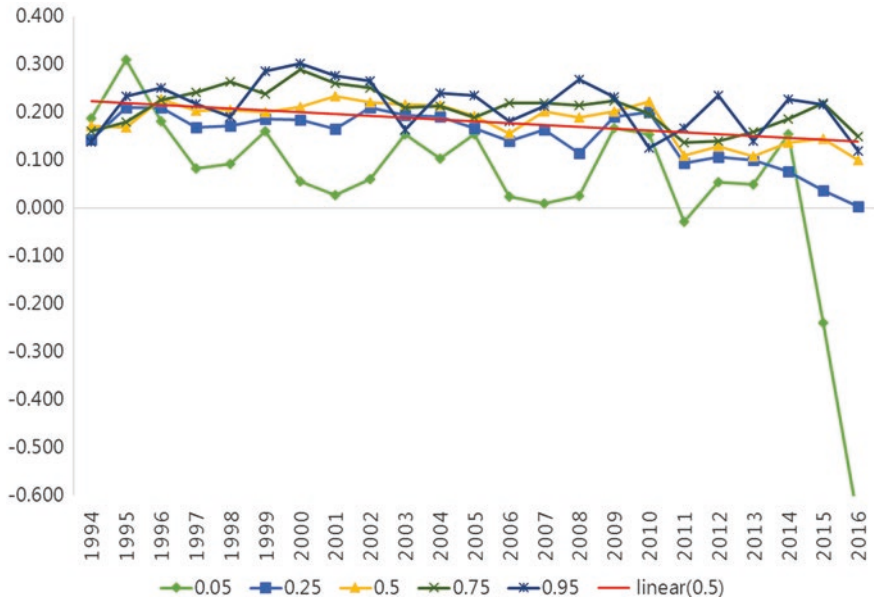


Fig. 7.1 The rate of return to higher education from 1994 to 2016

negative correlation with wages. This is consistent with the assumption of Mincer’s human capital model that age and wages present an inverted U-shaped correlation.

7.3 Quantile Regression Results for the Rates of Return to Higher Education in Various Fields of Study

Based on the SRDA⁴ database, various fields of study were divided into the following ten categories: humanities, law, business, science, engineering, agriculture, health care, military/law enforcement, education, and others. In this study, we used agriculture (with the lowest average wage in 2016) as a reference point by which to compare the rates of return to higher education in different fields of study.

Table 7.3 and Fig. 7.2 list the estimated rates of return to higher education in the 0.5 quantile from 1994 to 2016. These results show that—over the 20-year period of educational reform—employees who obtained education enjoyed the highest average rate of return at 23.8%. Looking back at 1994, health care, education, and humanities had the highest rates of return; whereas engineering, business, and military/law enforcement had the lowest return rates. Over the last 5 years, all fields have seen significant decreases in their rate of return to higher education (except for

⁴SRDA, Survey Research Data Archive. <https://srda.sinica.edu.tw/>.

Table 7.2 Rate of return to investment in higher education in 2016 (partial)

	Quantile	Coefficient	SD	<i>T</i> value	Significance
Constant	0.05	9.5260	0.0225	424.3870	***
	0.25	9.8644	0.0062	1586.2826	***
	0.50	9.9742	0.0067	1498.8952	***
	0.75	10.0760	0.0079	1277.9861	***
	0.95	10.3403	0.0224	461.3845	***
Gender	0.05	0.1128	0.0135	8.3315	***
	0.25	0.1501	0.0050	30.0284	***
	0.50	0.1787	0.0052	34.0827	***
	0.75	0.2179	0.0062	35.3842	***
	0.95	0.2315	0.0169	13.7277	***
Marital status	0.05	0.0336	0.0124	2.7136	**
	0.25	0.0597	0.0049	12.1474	***
	0.50	0.0827	0.0052	16.0393	***
	0.75	0.1204	0.0063	19.0684	***
	0.95	0.2279	0.0161	14.1184	***
Education	0.05	-0.6551	0.1723	-3.8016	***
	0.25	0.0028	0.0338	0.0840	
	0.50	0.0995	0.0287	3.4690	***
	0.75	0.1491	0.0284	5.2523	***
	0.95	0.1183	0.0821	1.4408	
Work experience	0.05	0.0351	0.0030	11.8659	***
	0.25	0.0249	0.0010	25.1862	***
	0.50	0.0265	0.0010	25.9320	***
	0.75	0.0294	0.0011	26.0869	***
	0.95	0.0335	0.0030	11.3414	***
Square of work experience	0.05	-0.0009	0.0001	-8.4458	***
	0.25	-0.0005	0.0000	-12.6077	***
	0.50	-0.0004	0.0000	-10.2838	***
	0.75	-0.0004	0.0000	-9.9491	***
	0.95	-0.0005	0.0001	-4.6398	***

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

military/law enforcement where the decline has been far less pronounced). For 2016, law, military/law enforcement, and education enjoyed the highest rates of return, whereas business and engineering saw the lowest rates.

Overall, the rates of return to higher education in most fields of study were unstable or declined during the period from 1994 to 2016. However, the return rates for military/law enforcement grew steadily, whereas the rates for health care remained largely unchanged.

Tables 7.4 and 7.5 compare the quantile regression coefficients in various fields of study using estimates for five quantiles for the years from 1994 to 2016.

In 1994, among lower-income workers, those in the fields of education, humanities, law, and health care enjoyed higher rates of return to higher education. Among higher-income workers, those in the fields of law, science, and health care enjoyed

higher return rates. In the field of health care, we observed a significant difference between higher- and lower-income workers in terms of the rates of return to higher education.

In 2016, among lower-income workers, those in the fields of education, military/law enforcement, and health care enjoyed higher rates of return to higher education. Among higher-income workers, those in the fields of law, military/law enforcement, and health care enjoyed higher return rates.

Table 7.6 summarizes the regression results for the 0.5 quantile in the various fields of study in 2016. Overall, these results indicate a positive correlation between education level and income. Work experience, region, gender, and marital status also demonstrated significant relationships with income. Specifically, employees earning higher wages were those with more work experience, those located in six specific municipalities (the largest cities in Taiwan), males, and married individuals. The square of job experience was negatively correlated with wages, which is in line with the assumption of Mincer's human capital model.

In summary, our results indicate that education, work experience, location in urban areas, being male, and marital status are all significantly correlated with income level, whereas the square of work experience is negatively correlated with income level. During the last 20 years of educational reform, the overall rate of return to higher education has gradually declined, regardless of the field of study. On average, the fields of law, humanities, and military/law enforcement enjoyed higher relative return rates. It is also worth noting that the field of health care had high rates of return among higher-income workers. Military/law enforcement was the only field that demonstrated steady increases during this period, perhaps due to the government's decision to provide financial support for students enrolled in police academies beginning in 1993.

7.4 Conclusions

This study used quantile regression to analyze the rates of return to higher education in Taiwan during the period of educational reform between 1994 and 2016. We focused on the variations in the rates of return to education in different wage quantiles and their distribution over the last 20 years. The results indicate a declining trend in the overall rate of return to education, particularly in the 0.05 quantile. This may be due to the expansion of higher education since 1997, which has resulted in there being 126 institutions of higher education in Taiwan and more than 300,000 graduates in 2016. The expansion of higher education has limited the importance of university diplomas in the search for employment. The consequences of over-education should be explored further and managed carefully.

In this study, we used agriculture (the sector with the lowest average wage) as a reference point by which to compare the rates of return among various fields of study. The results indicate that the field of education has enjoyed the highest rate of return over the last 20 years. The rates of return in all fields, except for military/law

Table 7.3 Rates of return to higher education in the 0.5 quantile for various fields of study

Year	Humanities	Law	Business	Science	Engineering	Health care	Military/law enforcement	Education
1994	0.1490	0.1360	0.0366	0.0846	-0.0055	0.1603	0.0378	0.1547
1995	0.1627	0.1659	0.0627	0.1099	-0.0042	0.2219	0.0713	0.1671
1996	0.1122	0.0767	0.0272	0.0917	-0.0645	0.1513	-0.0040	0.1610
1997	0.1573	0.1204	0.0361	0.1049	-0.0526	0.1830	0.0267	0.2004
1998	0.1393	0.1273	0.0217	0.1279	-0.0162	0.1796	0.0664	0.2117
1999	0.1585	0.1870	0.0234	0.1696	-0.0325	0.1958	0.0847	0.2199
2000	0.1504	0.1316	0.0239	0.1422	-0.0445	0.1846	0.0945	0.1851
2001	0.1743	0.1868	-0.0010	0.1346	-0.0537	0.1910	0.1066	0.2151
2002	0.1517	0.2354	0.0191	0.1360	-0.0294	0.1800	0.1405	0.2437
2003	0.1393	0.2079	0.0325	0.0807	-0.0140	0.2075	0.1727	0.2659
2004	0.1566	0.2110	0.0278	0.1183	-0.0053	0.2126	0.1547	0.2509
2005	0.1201	0.2252	0.0264	0.1515	-0.0156	0.1925	0.2165	0.2491
2006	0.1587	0.2526	0.0498	0.1065	0.0127	0.2177	0.2462	0.2511
2007	0.1098	0.2144	0.0186	0.0646	-0.0202	0.1879	0.2131	0.2247
2008	0.1524	0.1780	0.0184	0.0595	-0.0063	0.1951	0.2195	0.2794
2009	0.1220	0.2316	0.0041	0.0596	0.0111	0.1799	0.2457	0.2542
2010	0.0706	0.2565	-0.0145	0.0594	-0.0361	0.1355	0.2066	0.2078
2011	0.2138	0.3644	0.0946	0.1660	0.0887	0.2713	0.3167	0.3435
2012	0.1552	0.3372	0.0680	0.1525	0.0598	0.2639	0.3230	0.3437
2013	0.1185	0.2949	0.0853	0.1628	0.0739	0.2771	0.3207	0.2987
2014	0.0995	0.3771	0.0634	0.0883	0.0398	0.3133	0.2863	0.2700
2015	0.0786	0.2831	0.0303	0.0948	0.0084	0.2350	0.3248	0.2090
2016	0.1158	0.3489	0.0552	0.0922	0.0560	0.2154	0.3405	0.2745
Mean	0.138	0.224	0.035	0.111	-0.002	0.236	0.183	0.238
Rank	5	3	7	5	8	2	4	1

enforcement, have been declining gradually. This is a clear indication that educational reform should consider the divergent needs of the labor market and reconsider whether the continued expansion of higher education is the best approach to improve human resources.

Finally, we would like to provide suggestions for future work in this area. We recommend that future studies consider using more up-to-date data (this study used data from 1994 to 2016), especially the salary adjustment statistics, which might contribute to a more accurate estimation of the relationship among employees' demographics, work environments, and the rates of return to education in different fields of study as well as the effects of education on the development of human resources. Furthermore, this study was based on secondary data that was limited by the fixed structure of the official database. If we can integrate information collected at different stages of schooling, we can gain a more comprehensive understanding of how each educational stage affects the development of students, which—in turn—will enable us to better understand the contribution of higher education to human capital.

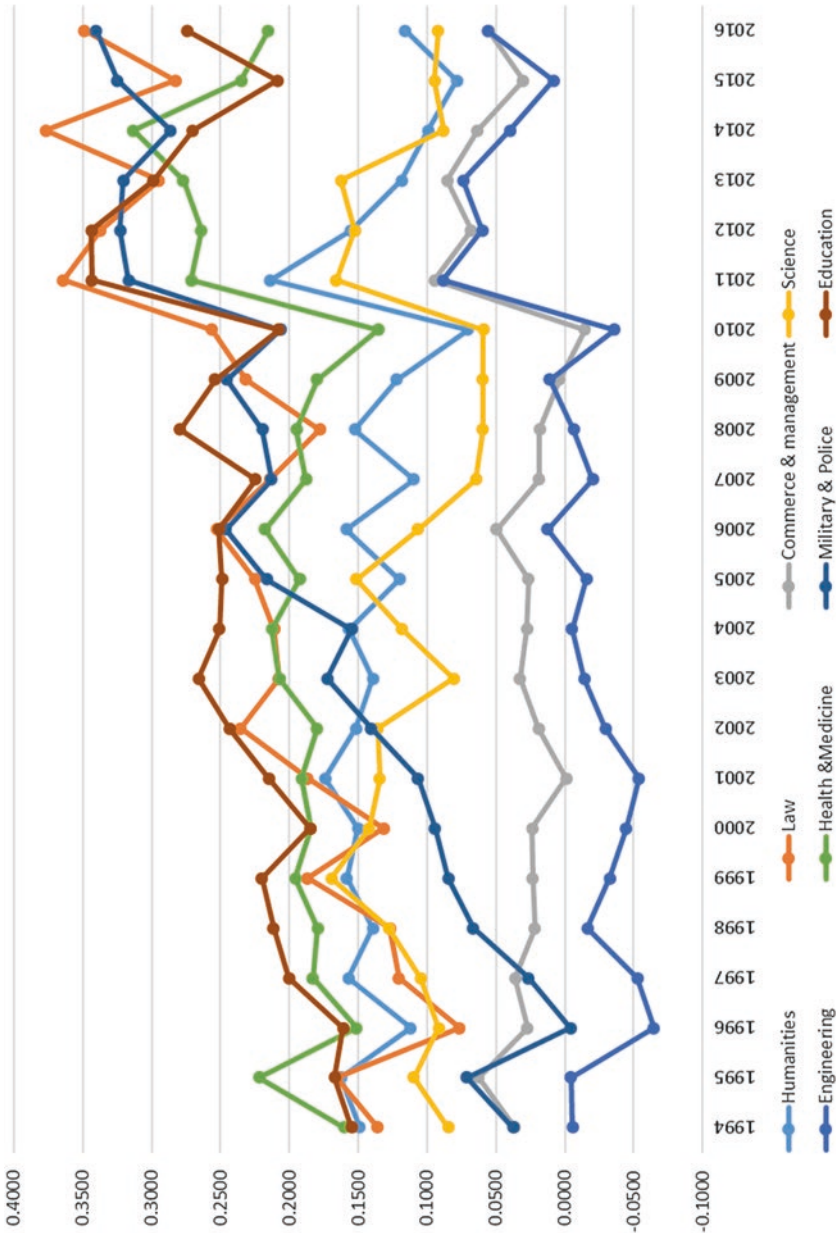


Fig. 7.2 The rates of return to higher education from 1994 to 2016 in various fields of study

Table 7.4 Quantile regression coefficients in various fields of study for five quantiles in 1994

PR (0.05– 0.95)	Humanities	Law	Business	Science	Engineering	Health care	Military/law enforcement	Education
0.05	0.1238	0.1094	0.0458	0.0480	0.0419	0.1082	−0.0946	0.1352
0.25	0.1624	0.1409	0.0770	0.0666	0.0363	0.1786	0.0320	0.1755
0.50	0.1490	0.1360	0.0366	0.0846	−0.0055	0.1603	0.0378	0.1547
0.75	0.1402	0.1571	0.0472	0.1380	−0.0213	0.1865	−0.0027	0.1451
0.95	0.0992	0.4014	0.1118	0.0958	0.0245	0.4749	0.0226	0.1138

Table 7.5 Quantile regression coefficients in various fields of study for five quantiles in 2016

PR (0.05– 0.95)	Humanities	Law	Business	Science	Engineering	Health care	Military/law enforcement	Education
0.05	0.8300	0.7669	0.8435	0.7747	0.8318	0.8867	0.8794	0.9064
0.25	0.1633	0.3277	0.1388	0.1288	0.1401	0.2408	0.4250	0.3028
0.50	0.1158	0.3489	0.0552	0.0922	0.0560	0.2154	0.3405	0.2745
0.75	0.1298	0.4062	0.0464	0.1074	0.0284	0.2696	0.3032	0.2439
0.95	0.1996	0.4719	0.1476	0.1138	0.0824	0.6853	0.2404	0.2144

Table 7.6 Regression results of rates of return to education in various fields of study in 2016

	Coefficient	SD	<i>T</i> value	<i>P</i> -value	Significance
Constant	9.9742	0.0067	1498.8952	0.0000	***
Humanities	0.1158	0.0335	3.4616	0.0005	***
Law	0.3489	0.0704	4.9585	0.0000	***
Business	0.0552	0.0289	1.9119	0.0559	
Science	0.0922	0.0368	2.5070	0.0122	*
Engineering	0.0560	0.0290	1.9319	0.0534	
Health care	0.2154	0.0317	6.7888	0.0000	***
Military/law enforcement	0.3405	0.0338	10.0885	0.0000	***
Education	0.2745	0.0334	8.2078	0.0000	***
Located in six municipalities	0.0378	0.0048	7.8489	0.0000	***
Male	0.1787	0.0052	34.0827	0.0000	***
Married	0.0827	0.0052	16.0393	0.0000	***
Smaller companies	0.0283	0.0096	2.9448	0.0032	**
Medium-sized companies	0.0350	0.0111	3.1552	0.0016	**
Larger companies	0.0769	0.0070	10.9949	0.0000	***
Undergraduate degree	0.0995	0.0287	3.4690	0.0005	***
Postgraduate	0.4111	0.0301	13.6504	0.0000	***
Years of work experience	0.0265	0.0010	25.9320	0.0000	***
Square of work experience	−0.0004	0.0000	−10.2838	0.0000	***

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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