Education and labour productivity in New Zealand

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21 February 2007

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2007

Abstract

We estimate the effect of four types of education qualifications, as a proxy for human capital and skill levels, on GDP per capita, and compute the average percentage returns. We also test the effect of the product of each proxy of human capital with R&D on GDP per capita. We find that only university qualification and its product with R&D to have a positive effect on the average economy-wide productivity.

Keywords: Labour productivity, education qualification, R&D

JEL Classification: C23, D20, J08

[†] The views expressed in this paper do not reflect those of the Department of Labour. We acknowledge Statistics New Zealand for giving us the data and thank Hans-Jürgen Engelbrecht and Victoria Johns for their valuable comments. Contacts are Weshah.razzak@dol.govt.zn and Jason.timmins@dol.govt.nz

1. Introduction

Economic literature on the relationship between "knowledge" and GDP, level and growth rate is voluminous. Endogenous growth models have externality or spillover effects of investments in education, where higher education level enables workers to more effectively deal with technological innovations. Nelson and Phelps (1966) hypothesized that "educated people make good innovators, so that education speeds the process of technological diffusion," which leads to a higher growth. Acemoglu (1998) argues that "the direction of technical change is determined by the size of the market of different inventions, which increases with more skilled labour," hence, skill-complementary technology and endogenous skill-bias technical change.

New Zealand is a small open economy with a relatively literate population of less than 4 million people (International Adult Literacy Survey, 2006). In the mid 1980s, New Zealand embarked on a wide micro-macro reform process, which ended up in the early 1990s, and resulted in a relatively much deregulated economy. Despite that, New Zealand has been cited as an example of a depressed economy, Prescott (2002).

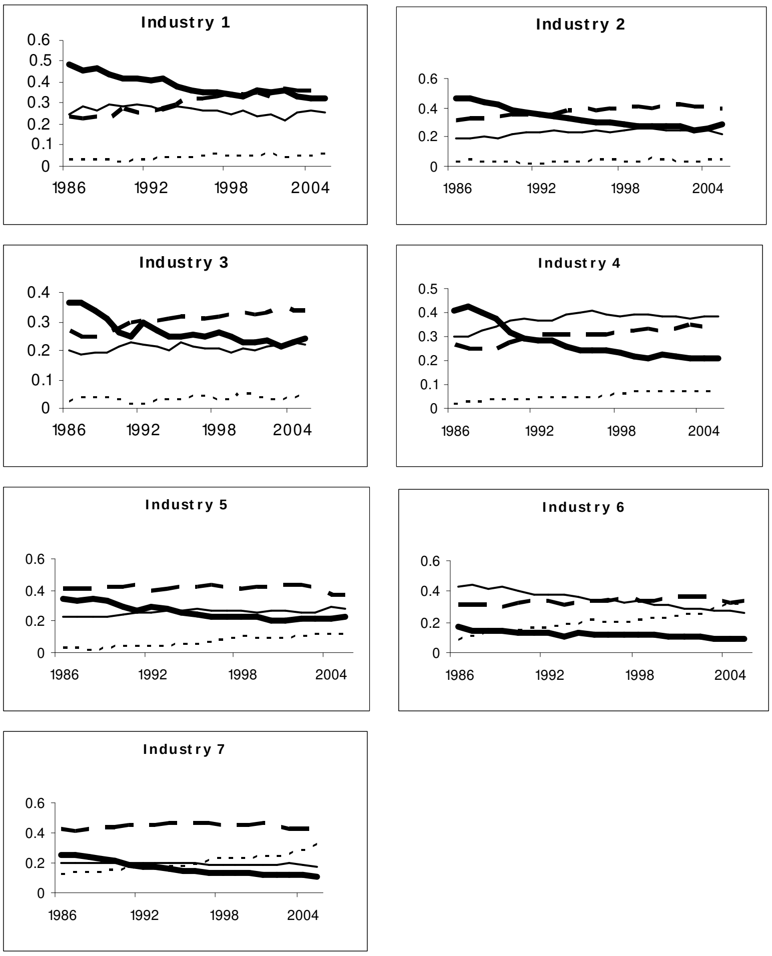
Johnson et al. (2006) test for externality (spillovers) and provide evidence that private rather than publicly owned R&D stocks have a significant impact on own-industry output per person, and higher rates of returns, in New Zealand. In the spirit of this literature, we extend this research by examining (1) the effect of education as a proxy for human capital and the level of skills on output per person, i.e. the social rate of return; and (2) the effect of the product of education qualifications and R&D on output per person. We report positive results for higher education.

2. The data

The data for real GDP, Capital stock, Labour, and private R&D stock are from Johnson et al. (2006). They tested for R&D spillover in New Zealand and found that private rather than public R&D stock to have a significant effect on average GDP per capita. The stock of qualifications data are from the Household Labour Force Survey (HLFS), where respondents are asked for their highest qualification. Vocational qualification is not very well defined. They include workers with more than high school and less than university qualifications.

Data are annual from 1986-2005 for 7 industries, which are the only available data in New Zealand. We also aggregated industries together to avoid missing values. The industries are: (1) Agriculture, Hunting, Forestry, Fishing, Mining and Quarrying, (2) Manufacturing, Electricity, Gas and Water, (3) Construction, (4) Wholesale and Retail Trade, Restaurants and Hotels, (5) Transport, Storage and Communications, (6) Finance, Insurance, Real Estate and Business Services, and (7) Community, Social and Personal Services. Although the share of university-qualified workers in total employment has been increasing, especially in the services industries such as finance, banking, insurance and education, the shares of workers with a high school and vocational qualification are larger in comparison. The share of workers with no qualification has been falling over time. Figure 1 plots the data by industry.

Figure 1: Percentage shares in total employment on the vertical axis. No qualification: Solid thick line; School qualification: Solid thin line; Vocational qualification: Dashed solid line; University qualification: Dotted thin line



(1) Agriculture, Hunting, Forestry, Fishing, Mining and Quarrying,
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3. Estimation

We estimate the effect of labour with no qualification, high school, vocational and university on labour productivity. The production function is:

(1) $$Y_{it} = Ae^{\lambda t} K_{it}^{\alpha} L_{it}^{\beta} \tilde{L}_{1,it}^{\gamma_1} \tilde{L}_{2,it}^{\gamma_2} \tilde{L}_{3,it}^{\gamma_3} \tilde{L}_{4,it}^{\gamma_4} e^{\varepsilon_{it}}$$

Output Y_{it} is a function of the stock of capital K_{it}, labour L_{it}, and four types of human capital (twiddle on top of the variables is to distinguish it from labour): workers with no qualification $\tilde{L}_{1,it}$, with a school qualification $\tilde{L}_{2,it}$, with a vocation qualification $\tilde{L}_{3,it}$, and workers with a university qualification $\tilde{L}_{4,it}$. The subscripts i and t denote industries $i = 1 \cdots 7$ and time respectively. The sample is 1986-2005. Taking log – lower case – and subtracting labour from both sides gives:

(2) $$\begin{aligned} y_{it} - l_{it} &= a + \lambda t + \rho(y_{i,t-1} - l_{i,t-1}) + \alpha(k_{it} - l_{it}) + \delta l_{it} + \gamma_1(\tilde{l}_{1,it} - l_{it}) + \gamma_2(\tilde{l}_{2,it} - l_{it}) \\ &+ \gamma_3(\tilde{l}_{3,it} - l_{it}) + \gamma_4(\tilde{l}_{4,it} - l_{it}) + \varepsilon_{it} \end{aligned}$$

Where ($\delta = \alpha + \beta + \gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 - 1$) measures the deviation from constant returns to scale. We estimate a fixed-effect regression. For robustness, we use both EGLS and GMM-EGLS methods to estimate the elasticities. The estimates are reported in table 1.[2]

Differences between GMM and EGLS are not significant, which means the instruments are not affecting the results a great deal. GDP per capita is persistent; the estimate of ρ is between 0.67-0.69. Also, the Cobb-Douglas production function does not exhibit a constant-return to scale with δ is estimated to between -0.19 and -0.34 and significant. The elasticity estimates γ_1 (no qualification) and γ_2 (high school) are mainly insignificant or negative. However, the elasticity γ_3 (vocational qualification) is either borderline significant in EGLS or statistically insignificant in GMM-EGLS. The estimated γ_4 is highly significant in both regressions and that, on average; a 10 percent increase in the share of university educated workers in total employment would increase GDP per capita by about ½ to 1 percent.[3]

The short-run return on each qualification is $\Delta \ln Y / \Delta \ln X = \hat{\gamma}$; thus, $(\Delta Y / \Delta X).(X / Y) = \hat{\gamma}$ and $\Delta Y / \Delta X = \hat{\gamma}.(Y / X)$, where X denote workers with: no qualifications, high school, vocational and university qualifications in

[2] We tested the data for unit root. We used commonly used unit root tests for time series and panel data. We estimated a variety of specifications (constant, time trend, etc) and examined a variety of lag structures using different Information Criteria. We could not reject the hypothesis that the data have unit roots. We estimated the production function in equation 2 (without a lagged dependent variable) and tested the residuals for unit root using a variety of unit root tests. We rejected the unit root hypothesis. We concluded that the variables are probably cointegrated, hence a log-level regression of the sort we report produces super-consistent parameters. All results are available upon request.

[3] University, vocational and high school qualifications are correlated. The correlation is weak. Although it is not quite obvious why, but the correlation between vocational and university qualification is strongest. We re-run the regressions by dropping the share of university qualification. We still find the share of vocational qualification insignificant.

each i industry respectively. For the long run, the $\hat{\gamma}$'s are replaced with the long-run elasticity $\hat{\gamma}/(1-\hat{\rho})$. We calculate the average-returns by industry assuming $\hat{\gamma}$ is the constant across industries.[4] We report the averages of vocational and university qualifications only because the rest are effectively zero.

The results are in table 2.[5] There are several observations. First, the returns to vocational qualifications are everywhere smaller than those to university qualifications. Second, the returns vary considerably across industries. Third, intuitively, the long-run returns to university qualification are relatively higher in industries that lack these kinds of qualifications and skills such as Agriculture, Construction, and Transport.[6]

On average over all industries, the short-run return to vocational qualifications is 2.0 to 2.6 percent compared with 26.6- 44.3 percent to a university qualification. The long-run return to vocational qualification is 6 to 8.2 percent compared with 84.2 – 137.4 percent to university qualification.

Then, we re-estimate the production function by replacing $\tilde{L}_{1,it} \ldots \tilde{L}_{4,it}$ with $\tilde{Z}_{1,it} \ldots \tilde{Z}_{4,it}$, where $\tilde{Z}$ is the product of $\tilde{L}$ with the stock of private R&D for each type of qualification by industry. Results are reported in table 3. We also found the coefficient of the product of private R&D and university qualification to be the only significant coefficient among all types of qualifications.

4. Summary and policy discussion

We estimate the effect of education on GDP per capita in New Zealand and the social rate of return using a panel of 7 industries over the period 1986 - 2005. We found that an increase in the share of university-qualified workers in employment is highly positively correlated with average GDP per person, thus the whole economy benefits from increasing the share of university-qualified workers. We also found that the product of *private* R&D stock with university-qualified labour has a positive effect on GDP per capita. We believe that our results are consistent with the 'endogenous' skill-biased technical change models, Acemoglu (1998), and with Nelson and Phelps (1966). We hope that our evidence would be useful for policy design, where a higher share of university qualified workers is good for New Zealand.

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[4] It is quite plausible that the coefficients vary across industries. We do not allow for that because we have a relatively small sample size.

[5] We report the GMM estimates of vocational qualifications even though the estimated coefficient was statistically insignificant.

[6] It is well documented in the literature that the private rate of return to education is smaller than the social rate of return.

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Table 1: The production function estimate regression

$y_{it} - l_{it} = a + \rho(y_{i,t-1} - l_{i,t-1}) + \alpha(k_{it} - l_{it}) + \delta l_{it} + \gamma_1(\tilde{l}_{1,it} - l_{it}) + \gamma_2(\tilde{l}_{2,it} - l_{it}) + \gamma_3(\tilde{l}_{3,it} - l_{it}) + \gamma_4(\tilde{l}_{4,it} - l_{it}) + \varepsilon_{it}$ and $\varepsilon_{it} = v_i + u_{it}$

Cross-section weights and white cross-section standard errors and covariance – degree-of-freedom correction

	EGLS		GMM-EGLS*	
	Sample 1988-2005		Sample 1991-2005	
	Estimate	P-value	Estimate	P-value
ρ	0.69	0.0000	0.67	0.0000
α	0.11	0.0000	0.14	0.0535
δ	-0.19	0.0000	-0.34	0.0000
γ_1	0.007	0.7799	-0.12	0.0503
γ_2	-0.06	0.0215	-0.06	0.0721
γ_3	0.05	0.1204	0.04	0.5539
γ_4	0.06	0.0000	0.10	0.0004
Weighted Stats				
$\bar{R}^2$	0.99		0.99	
$Jarque - Bera\ P value$ $(\text{Re} siduals\ Normaility)$	0.9535		0.3229	
$s.e.$	0.03		0.03	
$J - p\ value$	-	-	0.9900	

y is ln real GDP, l is ln labour, k is ln capital, $\tilde{l}_1$ is ln employed workers with no qualification, $\tilde{l}_2$ is ln employed workers with school, $\tilde{l}_3$ is ln vocational qualifications, and $\tilde{l}_4$ is ln employed workers with university qualification.

* The instruments are a constant, trend and 4 lags of the explanatory variables.

**We don't report the constant and trend to save space.

Table 2: Average Annual Percentage Returns to Qualification over 1986-2005

	EGLS				GMM-EGLS			
	Vocational		University		Vocational*		University	
Industry	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
1	5.5	17.7	52.3	165.5	4.4	13.3	87.1	270.0
2	1.2	3.8	9.8	31.0	0.9	2.9	16.3	50.6
3	3.7	11.9	75.9	240.5	2.9	8.9	126.6	392.4
4	1.3	4.2	10.7	33.9	1.0	3.1	17.8	55.4
5	3.2	10.3	30.2	95.8	2.6	7.7	50.4	156.4
6	2.4	7.7	5.3	16.8	1.9	5.8	8.8	27.5
7	0.6	2.0	1.76	5.60	0.5	1.5	2.9	9.1
All	2.6	8.2	26.6	84.1	2.0	6.2	44.3	137.4

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* The long run coefficient is not significant

Table 3: The production function estimate regression

$y_{it} - l_{it} = a + \rho(y_{i,t-1} - l_{i,t-1}) + \alpha(k_{it} - l_{it}) + \delta l_{it} + \gamma_1(\tilde{z}_{1,it} - l_{it}) + \gamma_2(\tilde{z}_{2,it} - l_{it}) + \gamma_3(\tilde{z}_{3,it} - l_{it}) + \gamma_4(\tilde{z}_{4,it} - l_{it}) + \xi_{it}$ and $\xi_{it} = e_i + u_{it}$

Cross-section weights and white cross-section standard errors and covariance – degree-of-freedom correction

	EGLS		GMM-EGLS*	
	Sample 1988-2005		Sample 1991-2005	
	Estimate	P-value	Estimate	P-value
ρ	0.65	0.0000	0.47	0.0000
α	0.17	0.0000	0.17	0.0001
δ	-0.19	0.0000	-0.35	0.0000
γ_1	0.0009	0.9735	-0.16	0.1560
γ_2	0.01	0.5786	0.02	0.6443
γ_3	0.0006	0.9812	0.12	0.2866
γ_4	0.04	0.0001	0.08	0.0055
Weighted Stats				
$\bar{R}^2$	0.99		0.99	
$Jarque - Bera\ P value$	0.8116		0.8139	
$(Residuals\ Normaility)$				
$s.e.$	0.03			
$J - p\ value$	-	-	0.9900	

y is ln real GDP, l is ln labour, k is ln capital, $\tilde{z}_1$ is ln (employed workers with no qualification*R&D), $\tilde{z}_2$ is ln (employed workers with school * R&D), $\tilde{z}_3$ is ln (vocational qualifications*R&D), and $\tilde{z}_4$ is ln (employed workers with university qualification*R&D).

* The instruments are a constant, trend and 4 lags of the explanatory variables.
**We don't report the constant and trend to save space.