NEW ZEALAND
WORK RESEARCH INSTITUTE

Labour market returns to literacy, numeracy, and problem solving in New Zealand

November 12, 2020

Christopher Erwin
Lisa Meehan

AUT
RESEARCH & INNOVATION

Disclaimer

The results in this paper are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI) managed by Statistics New Zealand.

The opinions, findings, recommendations and conclusions expressed in this paper are those of the author(s) not Statistics NZ.

Access to the anonymised data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business or organisation and the results in this [report, paper] have been confidentialised to protect these groups from identification.

Careful consideration has been given to the privacy, security and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.

The results are based in part on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes.

Any person who has had access to the unit-record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

Motivation

- In labour economics, there is a long history of studying the returns to human capital
  - How does work experience affect wages? How do years of schooling affect wages? How does degree receipt affect wages?
- However, many economists question traditional estimates on the labour market returns to human capital
  - Three reasons why…

Motivation

- Three reasons why…

1. We know there are many unobservable factors that affect both wages and schooling
    - E.g., unobserved ability, motivation, parental support/encouragement, career preferences, etc.
    - This would lead to biased and inconsistent results

Motivation

- Three reasons why…

2. Years of schooling may simply reflect underlying cognitive skills such as literacy, numeracy, and problem solving
    - For example, you aren't likely to get very far in school if you cannot read
    - If we include measures of cognitive skills in our regression equations, will years of schooling still have an effect on earnings?

Motivation

- Three reasons why…

3. Many rely on estimates from early-career workers in the U.S., although returns to skills are important throughout the lifecycle

    - Literacy is literacy, regardless of age

    - New Zealand is big on skilled immigration, so the landscape may be quite different from the U.S.

Motivation

- Survey of Adult Skills (PIAAC) to the rescue!
  - The PIAAC offers a representative sample of literacy, numeracy, and problem-solving skills for 39 countries between 2011 and 2018
  - Data are collected for individuals aged 16-65, so returns across the lifecycle can be analysed
  - PIAAC allows researchers to augment the standard returns to schooling equation with measures of underlying cognitive skills

Research Questions

1. What are the labour market returns to literacy, numeracy, and problem-solving skills in NZ?

2. Can we distinguish between labour market returns to work experience, degree receipt, and cognitive skills? In other words, is it only the underlying skills that matter?

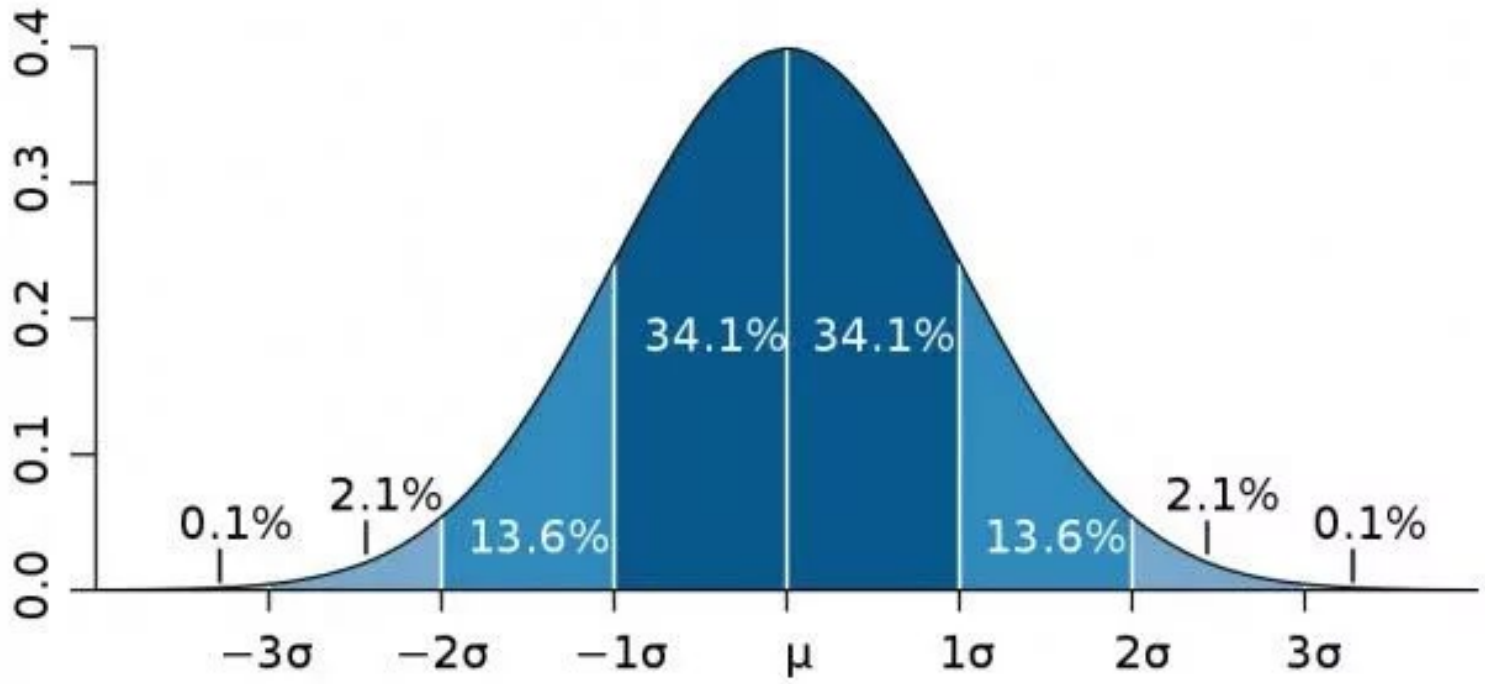
3. How do returns in NZ vary across the lifecycle? Are returns different for various groups?

Literature

- For brevity, we focus on the methods and findings of Hanushek *et al*. (2015)
  - We apply their approach to NZ data and compare to Australia, the U.K., the U.S., and the 1st round PIAAC pooled average
  - Hanushek et al. (2015)
    - Uses the first round of PIAAC data collected in 2011-2012 (24 countries)
    - Returns to literacy and numeracy are very similar
    - Returns range from 12.1% (Sweden) to 27.9% (U.S.)
      - Interpreted as the percent increase in wages for a one standard deviation unit increase in PIAAC numeracy score

Literature

- Recall the bell curve and standard deviation units…



Literature

- Other findings from Hanushek *et al*. (2015):
  - Returns appear to be lowest in countries with higher union density, stricter employment protections, and larger public-sector shares
  - On average, returns to skill increase with age until the early 40s, and decline thereafter
  - Returns are higher for men, those with more educated parents, private sector workers, natives, and full-time workers

Empirical Model

- Based on the pioneering work of Jacob Mincer (1974)
  - First economist to rigorously study the returns to schooling
- A simple Mincerian earnings function predicts wages as a function of years of work experience and years of schooling

(1) $$ln(w_i) = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 s_i + \varepsilon_i$$

  - Where w_i is typically measured as individual *i*'s hourly wage, *x* is years of work experience, and *s* is years of formal schooling

Empirical Model

(1) $$ln(w_i) = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 s_i + \varepsilon_i$$

- ε_i is the error term, which contains all unobserved (or not controlled for) factors that determine an individuals wages
  - E.g., motivation, unobserved ability, dedication, etc.
- Note that estimated coefficients are interpreted as the % change in wages for a one-unit increase in the in the righthand side variable
  - So if $\widehat{\beta_3} = .065$, then every additional year of schooling increases wages by 6.5% on average (this is true of literature in the U.S.)

Empirical Model

(1) $$ln(w_i) = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 s_i + \varepsilon_i$$

- We estimate different iterations of equation (1) including other controls such as sex and ethnicity

- We also run equation (1) for various subgroups, including by:

  - Age category
  - Men and women
  - Full-time and part-time workers
  - Immigrants and native workers
  - Public and private sector employees
  - Low, medium, and high parent education

Data

- New Zealand PIAAC data
  - From round 2 (9 countries) from 2014-2015
  - Restricted use files from the Ministry of Education
- 6,177 total observations, but most models use many fewer
  - Employed
  - Wage data, work experience, and years of schooling reported
  - Prime working age (35-54)
- We classify workers as early working age (16-34), prime working age (35-54), and exit working age (55-65)

Data

- For regressions, skill scores are standardised (score – average score / standard deviation)
  - This makes interpretation easier when examining regression results
    - Estimated coefficients are interpreted in terms of standard deviation units

Data

Table 1. Descriptive statistics

Variables	NZ Mean (SD)	AUS Mean (SD)	U.K Mean (SD)	U.S. Mean (SD)	Round 1 Pooled Mean (SD)
Hourly wage (PPP)	48.1 (1,055.1)				
Literacy	286.3 (47.2)				
Numeracy	279.3 (53.3)	283.8 (51.2)	274.0 (51.9)	266.0 (54.7)	279.1 (49.8)
Problem solving in technology-rich environments	286.4 (45.3)				
Years of schooling	14.2 (2.6)	15.0 (2.5)	13.2 (2.3)	14.3 (2.9)	13.4 (2.9)
Experience	23.5 (8.0)	24.1 (7.7)	24.5 (7.4)	24.0 (8.1)	22.3 (7.8)
Female	.42	.34	.39	.50	.43
White	.68				
Maori	.13				
Pasifika	.06				
Asian	.13				
MELAA	.01				
Other	< .01				
Observations	1,218	1,433	1,786	1,105	35,854

Notes: Standard deviation shown in parentheses. Statistics for Australia (AUS), the United Kingdom (U.K.), and the United States (U.S.) are taken from Hanushek *et al.* (2015). The authors only report estimates from the returns to numeracy, so literacy and problem scores are omitted for these countries above. PPP denoted purchasing power parity dollars.

Results

Table 2. Basic Mincer equation results, no years of schooling

Variables	Estimate (SE)	Estimate (SE)	Estimate (SE)
Literacy	.20*** (.02)		
Numeracy		.19*** (.02)	
Problem Solving			.16*** (.02)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)
Observations	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively.

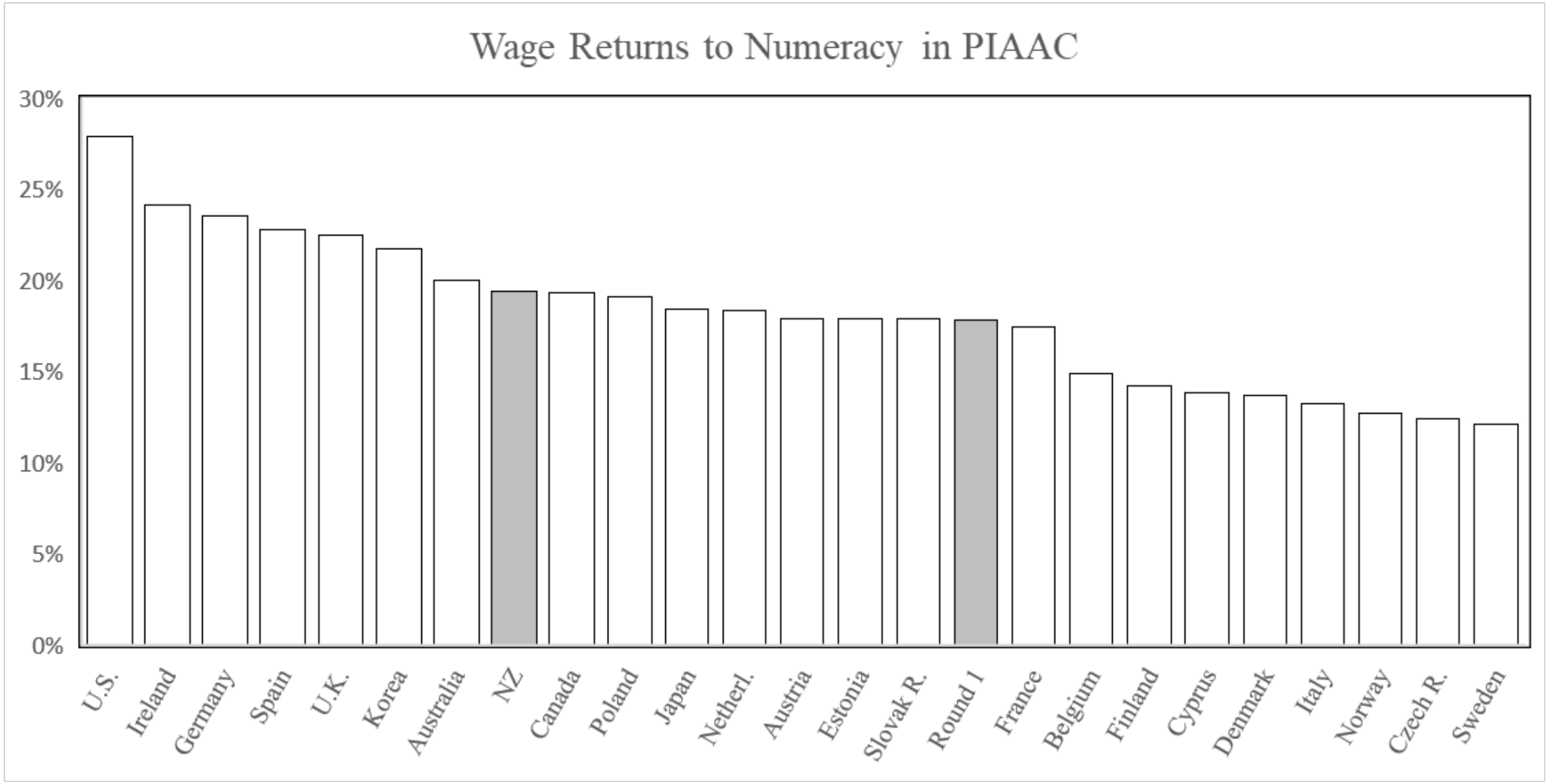
Results

Table 3. Basic Mincer equation results, numeracy

Variables	NZ Estimate (SE)	AUS Estimate (SE)	U.K. Estimate (SE)	U.S. Estimate (SE)	Round 1 Pooled Estimate (SE)
Numeracy	.19*** (.02)	.20*** (.01)	.23*** (.01)	.28*** (.02)	.18*** (< .01)
Experience	.018*** (.01)	.009 (.01)	.000 (.01)	.018*** (.01)	.022*** (.001)
Experience^2	-.0002** (.0001)	-.014 (.02)	-.002 (.018)	-.035** (.018)	-.040*** (.003)
Female	-.10*** (.03)	-.13*** (.03)	-.08*** (.02)	-.18*** (.03)	-.15*** (.01)
Observations	1,218	1,433	1,786	1,105	35,854

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively.

Results


Wage Returns to Numeracy in PIAAC
30%
25%
20%
15%
10%
5%
0%
U.S.
Ireland
Germany
Spain
U.K.
Korea
Australia
NZ
Canada
Poland
Japan
Netherl.
Austria
Estonia
Slovak R.
Round 1
France
Belgium
Finland
Cyprus
Denmark
Italy
Norway
Czech R.
Sweden

Results

- Now let’s add to our simple models:
  - Years of schooling
  - Ethnicity
  - Whether non-English was the primary language spoken at home

Table 4. Mincer equation results, literacy

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)
Literacy	.200*** (.022)	.147*** (.032)	.136*** (.039)	.136*** (.035)
Experience	.018*** (.006)	.031*** (.006)	.028*** (.006)	.027*** (.006)
Experience^2	-.002** (.0001)	-.557*** (.125)	-.522*** (.122)	-.503*** (.121)
Female	-.141*** (.028)	-.152*** (.038)	-.152*** (.037)	-.153*** (.037)
Schooling		.069*** (.008)	.074*** (.009)	.075*** (.009)
Maori			-.037 (.063)	-.039 (.063)
Pacific			.071 (.077)	.089 (.073)
Asian			-.146*** (.054)	-.116** (.054)
MELAA			.025 (.290)	.030 (.287)
Other			-.159* (.092)	-.161* (.091)
Other language at home				-.053 (.042)
Observations	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively.

Table 5. Mincer equation results, numeracy

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)
Numeracy	.194*** (.022)	.127*** (.019)	.116*** (.021)	.116*** (.021)
Experience	.018*** (.006)	.034*** (.006)	.030*** (.006)	.029*** (.006)
Experience^2	-.0002** (.0001)	-.617*** (.129)	-.564*** (.127)	-.545*** (.127)
Female	-.096*** (.030)	-.122*** (.039)	-.125*** (.039)	-.126*** (.038)
Schooling		.072*** (.010)	.078*** (.011)	.079*** (.011)
Maori			-.028 (.056)	-.028 (.059)
Pacific			.059 (.058)	.079 (.057)
Asian			-.188*** (.043)	-.155*** (.049)
MELAA			-.001 (.289)	.003 (.286)
Other			-.153 (.124)	-.155 (.123)
Other language at home				-.057 (.040)
Observations	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively.

Table 6. Mincer equation results, problem solving

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)
Problem solving	.159*** (.022)	.112*** (.031)	.096*** (.035)	.095*** (.035)
Experience	.023*** (.005)	.035*** (.007)	.031*** (.006)	.030*** (.006)
Experience^2	-.0003** (.0001)	-.613*** (.135)	-.556*** (.129)	-.542*** (.128)
Female	-.148*** (.030)	-.159*** (.041)	-.159*** (.040)	-.160*** (.040)
Schooling		.078*** (.010)	.084*** (.011)	.084*** (.011)
Maori			-.037 (.064)	-.039 (.065)
Pacific			.011 (.066)	.020 (.064)
Asian			-.175*** (.054)	-.153*** (.057)
MELAA			.027 (.338)	.024 (.338)
Other			-.191 (.156)	-.191 (.153)
Other language at home				-.039 (.049)
Observations	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively.

Results

- Now let’s consider which cognitive skills matter most in terms of wages…

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

Table 7. Returns to skills, literacy, combining alternative skill measures

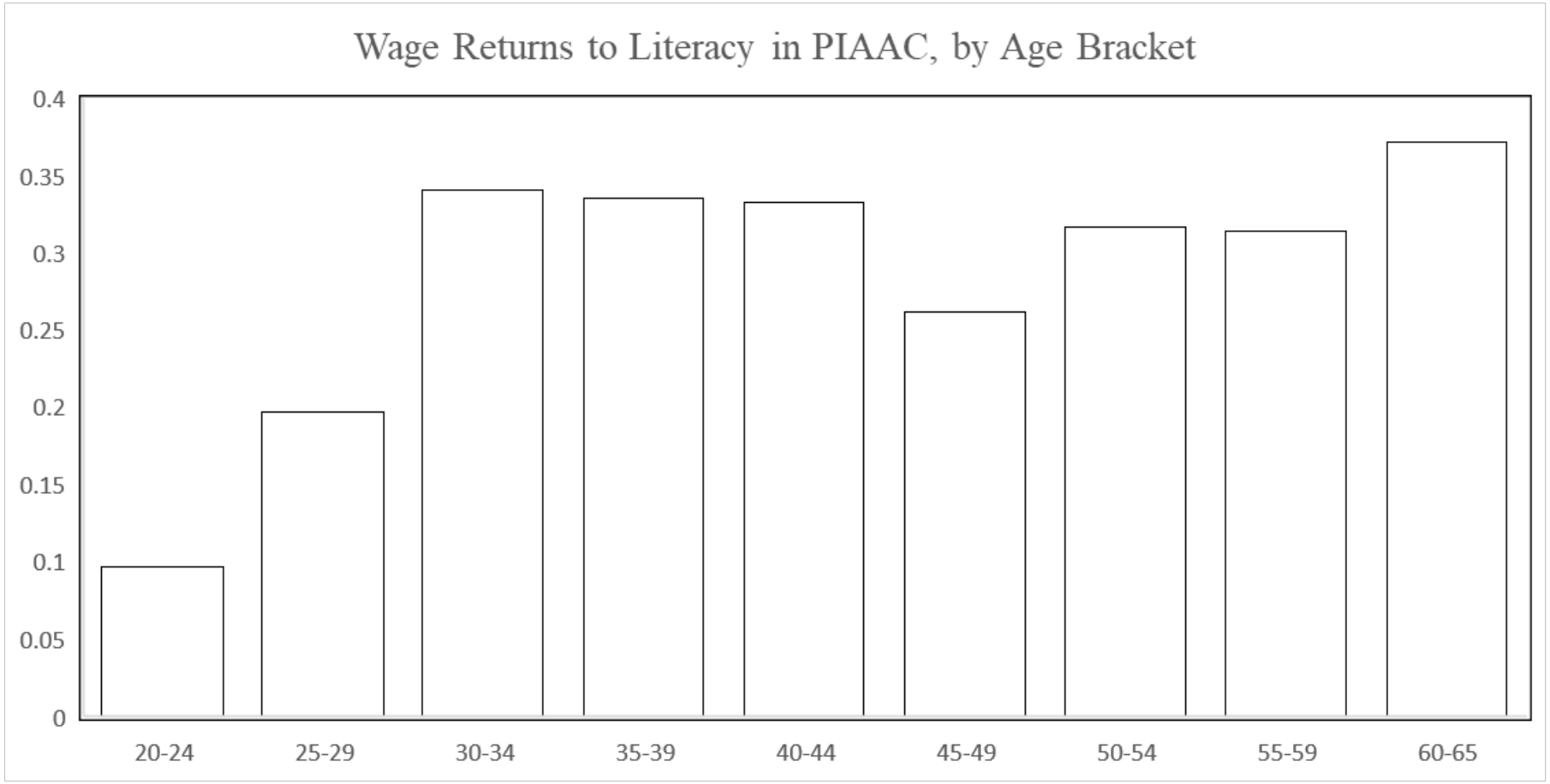
Variables	(1) Estimate (SE)	(2) Estimate (SE)	(3) Estimate (SE)	(4) Estimate (SE)	(5) Estimate (SE)	(6) Estimate (SE)	(7) Estimate (SE)
Literacy	.200*** (.02)			.129** (.064)	.210** (.046)		.163** (.074)
Numeracy		.19*** (.02)		.082 (.066)		.170*** (.035)	.069 (.064)
Problem Solving			.16*** (.02)		-.011 (.041)	.030 (.041)	-.026 (.064)
Experience	.018*** (.01)	.018*** (.01)	.023*** (.01)	.018*** (.006)	.020*** (.006)	.021*** (.005)	.020*** (.006)
Experience^2	-.0002** (.0001)	-.0002** (.0001)	-.0003** (.0001)	-.0002*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)	-.0003*** (.0001)
Female	-.14*** (.03)	-.10*** (.03)	-.15*** (.03)	-.122*** (.026)	-.147*** (.030)	-.104*** (.030)	-.130*** (.028)
Observations	1,218	1,218	1,218	1,218	1,218	1,218	1,218

Notes: Dependent variables are standardized cognitive skill scores. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the one, five, and ten percent-levels, respectively. The sample is limited to prime age workers (35-54) who are working at the time of the survey.

Results

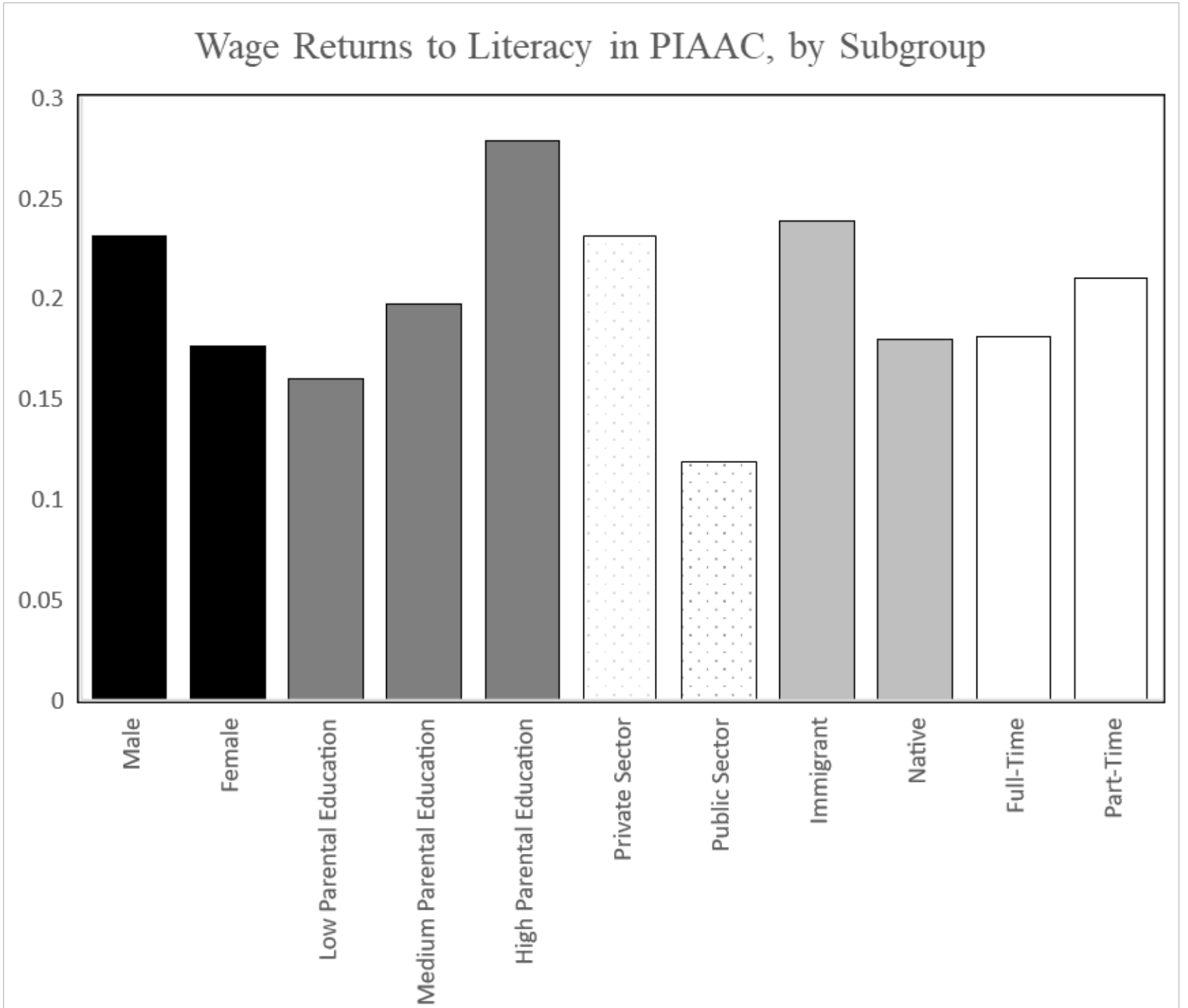
- Now let’s consider how effects differ over the lifecycle…

Results


Wage Returns to Literacy in PIAAC, by Age Bracket
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-65

Results

- Now let’s consider how effects differences by subgroup…


Wage Returns to Literacy in PIAAC, by Subgroup
0.3
0.25
0.2
0.15
0.1
0.05
0
Male
Female
Low Parental Education
Medium Parental Education
High Parental Education
Private Sector
Public Sector
Immigrant
Native
Full-Time
Part-Time

Conclusions

- Revisiting our research questions…

1. A one standard deviation unit increase to literacy is estimated to increase wages by between 13-15%

   For numeracy the increase is 11-13%

   For problem solving the increase is 9-11%

   Returns to skills in New Zealand are well above the average for the 24 round 1 PIAAC countries

Conclusions

- Revisiting our research questions…

2. There are separate and significant effects of both schooling and cognitive skills

   The effect of years of schooling on wages does not disappear after accounting for literacy, numeracy, and problem solving skills

   Each additional year of schooling is estimated to increase wages by 7-8%

Conclusions

- Revisiting our research questions…

3. Returns to skill in NZ increases rapidly with age, levelling off in the early 30s

   Returns do not decline at older ages, as is the case in many other countries

   Returns are higher for men, those whose parents are more educated, immigrants, private sector workers, and part-time workers

Conclusions

- Literacy and numeracy are highly correlated
  - However, results suggest that literacy in NZ is a larger determinant of earnings than numeracy or problem solving
- This makes sense, as math is just shorthand for typical verbal communication (almost like a second language)
  - Consider how we teach children basic mathematics:

    $3 + 5 = 8$

  - Literacy as a bridge to numeracy

Conclusions

- There are still concerns that unobservables are confounding the analysis (e.g., motivation, persistence, unobserved ability, etc.)
- Future work will use instrumental variables (IV) methods to directly confront this issue
- Results not expected to fundamentally change
  - Estimates more likely to increase in magnitude

NEW ZEALAND
WORK RESEARCH INSTITUTE

Thank you

Questions?

AUT
RESEARCH & INNOVATION