The Persistence of Early Childhood Maturity: International Evidence of Long-Run Age Effects

Kelly Bedard
Elizabeth Dhuey

Department of Economics
University of California, Santa Barbara

Why might relative age be important?

(1) Age at school entry interacts with the educational structure – school readiness, in-class program placement, streaming

(2) Educational structures may propagate relative age effects long after small age differences matter in and of themselves

(3) If relative age effects persist, they have long-run implications for:

- Skill accumulation and distribution of skills
- Educational attainment
- Labor market outcomes

What do we know about relative age effects?

Economics: Allen and Barnsley (1993), Datar (2003), Fredriksson and Öckert (2004), Puhani and Weber (2005)

Education: Morrison et al. (1997), Alton and Massey (1998), Crone and Whitehurst (1999), McClelland et al. (2000), Stipek and Byler (2001), and Strom (2004)

A Simple Model of Relative Age Effects and Education

Additive Human Capital Accumulation

Two age groups:	Old (*O*) and Young (*Y*)
Innate ability:	$\theta \sim N(\mu, \sigma^2)$
Maturity at time t:	$A(t)$ where $A(t) \geq A(t+1)$
School entry:	in period *k* (kindergarten)
Human Capital:	*H* units per school year

Observed skill, *X*, at age *t* for individual *i* is:

$$X_{Yti} = \theta_i + \sum_{j=1}^{t} A(j) + (t-k)H \quad \forall Y \quad \text{and}$$

$$X_{Oti} = \theta_i + \sum_{j=1}^{t+1} A(j) + (t-k)H \quad \forall O$$

Average observable skills are:

$$\bar{X}_{Yt} = \mu + \sum_{j=1}^{t} A(j) + (t-k)H \quad \text{and} \quad \bar{X}_{Ot} = \mu + \sum_{j=1}^{t+1} A(j) + (t-k)H$$

And, the mean skill difference is:

$$\bar{X}_{Ot} - \bar{X}_{Yt} = A(t+1)$$

Stream Placement (beginning in period *s*)

The L students with the lowest X's enter the lower stream:

$$F(m_Y) + F(m_O) = L$$

where F( ) is a cumulative normal and m_Y and m_O are innate ability levels of the marginal young and old students

Since the cut-off people must have identical X's:

$$m_Y = m_O + A(s+1)$$

With faster per period HC accumulation in the upper stream, $H_U > H_L$, and permanent stream placement:

$$E(X_{Os+n}) - E(X_{Ys+n}) = A(s+n+1) + n(H_U - H_L)[F(m_Y) - F(m_O)]$$

where n is the number of post-stream periods

Multiplicative Human Capital

We began with additive HC accumulation because it isolates the impact of the concave aging function and highlights the interaction between early skill-based program placement and relative maturity

However, it might seem that HC accumulation might alternatively be described by a multiplication function: Student skill augmentation depends on the current skill base

In this case, HC accumulation is faster for those who begin with more skills even though we continue to assume a common HC accumulation factor, $H > 1$

Observed skill at age *t* for individual *i* is:

$$X_{Yti} = [\theta_i + \sum_{j=1}^{k} A(j)]H^{t-k} + \sum_{j=k+1}^{t} A(j)H^{t-j} \quad \forall Y$$

and

$$X_{Oti} = [\theta_i + \sum_{j=1}^{k+1} A(j)]H^{t-k} + \sum_{j=k+1}^{t} A(j+1)H^{t-j} \quad \forall O$$

And, the average observable skill differential is:

$$\bar{X}_{Ot} - \bar{X}_{Yt} = A(k+1)H^{t-k} + \sum_{j=k+1}^{t} [A(j+1) - A(j)]H^{t-j}$$

Main Data Source

Trends in International Mathematics and Science Study (TIMSS) 1995 & 1999 Microdata samples

- Math and science tests
- Two test grades
- Within country or internationally standardized
- Limited background controls

Supplementary Sources

The Early Childhood Longitudinal Study (ECLS)

- used to examine the impact of relative age on third grade test scores

National Education Longitudinal Study

- used to examine the impact of relative age on eighth grade test scores
- used to examine the persistence of relative age effects as measured by school and college eligibility / attendance

Longitudinal Education Data from British Columbia

- used to examine the persistence of relative age effects as measured by college eligibility

School Starting Age Rules

	School Start Date
Austria	January 1
Belgium	January 1
Canada	January 1
Czech Republic	September 1
Denmark	January 1
England	September 1
Finland	January 1
France	January 1
Greece	April 1
Iceland	January 1
Italy	January 1
Japan	April 1
New Zealand	May 1
Norway	January 1
Portugal	January 1
Slovak Republic	September 1
Spain	January 1
Sweden	January 1

Empirical Framework

We begin with a simple model of the relationship between student performance and observed age:

$$S_{cgi} = \alpha_{cg} + \beta_{cg} A_{cgi} + X_{cgi}\gamma_{cg} + \varepsilon_{cgi}$$

c denotes country	A is observed age in months
g denotes grade	X is a vector of controls
i denotes individual	ε is the usual error term

⇒ All models are estimated separately for each grade level and country

⇒ The parameter of interest is β_{cg} – the causal impact of relative age

⇒ However, the causal interpretation rests on the assumption that unobservables do not confound the relative age effect, which is clearly untrue given non-random grade retention (failure)

Instrumental Variables

We propose an IV solution using birth month relative to the school cut-off date (assigned relative age) as an exogenous determinant of observed age

First Stage: $A_{cgi} = \pi_{1cg} + \pi_{2cg} R_{cgi} + X_{cgi} \pi_{3cg} + v_{cgi}$

(1) Since a vast majority of students enter school on-time and are not retained in any grade observed age and assigned age are clearly correlated (the F-statistics for the FS range from 189-125,577)

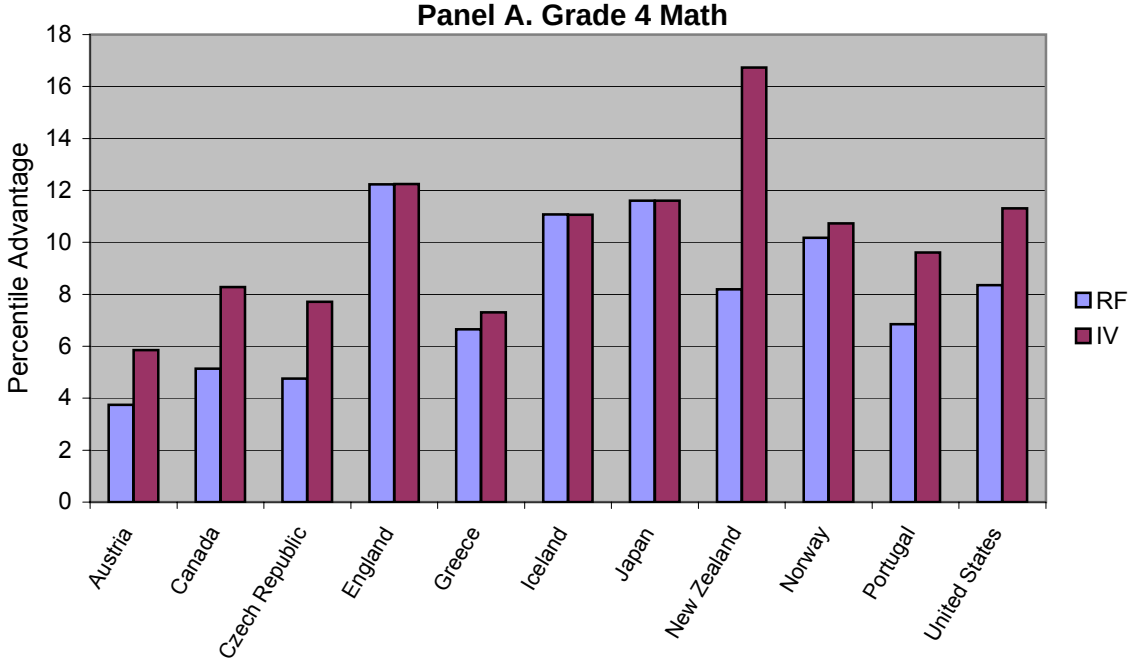
(2) Assigned relative age influences test scores only through its affect on observed age. This assumption is violated if, for example, children born at different times of the year have higher or lower unobserved ability levels.

Reduced Form: $S_{cgi} = \theta_{1cg} + \theta_{2cg} R_{cgi} + X_{cgi} \theta_{3cg} + u_{cgi}$

θ_{2cg} is the overall or reduced form impact of assigned age on test scores at a given grade level g. In other words, it is the impact net of grade repetition and late entry.

Figure I
Percentile Advantage of Oldest Versus Youngest

Panel A. Grade 4 Math



Panel B. Grade 8 Math