1 Introduction

In many countries, demographic changes such as fluctuations in cohort size and child dependency ratios pose significant challenges for education systems. As the number of school-aged children increases or decreases, educational resources such as teacher-student ratios, classroom sizes, and public funding become strained or underutilized. These demographic pressures can influence the quality of education that individuals receive, ultimately affecting their ability to develop essential skills. Literacy and numeracy skills, in particular, are critical for workforce readiness and long-term economic productivity, making it essential to understand how demographic shifts affect educational outcomes.

This paper investigates the impact of cohort size and the average child dependency ratio during educational years on literacy and numeracy skills, using data from the Programme for the International Assessment of Adult Competencies (PIAAC). The analysis focuses on individuals born between 1955 and 1984 and includes controls for factors such as parental education, nativity, parental birthplace, as well as age and country fixed effects. The two main variables of interest are the logarithm of cohort size (*log cohort size*) and the average exposure to the child dependency ratio (*average exposed child dependency ratio*) during the years spent in education. Both cohort size and child dependency ratio are closely linked to a country's fertility levels, which affect the number of children in families and the number of children supported by the working-age population. At the micro level, families with more children may have fewer resources to allocate per child, reducing the quality of education that each child receives. At the macro level, a higher child dependency ratio means that fewer economic resources are available per child from the working-age population, limiting the public investment in education. These demographic pressures influence the quality of education both within families and across society, shaping long-term skill development.

Research consistently shows that cohort size and educational quality significantly impact labor market outcomes. Morin (2015) demonstrates that a sharp increase in labor supply—caused by the abolition of Grade 13 in Ontario—led to a measurable decline in earnings among high-school graduates. Similarly, Hu and Bollinger (2021) finds that an increase in the relative size of college graduates lowers the college earnings premium, particularly for younger workers. Demographic

cycles also affect educational choices; Falaris and Peters (1992) shows that individuals born during periods of increasing cohort size tend to acquire more education and take longer to complete it. Brunello (2010) further confirms that larger cohorts can depress earnings, particularly among older workers.

Educational quality also plays a crucial role in determining economic outcomes. Hanushek and Woessmann (2008), Lutz et al. (2019), and Burns et al. (2020) emphasize that cognitive skills—rather than years of schooling alone—are key drivers of both earnings and productivity. Égert et al. (2024) highlights that the quality of education often outweighs the quantity in fostering long-term productivity gains.

This paper builds on these insights by considering both macro-level (national) and micro-level (individual) factors in analyzing skills formation. At the macro level, variables such as GDP per capita and child dependency ratio affect the resources allocated to education, while at the micro level, these same factors can act as proxies for a family's economic well-being and their capacity to invest in a child's education. These resources, independent of the number of years spent in school, can significantly influence educational quality and thus, skill development.

To address potential biases from unobserved variables, such as country-specific wealth trends over time, I instrument the years of education variable with GDP per capita. This method accounts for macroeconomic conditions that influence cohort size and child dependency ratios, providing a more accurate assessment of their effects on skill development.

The purpose of this paper is to examine how cohort size and child dependency ratios during the years of education affect literacy and numeracy skills in adulthood. I hypothesize that larger cohort sizes and higher child dependency ratios negatively impact educational outcomes by stretching the available resources in education systems.

This study makes two main contributions. First, it extends the analysis of cohort size effects beyond labor market outcomes to focus on cognitive skills development. Second, it incorporates both macroeconomic and microeconomic factors (GDP per capita and child dependency ratio) as determinants of education quality. Using a unique dataset (PIAAC) and applying robust controls, this analysis provides new insights into how demographic and economic pressures shape long-term skill development.

2 Data and Variables

The dataset used in this analysis is from the Programme for the International Assessment of Adult Competencies (PIAAC), which focuses on individuals born between 1955 and 1984. This cohort was selected because individuals born in 1984 are expected to have largely completed their education. The dependent variables in the analysis are literacy and numeracy skills. The key independent variables are as follows:

- *LOG_COHORT_SIZE*: The logarithm of cohort size, sourced from UN Population data.
- *AVG_CD*: The average child dependency ratio during the individual's years of education, also sourced from UN Population data.
- *YRSQUAL*: The number of years of formal education completed by the individual, provided by PIAAC.
- *ADJ_YE*: GDP-adjusted years of education, which adjusts the quality of education based on the country's GDP per capita during the individual's years in school. GDP per capita data is obtained from the World Bank Indicators.

Control variables include various demographic characteristics, represented as X_i, which include:

- Parental Education (PARED), sourced from PIAAC.
- Nativity and language (BORNLANG), sourced from PIAAC.
- Parental place of birth (IMPAR), sourced from PIAAC.
- AGE and COUNTRY (included as dummy variables), sourced from PIAAC.

Both *YRSQUAL* and *ADJ_YE* are included to differentiate between the quantity and quality of education, allowing for a more comprehensive view of how educational attainment and the economic context during schooling impact skill development.

The analysis includes data from 20 countries. Some countries could not be included in the final analysis due to missing GDP per capita data, particularly for countries where GDP data was only available after 1990.

3 Methodology and Models

This study examines the impact of both cohort size and child dependency ratio on literacy and numeracy skills. While years of education is a standard measure of educational attainment, it does not fully account for the **quality of education** or the **socioeconomic conditions** individuals experienced during their schooling.

Both **cohort size** and **child dependency ratio** represent demographic pressures that influence educational outcomes, but each captures distinct aspects:

- *Cohort size* reflects the size of the individual's peer group and competition within the educational system, such as teacher-student ratios and class sizes.
- *Child dependency ratio* represents the broader economic context, showing how the working-age population supports the young, which in turn affects the resources available for education.

Including both measures allows for capturing the combined effect of educational and economic pressures on skill development.

Years of education alone do not capture differences in the **quality** of education or the **economic conditions** during schooling. Individuals with the same years of education may have experienced vastly different learning environments depending on the economic context. Therefore, relying solely on years of education may lead to biased estimates when comparing individuals from different socioeconomic backgrounds.

To address the issue of varying education quality, the *years of education* variable is adjusted by incorporating *GDP per capita* during the individual's schooling years. This adjustment provides a more accurate measure of the resources available to the education system and the economic context in which education occurred.

Model 1: Impact of Cohort Size

This model estimates the effect of cohort size on literacy and numeracy skills. The initial model, excluding years of education, is specified as:

$$Y_i = \beta_0 + \beta_1 \log(\text{COHORT\_SIZE}_i) + \gamma X_i + \epsilon_i$$

Next, *years of education (YE)* is included:

$$Y_i = \beta_0 + \beta_1 \log(\text{COHORT\_SIZE}_i) + \beta_2 \text{YE}_i + \gamma X_i + \epsilon_i$$

Finally, *YE* is replaced with *GDP-adjusted years of education (ADJ_YE)*:

$$Y_i = \beta_0 + \beta_1 \log(\text{COHORT\_SIZE}_i) + \beta_2 \text{ADJ\_YE}_i + \gamma X_i + \epsilon_i$$

Model 2: Impact of Child Dependency Ratio

The second model focuses on the effect of the average child dependency ratio during educational years. The initial model is:

$$Y_i = \beta_0 + \beta_1 \text{AVG\_CD}_i + \gamma X_i + \epsilon_i$$

Next, *years of education (YE)* is included:

$$Y_i = \beta_0 + \beta_1 \text{AVG\_CD}_i + \beta_2 \text{YE}_i + \gamma X_i + \epsilon_i$$

Finally, *YE* is adjusted using GDP per capita during the educational years:

$$Y_i = \beta_0 + \beta_1 \text{AVG\_CD}_i + \beta_2 \text{ADJ\_YE}_i + \gamma X_i + \epsilon_i$$

4 Results and Discussion

The results from the literacy and numeracy models reveal several key findings:

- When *Years of Education* is included in the model, *Cohort Size* and *Child Dependency Ratio* have a negative impact on literacy and numeracy, but these effects are relatively moderate.
- However, when the *GDP-Adjusted Years of Schooling* is used, the negative effects of both *Cohort Size* and *Child Dependency Ratio* increase significantly. This indicates that in contexts where the quality of education (captured by GDP per capita during the schooling years) is

factored in, demographic pressures like larger cohort sizes and higher child dependency ratios impose a stronger negative effect on educational outcomes.

- Control variables such as *Parental Education*, *Gender*, and *Nativity and Language* behave as expected. Higher parental education correlates with better literacy and numeracy scores, while women exhibit lower scores compared to men. Individuals who are native-born and speak the native language outperform those who are foreign-born or speak a foreign language.

	I	**II**	**III**	**IV**
Variable	**Model 1**	**Model 1**	**Model 2**	**Model 2**
Intercept	162.58***	177.7***	154.79***	121.64***
	(16.75)	(17.67)	(3.55)	(4.53)
Cohort Size (log)	-1.7	-6.36*		
	(3.07)	(3.19)		
Avg Child Dependency Ratio			-0.04	-0.95***
			(0.03)	(0.04)
Years of Schooling	4.96***		5.01***	
	(0.08)		(0.08)	
GDP Adjusted Years of Schooling		5.78***		11.36***
		(0.2)		(0.31)
Men *(Ref.)*				
Women	-2.52***	-3.41***	-2.52***	-3.27***
	(0.52)	(0.53)	(0.52)	(0.53)
Neither parent has attained upper secondary *(Ref.)*				
At least one parent has attained upper secondary	8.03***	16.43***	7.95***	14.15***
	(0.63)	(0.68)	(0.62)	(0.65)
At least one parent has attained tertiary	14.71***	29.52***	14.56***	26.41***
	(0.81)	(0.85)	(0.82)	(0.82)
Both parents foreign-born *(Ref.)*				
One parent foreign-born	13.14***	12.81***	13.1***	12.82***
	(1.98)	(2.08)	(1.97)	(2.01)
Both parents native-born	10.87***	10.33***	10.78***	9.67***
	(1.74)	(1.85)	(1.74)	(1.83)
Native-born and native-language *(Ref.)*				
Native-born and foreign-language	-17.89***	-20.15***	-18.14***	-21.25***
	(2.56)	(2.54)	(2.57)	(2.69)
Foreign-born and native-language	-10.53***	-11.54***	-10.57***	-11.82***
	(1.73)	(1.83)	(1.74)	(1.8)
Foreign-born and foreign-language	-28.43***	-31.84***	-28.43***	-31.47***
	(2.18)	(2.23)	(2.18)	(2.23)
Age	FE	FE	FE	FE
Country	FE	FE	FE	FE

Table 1: Literacy Skills:

Variable	I Model 1	II Model 1	III Model 2	IV Model 2
Intercept	142.2***	167.85***	137.21***	95.78***
	(19.73)	(20.67)	(4.07)	(5.44)
Cohort Size (log)	-2.1	-7.72*		
	(3.59)	(3.67)		
Avg Child Dependency Ratio			-0.19***	-1.33***
			(0.04)	(0.05)
Years of Schooling	6.01***		6.21***	
	(0.10)		(0.10)	
GDP Adjusted Years of Schooling		6.36***		14.14***
		(0.24)		(0.38)
Men *(Ref.)*				
Women	-13.23***	-14.34***	-13.23***	-14.15***
	(0.67)	(0.69)	(0.67)	(0.68)
Neither parent has attained upper secondary *(Ref.)*				
At least one parent has attained upper secondary	8.21***	18.66***	7.81***	15.48***
	(0.74)	(0.79)	(0.74)	(0.77)
At least one parent has attained tertiary	15.7***	34.01***	15***	29.67***
	(0.99)	(1.05)	(1)	(1.03)
Both parents foreign-born *(Ref.)*				
One parent foreign-born	15.13***	14.64***	15.01***	14.67***
	(2.26)	(2.34)	(2.24)	(2.25)
Both parents native-born	13.94***	13.14***	13.6***	12.23***
	(1.97)	(2.11)	(1.97)	(2.08)
Native-born and native-language *(Ref.)*				
Native-born and foreign-language	-17.72***	-21.22***	-18.91***	-22.76***
	(2.65)	(2.86)	(2.77)	(2.95)
Foreign-born and native-language	-9.51***	-10.85***	-9.69***	-11.25***
	(2.05)	(2.11)	(2.06)	(2.08)
Foreign-born and foreign-language	-26.51***	-30.82***	-26.56***	-30.32***
	(2.49)	(2.53)	(2.49)	(2.52)
Age	FE	FE	FE	FE
Country	FE	FE	FE	FE

Table 2: Numeracy Skills:

5 Conclusion

This study highlights the importance of both cohort size and child dependency ratio in shaping literacy and numeracy outcomes. While larger cohorts and higher dependency ratios negatively affect skill development, the inclusion of *GDP-Adjusted Years of Schooling* shows that the quality of education can mitigate these effects. Control variables such as parental education, gender, and nativity behave as expected, underscoring the significant influence of family background and

demographic factors on educational outcomes.

Overall, the results suggest that considering both the quantity and quality of education is crucial for understanding how demographic pressures influence skill development.

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Appendix

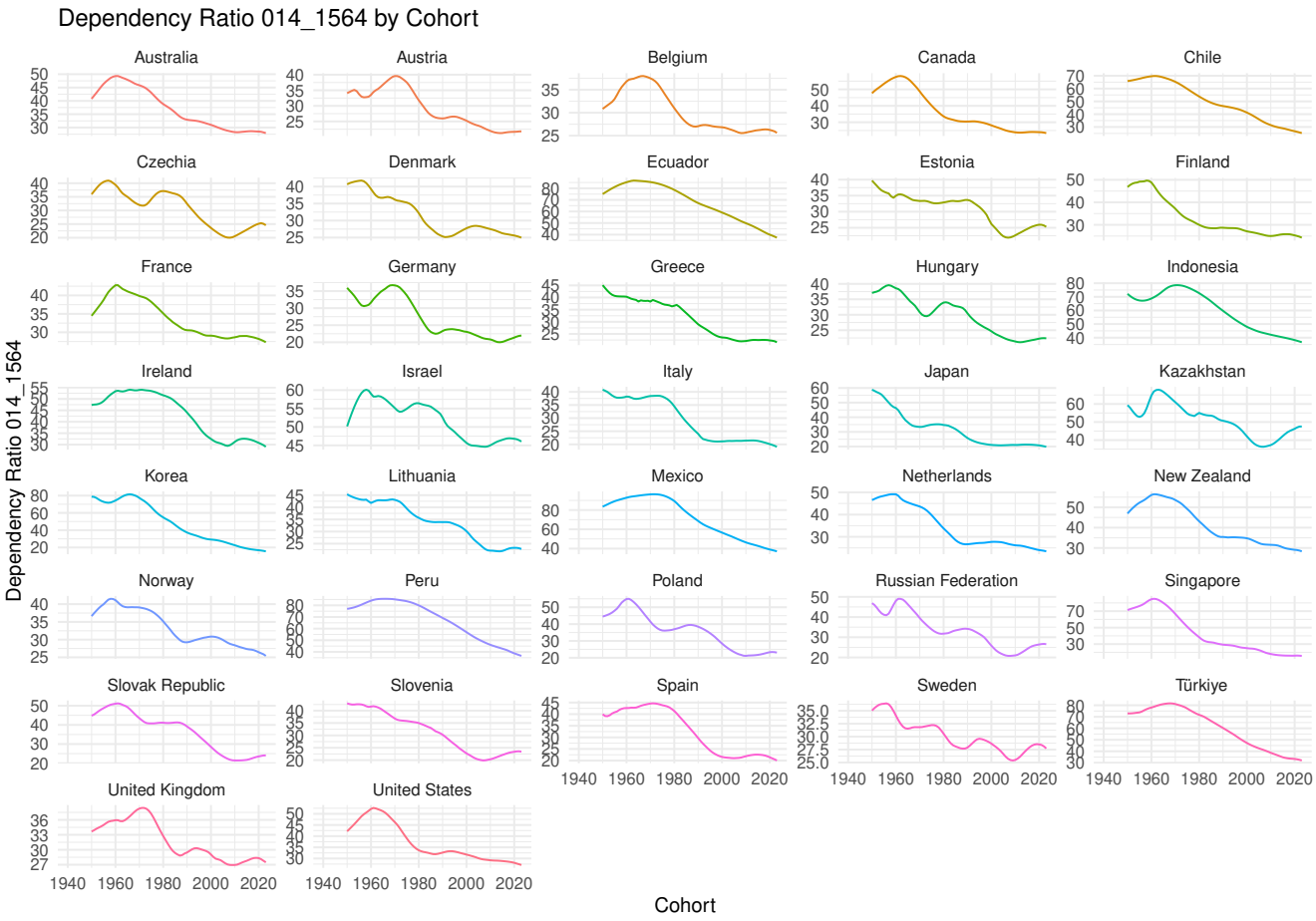

Figure 1: Dependency Ratio (Ages 0-14 to 15-64)
Source: UN Population Prospects

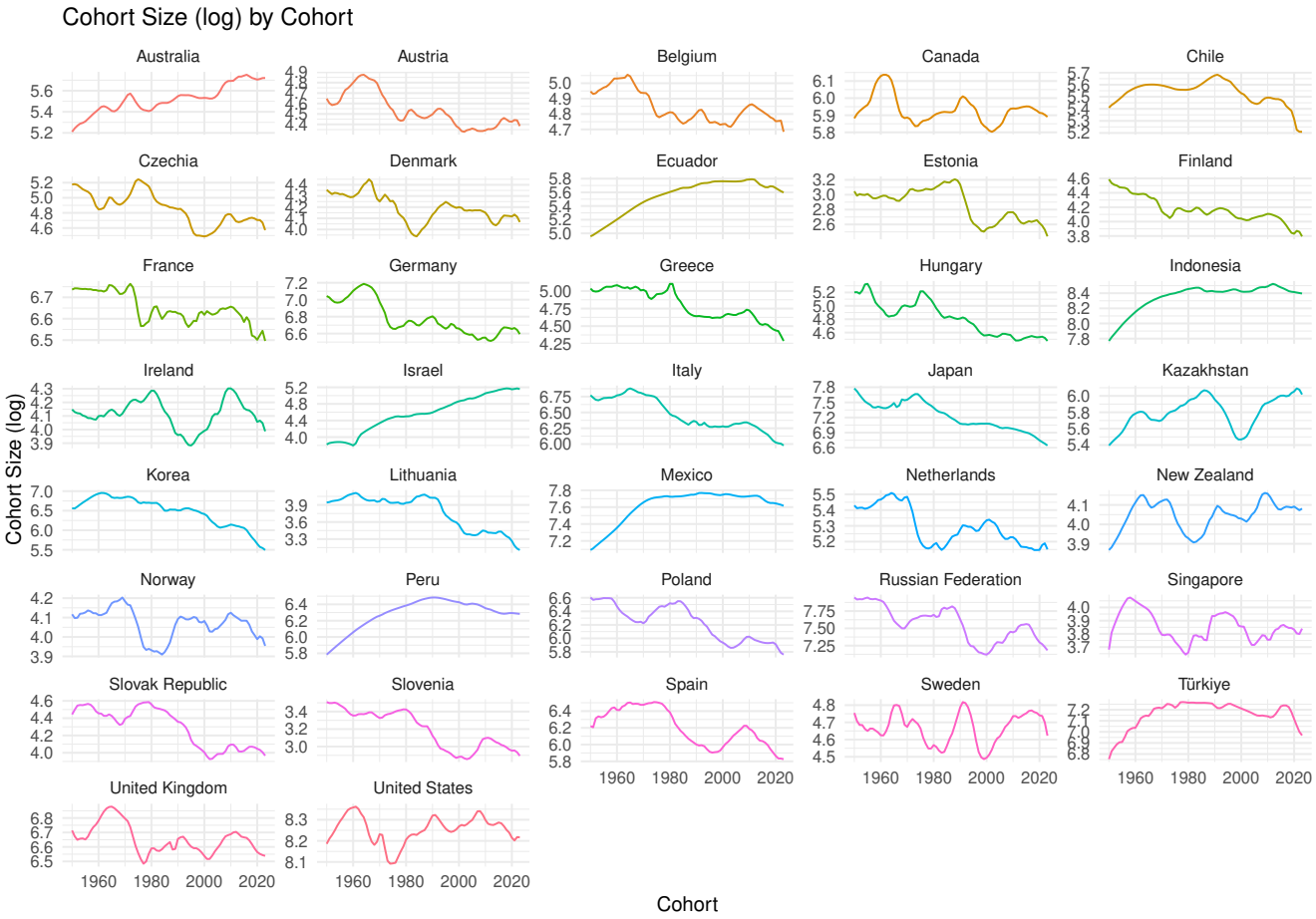

Figure 2: Cohort Size (log))
Source: UN Population Prospects

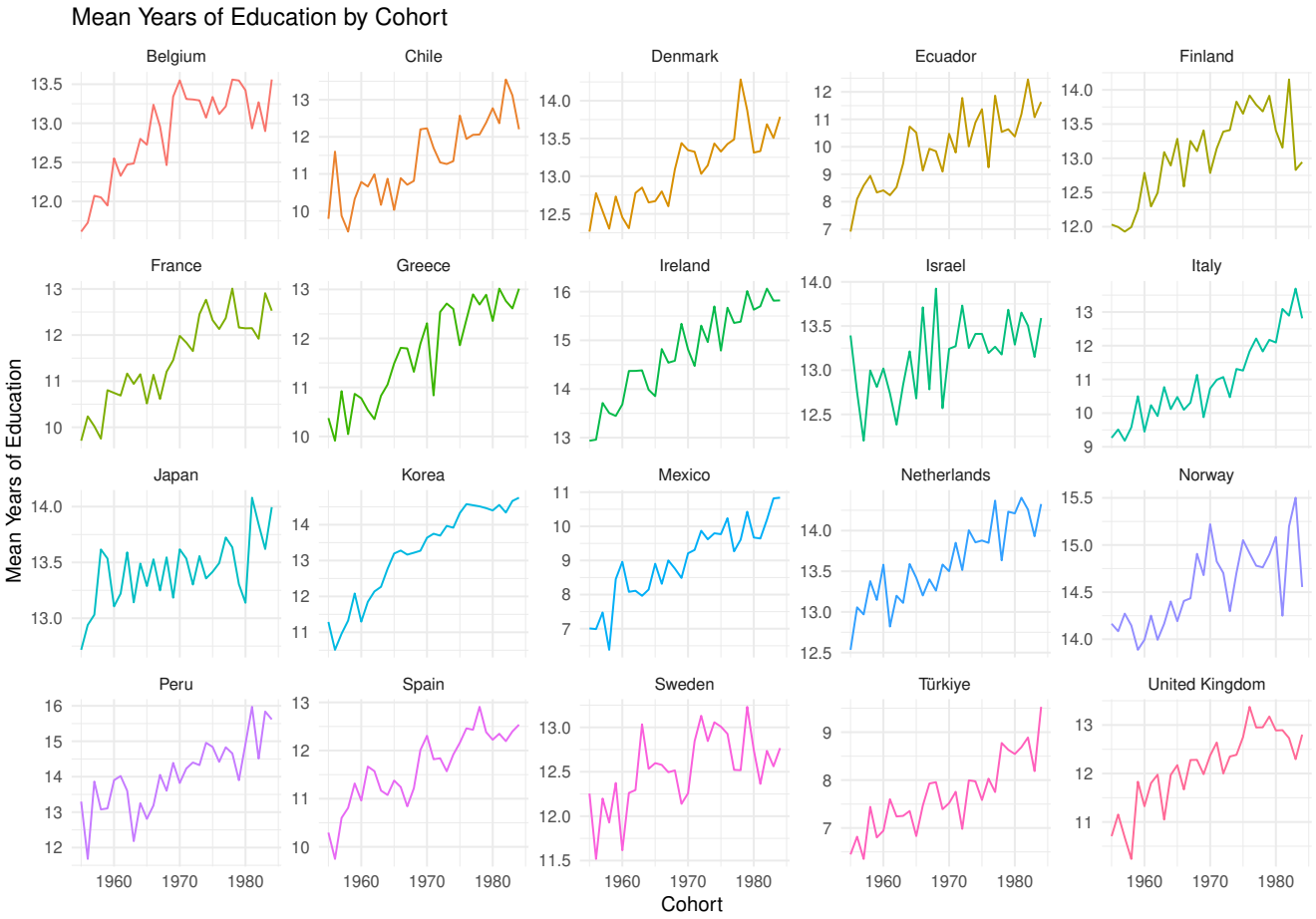

Figure 3: Years of Schooling
Source: PIAAC, OECD

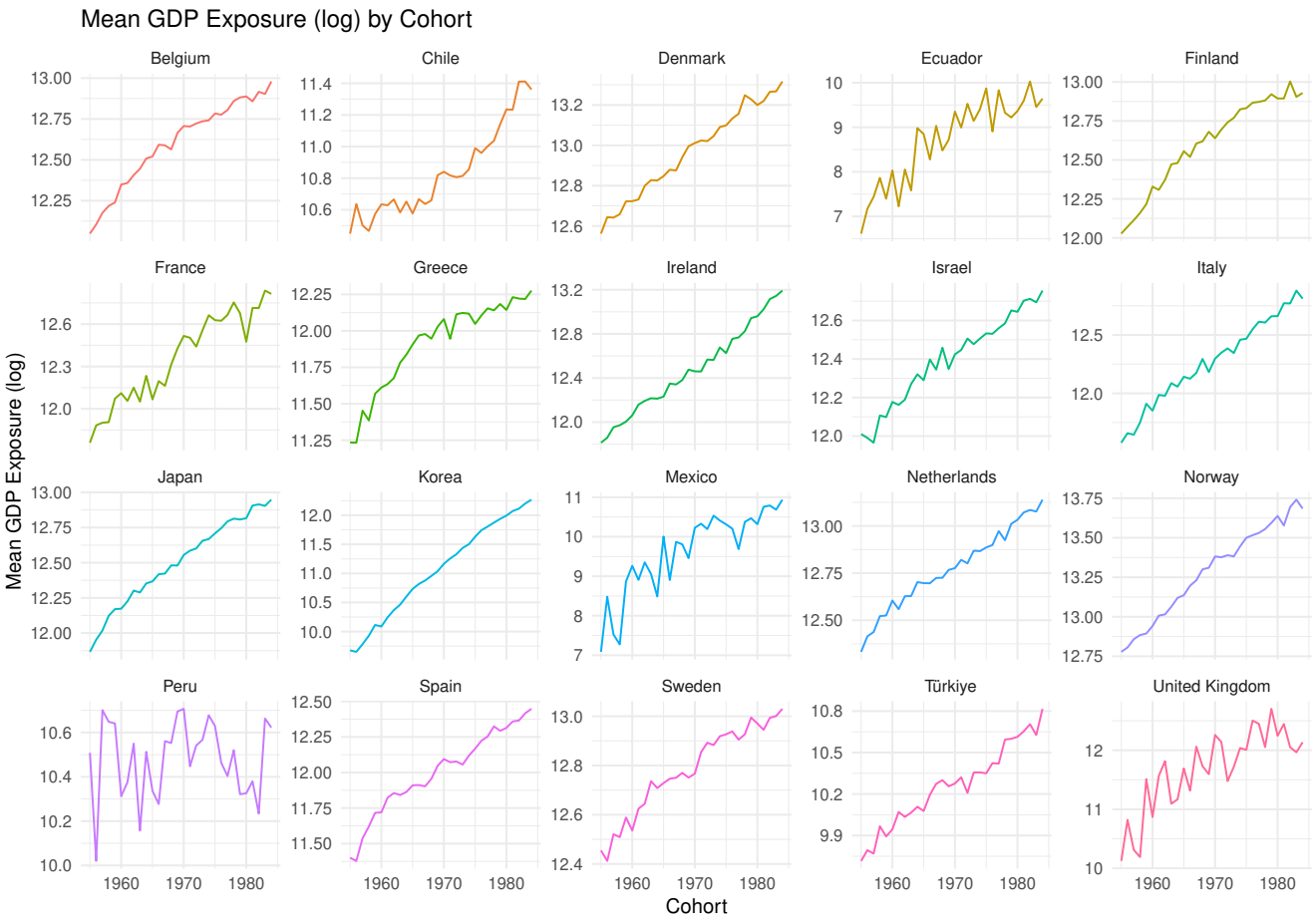

Figure 4: GDP Adjusted Years of Schooling
Source: OECD, PIAAC Survey and World Bank Indicators