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Causal Returns to Education

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Abstract

Using 182 estimates from 140 studies in 55 countries, this paper compares ordinary least squares (OLS) and instrumental variables (IV) estimates of the private returns to schooling. IV returns average 9.7 percent—38 percent higher than OLS—and exceed OLS in nearly 80 percent of cases, with the largest gaps in developing countries. These patterns align with theories of diminishing marginal returns, scarcity rents, and attenuation from measurement error. While IV methods mitigate bias, instrument validity and external validity concerns persist. Evidence consistently shows substantial causal returns, particularly for disadvantaged populations, underscoring the need for rigorous research.

Keywords: Returns to education; Endogeneity; Human capital

JEL Codes: I26; J24

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1. Introduction

Understanding the causal impact of education on earnings remains a central question in labor economics and education policy. While ordinary least squares (OLS) estimates of the returns to schooling are widely reported, they are often criticized for potential biases due to omitted variables, measurement error, and ability differences (Griliches 1977; Card 1999). Instrumental variables (IV) techniques have become the leading approach for addressing these concerns, exploiting exogenous variation from sources such as compulsory schooling laws, educational reforms, and geographic access to schooling (Angrist and Krueger 1991; Duflo 2001; Meghir and Palme 2005).

A consistent finding in the literature is that IV estimates often exceed OLS estimates, but the magnitude and consistency of this pattern—especially across different income contexts—are less well understood. Previous reviews document this gap (Harmon et al. 2003; Psacharopoulos and Patrinos 2018), yet few studies provide a comprehensive synthesis that compares OLS and IV estimates systematically across countries and decades.

This paper compiles 182 comparable estimates from 140 studies covering 55 countries to assess the relationship between OLS and IV estimates of the returns to schooling. We find that IV estimates exceed OLS in 79 percent of cases, with the difference particularly pronounced in developing countries. Our results suggest that higher IV returns in these settings may reflect diminishing marginal returns to education at higher attainment levels, scarcity rents in less saturated labor markets, and greater attenuation bias in OLS estimates due to measurement error. We also document substantial temporal variation, with the IV–OLS gap largest in the 1970s, coinciding with major education reforms that disproportionately affected groups with high marginal returns.

These findings contribute to both the econometric debate on the validity and interpretation of IV estimates and to the policy discussion on the distributional and developmental impacts of education. By clarifying where and when IV estimates most exceed OLS, we help inform the design of education policies that target populations with the highest marginal returns.

2. The Human Capital Framework and the Returns to Schooling

2.1. *The Mincer Specification*

The analysis of educational choices is grounded in the concept of human capital (Becker 1964; Schultz 1961). Human capital theory views education as an investment—individuals incur costs today, including both direct expenses and foregone earnings, in exchange for higher expected income in the future. This framework treats schooling as a decision made to maximize the net present value of lifetime earnings.

The most influential empirical model arising from this theory is the Mincerian earnings function (Mincer 1974). Under simplifying assumptions—including no direct schooling costs, competitive labor markets, and constant returns to scale—this model implies a log-linear relationship between

earnings and years of schooling. Mincer extends the model to include potential labor market experience and its square, capturing the concave earnings profile over the life cycle:

$$\ln Y_i = \alpha + \beta S_i + \gamma_1 EX_i + \gamma_2 EX^2{}_i + \varepsilon_i$$

where Y is earnings; S is years of schooling; EX denotes potential experience, typically approximated as age minus years of schooling minus six (Patrinos 2024); ε is the error term with standard assumptions of independence, homoscedasticity, and zero mean; and β is interpreted as the average private rate of return to an additional year of education.

2.2 Challenges in Estimating Returns to Schooling

Despite its widespread use, the Mincer equation is not without limitations. Estimating the return to education is complicated by several methodological challenges—chief among them is endogeneity. Schooling decisions are not randomly assigned: they may be influenced by unobserved factors such as innate ability, family background, motivation, or access to credit. These unobservable characteristics are often correlated with both educational attainment and earnings, potentially biasing the estimated coefficient β.

Personal ability can be seen as an estimation issue (Card 1999; Griliches 1977). This can be addressed by explicitly incorporating ability into the derivation of the log-linear earnings function. Introducing unobserved ability into this model presents an identification challenge: ability affects both the decision to invest in schooling and the productivity of that investment.

This identification problem is analogous to a challenge in clinical medicine: we cannot observe both the treated and untreated outcomes for the same person. In medical research, randomized controlled trials (RCTs) solve this by assigning treatment randomly. In education, RCTs are rare, but researchers have identified natural experiments that mimic random assignment—such as changes in compulsory schooling laws or proximity to colleges. These studies use instrumental variables (IV) to isolate exogenous variation in schooling that is uncorrelated with the error term in the earnings equation.

These approaches often yield the local average treatment effect (LATE) (Imbens and Angrist 1994), the causal effect for individuals whose schooling decisions are influenced by an external instrument—such as compulsory schooling law changes. LATE is policy-relevant because it reflects returns for those at the margin, who are most likely to respond to shifts in educational incentives or constraints. The next section compiles empirical evidence from a global dataset, comparing OLS and IV estimates, and examining how patterns vary across contexts, over time, and by country income group.

3. Review of the Empirical Literature

3.1 Review of the OLS literature

The availability of microdata and the ease of estimation have resulted in many studies estimating the Mincer specification. A compilation of published results is presented in the compilation of returns to schooling from 165 economies (Table 1). The studies are generally typical in that they use representative, structured surveys and estimate earnings profiles using cross-section data. Overall, the returns to schooling are highest in low-income countries, at 11 percent. The overall global average return is 9.5 percent.

Table 1: Average returns to schooling (%), OLS estimates

Country income group	Mean	N
High	9.1	599
Low	11.3	66
Lower Middle	9.2	302
Upper Middle	9.8	573
Total	9.5	1540

Source: Patrinos (2024)

3.2 Does Schooling Increase Wages?

Education is widely found to raise earnings, largely by increasing productivity—but an alternative view, the signaling hypothesis, suggests that schooling may instead function as a way to certify desirable traits like ability or discipline (Patrinos 2024). Empirical evidence tends to support the productivity-enhancing view: Clark and Martorell (2014) find little wage gain from simply earning a high school diploma, while Arteaga (2018) shows that reducing university coursework leads to lower wages, implying human capital matters more than credentials. Although some studies detect weak signaling effects, the broader literature finds that education primarily boosts earnings by building skills (Card 2001).

To address confounding factors and better estimate causal effects, researchers often employ instrumental variables (IV). The IV approach involves using a variable that influences educational attainment but is otherwise uncorrelated with potential earnings—allowing for cleaner identification of causal effects. For example, changes in school-leaving age laws or geographic proximity to colleges serve as instruments that generate exogenous variation in schooling. By controlling for both observed and unobserved characteristics, IV methods can provide less biased estimates of the return to education (Patrinos 2024). Economic theory suggests that individuals make schooling decisions based on a cost–benefit calculation, weighing current costs against expected future returns (Angrist and Krueger 2001). When individuals differ in ability and face

varying costs of education, heterogeneity in both schooling choices and returns is expected (Angrist et al. 1996; Card 2001; Ichino and Winter-Ebmer 1998; Imbens and Angrist 1994).

Suppose there exists a variable, such as a change in compulsory schooling laws, which influences educational attainment but is otherwise uncorrelated with potential earnings. This variable can serve as an instrument (Z_i), affecting the schooling decisions of a specific subset of individuals. By exploiting exogenous variation in schooling induced by such instruments, researchers can control for both observed and unobserved factors influencing earnings (Patrinos and Sakellariou 2005).

With heterogeneity in returns and costs, IV estimates identify the local average treatment effect (LATE)—the marginal return for individuals whose education decisions are altered by the instrument, often those who are liquidity-constrained or otherwise at the margin (Imbens and Angrist 1994).

In many developing countries, where credit constraints are widespread, this subgroup may represent a sizable share of the population. As a result, IV-based estimates that use educational reforms as instruments often yield relatively high returns. While this could be partly due to measurement error or inadequate instrumentation (Trostel et al. 2002), it could also be because they capture the marginal effect of schooling on individuals who were induced to acquire more education by the reform—typically those who would not have continued otherwise. These local average treatment effects (LATEs) can differ meaningfully from average treatment effects (ATEs) and may not generalize to individuals with different characteristics or educational trajectories.

Nonetheless, it is notable that return estimates derived from advanced econometric methods—which account for observed and unobserved heterogeneity—often converge toward the global average rate of return reported in comprehensive reviews of the literature. To estimate the true causal effect of education on earnings, many studies rely on instrumental variables (IV). A valid instrument must be strongly correlated with educational attainment but exogenous—that is, uncorrelated with the unobserved determinants of earnings.

3.3 Review of Causal Literature

Recent research increasingly relies on supply-side education reforms as instruments to identify causal effects of schooling. Since people base education decisions on perceived costs and benefits, reforms that lower costs—such as changes in tuition, loan availability, or school proximity—can shift behavior and serve as valid instruments. Institutional constraints like compulsory schooling laws or improved school access (Card 1993) provide natural experiments, influencing education without directly affecting earnings.

These instruments typically affect a subset of individuals, those at the margin, who face higher returns to schooling than the average (Card 2001). However, not all instruments are valid: some fail to raise schooling or impact earnings, often due to low-quality education or weak policy design (Clark 2023; Harmon et al. 2003).

Causal estimates of the returns to schooling have been shaped by a series of influential studies in the economics of education and labor markets. Table 2 summarizes ten highly-cited contributions. For example, Angrist and Krueger (1991) use quarter of birth as an instrument for years of schooling under US compulsory schooling laws. They find that more schooling leads to higher earnings, with IV estimates closely matching OLS results, suggesting minimal bias from unobserved ability. Oreopoulos (2006) leverages variation in compulsory schooling laws in Canada, the UK, and the US to estimate both average and local average treatment effects, finding substantial returns to education for those compelled to stay in school. Acemoglu and Angrist (2000) examine externalities in education and, using similar instruments, find that social returns are modest compared to private returns, indicating limited spillover effects.

Using twins to control for unobservable ability and family background, Ashenfelter and Krueger (1994) show that returns to schooling may be underestimated in standard OLS models, pointing to limited omitted variable bias. Duflo (2001) studies a large Indonesian school construction program, using regional and cohort variation as an instrument, and finds wage gains of 7.8 percent (OLS) and 9.1 percent (IV) per additional year of schooling—evidence of strong private returns. Carneiro et al. (2011) develop a framework for estimating marginal treatment effects (MTEs), finding that individuals with higher unobserved ability benefit more from education and that IV estimates capture returns for specific subpopulations.

In Germany, Pischke and von Wachter (2008) find no significant earnings gains from increased compulsory schooling, highlighting the importance of institutional context and reform quality. Pischke (2007), using variation in school year length across German states, finds that longer school years improve test scores and modestly raise earnings, suggesting that schooling quality and intensity are key components of educational returns.

Table 2: Selected IV Studies

Study	Sample	Returns (%) OLS	IV	Instruments
Acemoglu & Angrist 2000	US Census 1960–1980: white men aged 40–49	6.1	6.7	Compulsory schooling laws (state ×birth cohort)
Angrist & Krueger 1991	US 1970/1980 Census, men born 1920–49	6.3	8.1	Year×birth quarter; state×birth quarter
Ashenfelter & Krueger 1994	US Twin Sample	7.4	9.8	Twin fixed effects
Black et al 2005	Norway administrative data 1967–1976	6.7	4.0	Twin fathers; adoption (separating genetic/environmental factors)
Card 2001	Review of US studies	8.5	11.0	Various: proximity to college, compulsory schooling laws, quarter of birth
Carneiro et al 2011	US NLSY 1979	8.4	5.8	Latent variable model; family background IVs
Duflo 2001	Indonesia	7.8	9.1	School construction program (variation across regions and cohorts)
Oreopoulos 2006	US, UK, Canada Census: men affected	7.8	14.2	Compulsory schooling law changes by birth cohort & region
Pischke & von Wachter 2008	Germany, men born 1930–1950	6.1	0.0	Compulsory schooling law
Pischke 2007	Germany, school leavers affected by school reforms	6.0	7.0	Variation in length of school year across states and time

3.4. Empirical Comparisons of OLS and IV Estimates

The dataset used in this review draws on estimates reported in prior meta-analyses and global reviews (Psacharopoulos and Patrinos 2018; Harmon et al. 2003; Soon and Lim 2024), supplemented with additional studies identified through targeted literature searches. Inclusion criteria required that each study report both OLS and IV estimates of the private return to schooling, be based on individual-level data, and clearly describe the instrument used. Studies with incomplete earnings or schooling measures, or without sufficient methodological detail, were excluded.

Harmon et al. (2003) review the evidence from 94 IV studies and find that IV estimates of the returns to schooling are typically 9 to 14 percent higher than OLS estimates. Those exploiting education reforms yield particularly high returns, whereas those using family background as instruments produce estimates similar to OLS. The evidence on private returns is compelling: participation in education positively affects individual earnings.

Card (2001) examines studies that exploit institutional features of the education system—such as compulsory schooling laws and variation in school accessibility—as exogenous determinants of educational attainment. He finds that IV estimates from such supply-side instruments are often as large or larger than OLS estimates. One interpretation is that marginal returns among low-

education subgroups—those most affected by supply-side reforms—are relatively high, reflecting high marginal costs of schooling rather than low ability.

Clark and Nielsen (2024) review 66 causal estimates, most based on administrative changes in the minimum school-leaving age. While many studies report substantial gains, some find no effect. The mean return across studies is 8.5 percent, but the authors argue that publication bias likely inflates this figure by omitting negative-return estimates. This assumption—that negative-return studies are as likely as positive-return studies to be missing—is questionable. Even with some publication bias, large negative returns are implausible (Smith 2024). Because educational investment is endogenous to expected returns, the distribution of returns is right-skewed in the population. Meager (2024) argues that modelling the distribution in logs is more appropriate, given the bounded and skewed nature of earnings (Imdad et al. 2022). While some programs yield negative returns (Belfield et al. 2018; Gillen 2024), most individuals benefit from schooling; even college dropouts generally see positive, albeit smaller, returns (Berlingieri and Bolz 2025). Comprehensive reviews (Buscha and Dickson 2023; Psacharopoulos and Patrinos 2018) find no zero or negative point estimates among more than 700 recent studies.

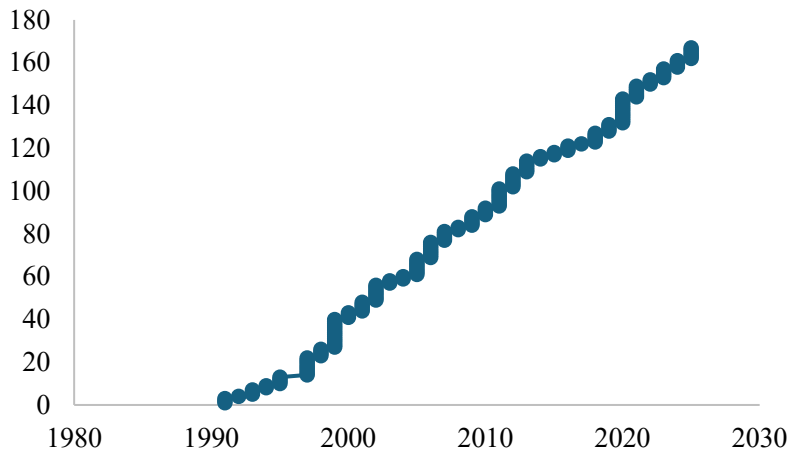
Ashenfelter et al. (1999) document "file drawer" bias, showing that statistically significant differences between OLS and IV have a higher probability of publication. Correcting for this bias accounts for about two-thirds of the average OLS–IV gap, though some statistically significant differences remain. They also find that estimated returns are higher in the U.S. and have increased over the past two decades.

Soon and Lim (2024) conduct a meta-analysis of 74 studies comparing IV and non-IV estimates. They find that each additional year of schooling increases earnings by an average of 9 percent, with returns trending upward over time. Their evidence suggests that policy-related instruments—not family background—are the primary drivers of these effects.

3.5 Results

Combining results from the above reviews, the authors' own compilations (Psacharopoulos and Patrinos 2018), and new searches yields 182 estimates from 140 studies covering 55 countries. The number of causal studies has increased considerably over time (Figure 1).

Figure 1: Number of estimates by publication year, cumulative count



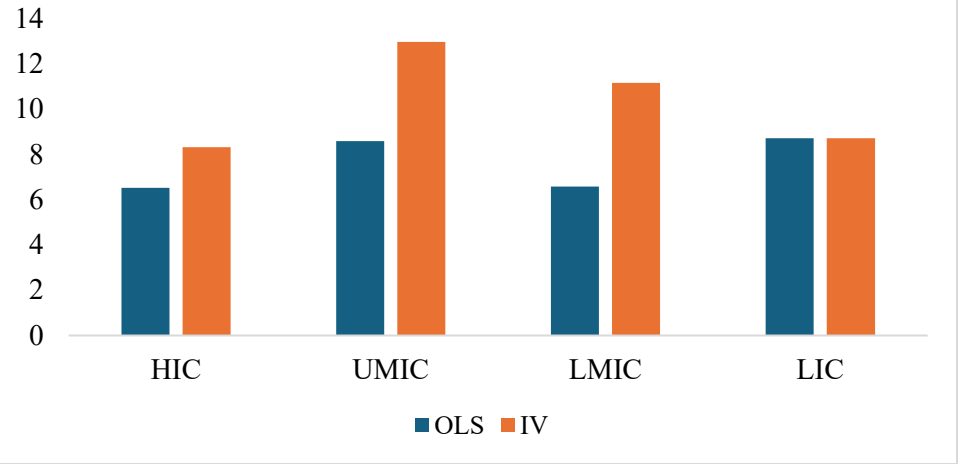
In 79 percent of cases, IV returns exceed OLS; only 21 percent of cases report higher OLS returns (Table 3). This suggests that OLS estimates may be downward biased—due to measurement error or omitted variables—and that IV estimates may capture the effect of schooling on individuals whose decisions are influenced by exogenous variation (for example, policy reforms). Of the 182 cases, 145 show IV estimates greater than OLS estimates.

Table 3: Comparison of OLS and IV estimates of the returns to schooling

	OLS	IV	N
Overall	7.0	9.7	182
High Income Countries	6.6	8.3	125
Developing Countries	8.1	12.6	57

On average, IV returns are 38 percent higher than OLS. The difference is smaller in high-income countries (27 percent) but larger in developing countries (56 percent) (see Figure 2).

Figure 2: Comparison of OLS and IV by Income Group



Notes: HIC=high income country; UMIC=upper middle income country; LMIC=lower middle income country; LIC=low income country

In the race between technology and education framework (Tinbergen 1974; Goldin and Katz 2008), returns to schooling are expected to vary over time—sometimes substantially—depending on shifts in labor market demand and technological change. Consequently, estimates from many years ago may be of limited relevance for understanding current returns. Table 4 presents period- and decade-specific estimates. The most recent periods show high returns under both OLS and causal (IV) estimation, with IV consistently exceeding OLS. This pattern holds across all decades, with the gap particularly pronounced in the 1970s. That decade's large differential likely reflects the nature of the instruments employed, such as compulsory schooling reforms, that disproportionately influenced cohorts with high marginal returns (Angrist and Krueger 1991; Meghir and Palme 2005).

Table 4: Returns to Schooling over Time

Period	OLS	IV	N
1930-1960	6.3	7.7	24
1970	6.5	13.0	13
1980	6.4	8.7	26
1990	6.0	8.1	45
2000	8.3	10.5	32
2010-2020	8.5	11.8	38

The consistently larger IV returns relative to OLS may be explained by three mechanisms. First, diminishing marginal returns: in developing countries with lower average attainment, marginal years of schooling yield larger productivity gains (Psacharopoulos and Patrinos 2018; Montenegro and Patrinos 2023). IV strategies in these settings often identify low-education compliers, capturing higher marginal returns. Second, quality and scarcity effects: higher education in many

low-income economies is concentrated in elite institutions. Marginal students induced to attend by policy reforms can reap skill gains and scarcity rents (Tinbergen 1975; Goldin and Katz 2008). In high-income countries, broader access to education reduces scarcity rents and compresses wage differentials. Third, measurement error: schooling variables in developing-country surveys often suffer greater misreporting, attenuating OLS coefficients toward zero; IV methods correct this bias (Card 2001; Angrist and Pischke 2009).

4. Conclusion

Across 182 estimates from 55 countries, we find that IV returns to schooling are, on average, 38% higher than OLS returns, with the gap especially large in developing countries. This pattern is consistent with theoretical explanations involving diminishing marginal returns to education, scarcity rents in less saturated labor markets, and correction of measurement error bias in OLS estimates.

While these results reinforce the view that causal estimates often capture higher returns than OLS estimates, they also highlight the importance of instrument choice. Not all instruments are equally valid, and concerns about external validity and selective reporting remain. Nevertheless, meta-analyses and global reviews consistently affirm that the causal impact of education on earnings is both positive and substantial—particularly for lower-income and disadvantaged populations.

Future research should prioritize quasi-experimental designs that expand the range of contexts and populations studied and should rigorously evaluate education policies and reforms for both their average and distributional impacts. Taken together, the evidence confirms that education delivers substantial causal earnings gains—particularly for lower-income and disadvantaged populations—and underscores the importance of well-designed policies that expand access to high-quality schooling as a driver of both individual prosperity and broader economic development.

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