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Too much or too little? Financial and digital literacy and IPO underpricing in Europe

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ABSTRACT

This paper examines the non-linear relation between country-level financial and digital literacy and initial public offering (IPO) underpricing in European stock markets. Using 856 IPOs from 26 countries over 2015–2024, we estimate regression models with controls for offer size, firm age, overallotment, multi-bookrunner, venture capital backing, hot-market conditions, foreign direct investment, GDP growth, GDP, the anti-self-dealing index, and regional, month-of-issuance, and industry fixed effects. We find U-shaped relationships between IPO underpricing and both financial and digital literacy. Underpricing is minimized at intermediate literacy levels, implying that countries with very low or very high literacy exhibit higher first-day returns than countries with moderate literacy. For financial literacy, the interior minimum is at a score of 52.2 (Sasabuchi joint $p = 0.013$). Moving from the lowest observed score (22) to this inflection point reduces predicted underpricing by 13.7 percentage points, whereas moving from the inflection point to the highest observed score (71) increases it by 5.3 percentage points. For digital literacy, the interior minimum is 63.6 (Sasabuchi joint $p = 0.020$). Moving from the lowest observed score (42) to this point reduces underpricing by 9.3 percentage points, while increasing digital literacy to the sample maximum (81) raises underpricing by 5.7 percentage points. These dual-literacy effects provide the first joint cross-country test of adverse-selection and rent-extraction mechanisms. The findings show that human capital, particularly financial and digital skills, shapes primary-market pricing efficiency through competing frictions, with implications for issuers, underwriters, investors, and regulators seeking to improve IPO pricing design and market functioning.

1. Introduction

IPO underpricing constitutes a critical market anomaly, generating sizable wealth transfers from issuers to investors as first-day prices exceed offer price – a phenomenon that has long attracted the attention of academic, market practitioners and regulators alike (Leleux and Muzyka, 1997; Ljungqvist, 1997; Loughran and Ritter, 2002; Guo et al., 2025). The great majority of studies reveal that European IPOs exhibit pronounced cross-country variation, driven by heterogeneous legal frameworks, bookbuilding practices, and investor composition (domestic vs. international, retail vs. institutional) that generate differences in initial returns and post-listing outcomes (Jenkinson et al., 2006; Ritter, 2003). Furthermore, stronger investor protection and governance standards reduce

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information asymmetry and underpricing (Akyol et al., 2014; Hopp and Dreher, 2013), while certification by top underwriters improves pricing accuracy and lowers withdrawal risk (Cioli et al., 2025; Helbing, 2019). Although firms' trademark-based intangible capital signals growth options (Fisch et al., 2022), European issuances often underperform long-term relative to benchmarks, despite substantial first-day price appreciations (Ljungqvist, 1997). Unlike the U.S., European IPOs feature lower gross spreads and pricing within indicative ranges, even amid intense pre-marketing, reflecting conservative bookbuilding practices (Jenkinson et al., 2006; Ritter, 2003). In specialized segments, such as Special Purpose Acquisition Companies (SPACs), European vehicles exhibit more moderate initial short-term underpricing but more stable long-run performance than their U.S. counterparts, consistent with more conservative regulatory regimes (Cioli et al., 2025). The state-of-the-art on IPO underpricing drivers relies primarily on traditional mechanisms like information asymmetry, agency costs, risk and investor sentiment (Peng et al., 2022; Zheng et al., 2024; Gu et al., 2025; Guo et al., 2025; Han et al., 2026). Most prior studies examine only linear relationships between financial literacy and underpricing (e.g. Jia et al., 2024), overlooking two critical gaps: (1) the possibility of non-linear effects, where underpricing responds asymmetrically to literacy changes, and (2) the impact of digital literacy. We hypothesize a non-linear (U-shaped) relationship: at low literacy, adverse selection (Rock, 1986) forces issuers to underprice severely to offset risk; at high literacy, sophisticated investors extract rents (Loughran and Ritter, 2002) by demanding greater underpricing in exchange for support; at intermediate literacy, information asymmetry diminishes without concentrated investor bargaining power, yielding an intermediate-literacy interior minimum. This paper makes three contributions to the cross-country IPO literature. First, it provides the first joint test of the adverse-selection mechanism (Rock, 1986) and the rent-extraction mechanism (Loughran and Ritter, 2002) within a single specification, exploiting the fact that both frictions operate simultaneously — but in opposite directions — across the literacy distribution. Second, it introduces digital literacy as a distinct human-capital dimension in cross-country IPO research, extending Jia et al. (2024) who use a financial literacy proxy only. Third, it validates these mechanisms across 856 IPOs from 26 European countries (2015–2024) spanning diverse literacy levels in a market characterised by regulatory fragmentation, yielding policy-relevant insights for issuers, underwriters, and regulators.

The remainder of the paper is structured as follows: Section 2 describes the data and methodology. Section 3 presents results. Section 4 concludes.

2. Data and methodology

2.1. Sample and data

The IPO data were collected from Refinitiv Eikon for all European offerings between 2015 and 2024, yielding an initial universe of 1709 IPOs. From this universe, we excluded 214 financial-sector IPOs and 100 real estate IPOs, consistent with prior IPO-pricing literature (e.g., Akyol et al., 2014; Ritter and Welch, 2002). The remaining 1395 observations were further restricted by removing 188 IPOs without first-day returns and 333 IPOs lacking founding-year information (*Firm Age*), which we use as a core control for IPO uncertainty following prior work (Akyol et al., 2014). A final exclusion of 18 IPOs from four countries for which the anti-self-dealing index (Djankov et al., 2008) is unavailable, reduced the sample to 856 IPOs spanning 26 European countries.

Country-level financial literacy data were retrieved from the S&P Global Financial Literacy Survey, which measures the percentage of adults demonstrating understanding of four fundamental financial concepts: interest compounding, inflation, risk diversification, and numeracy. Country-level digital literacy scores (ranging from 0 to 100) were sourced from the World Economic Forum's Global Competitiveness Index 2019, specifically the Digital Skills Among Active Population metric. Both literacy proxies are quasi-static across the 2015–2024 window. With monthly fixed effects included, their identifying variation is primarily cross-sectional. We retain the time-invariant treatment because the underlying constructs — adult financial competence and digital-skills endowment — evolve slowly over a decade (Lusardi and Mitchell, 2014), and the time constraint where this type of data is not collected in a regular basis. The control variables were retrieved as follows: Offer Size (natural logarithm of gross proceeds in million euros), Firm Age (natural logarithm of years since company founding), Overallotment (a binary indicator equal to 1 if the IPO used a greenshoe option, 0 otherwise), Multi-bookrunner (a binary indicator equal to 1 if the IPO is managed by multiple bookrunners, 0 otherwise), VC-backed (a binary indicator equal to 1 if the issuing firm is venture capital-backed, 0 otherwise), hot-market conditions (a binary indicator equal 1 if the IPO is issued during a period of above-average issuance volume, 0 otherwise), were obtained from Refinitiv Eikon. Foreign Direct Investment (FDI) net inflows as a percentage of GDP, GDP Growth is the annual real GDP growth rate of the issuer's home country, and GDP is the natural logarithm of the issuer's home country nominal GDP, were sourced from the World Bank's World Development Indicators (e.g., Khiar and Kooli, 2026). Anti-self-dealing index (Country-level investor protection score) were sourced from Djankov et al. (2008). All continuous variables have been winsorized at the 1st and 99th percentiles to mitigate the influence of extreme outliers, consistent with standard practice in IPO research.

2.2. Research model

To examine the non-linear relationship between country-level literacy and IPO underpricing, we estimate the following models

$$\begin{aligned}\text{Underpricing}_{i,t} = {} & \beta_0 + \beta_1 \text{FinLit}_{i,t} + \beta_2 \text{FinLit}_{i,t}^2 + \beta_3 \text{OfferSize}_{i,t} + \beta_4 \text{Firmage}_{i,t} + \beta_5 \text{Overallotment}_{i,t} + +\beta_6 \text{Multibookrunner}_{i,t} \\ & + \beta_7 \text{VCbacked}_{i,t} + \beta_8 \text{Hotmarket}_{i,t} + \beta_9 \text{FDI}_{i,t} + \beta_{10} \text{GDPgrowth}_{i,t} + \beta_{11} \text{GDP}_{i,t} + \beta_{12} \text{Antiselfdealing}_{i,t} \\ & + \beta_{13} \text{WesternEurope}_{i,t} + \gamma_m (\textit{Monthly dummies}) + \delta_j (\textit{Industry dummies}) + \varepsilon_{i,t} \end{aligned} \quad (1)$$

$$\begin{aligned}\text{Underpricing}_{i,t} = {} & \beta_0 + \beta_1 \text{DigLit}_{i,t} + \beta_2 \text{DigLit}_{i,t}^2 + \beta_3 \text{OfferSize}_{i,t} + \beta_4 \text{FirmAge}_{i,t} + \beta_5 \text{Overallotment}_{i,t} + \beta_6 \text{MultiBookrunner}_{i,t} \\ & + \beta_7 \text{VCBacked}_{i,t} + \beta_8 \text{HotMarket}_{i,t} + \beta_9 \text{FDI}_{i,t} + \beta_{10} \text{GDPGrowth}_{i,t} + \beta_{11} \text{GDP}_{i,t} + \beta_{12} \text{AntiSelfDealing}_{i,t} \\ & + \beta_{13} \text{WesternEurope}_{i,t} + \gamma_m(\textit{Monthly dummies}) + \delta_j(\textit{Industry dummies}) + \varepsilon_{i,t} \end{aligned} \quad (2)$$

where i and t refer to the number of IPOs and time, respectively. In the Eqs. above β_0 is the constant, $\gamma_m$denotes the month-of-issuance fixed effects, δ_j the macro industry fixed effects, $\varepsilon_{i,c,\ t}$ is the error term and $FinL_{it}$ and $DigL_{it}$ are the financial and digital literacy levels, respectively. The dependent variable $Underpricing_{i,t}$is the first-day underpricing expressed as the closing price minus the offer price divided by the offer price while the controls are denoted by OfferSize_{it} – the issue amount of the IPO, FirmAge_{it} – the lifespan of a company, $\text{Overallotment}_{it}$ – also known as greenshoe option, i.e., a stock option that allows the sale of additional shares of a company in IPOs, $\text{MultiBookrunner}_{it}$ – a binary indicator equal to 1 if the IPO is managed by multiple bookrunners, 0 otherwise; VCBacked_{it} – a binary indicator equal to 1 if the issuing firm is venture capital-backed, 0 otherwise; Hotmarket_{it} – a binary indicator equal to 1 if the IPO is issued during a period of above-average issuance volume, 0 otherwise; FDI_{it} – foreign direct investment net inflows as a percentage of GDP; GDPgrowth_{it} – the annual real GDP growth rate of the issuer's home country; GDP_{it} – the natural logarithm of the issuer's home-country nominal GDP; and $\text{AntiSelfDealing}_{it}$ – the country-level anti-self-dealing index, a proxy for investor protection, plus the regional, month-of-issuance and industry fixed effects.

We estimate separate specifications for financial literacy (Eq. (1)) and digital literacy (Eq. (2)). Robust standard errors are employed to address heteroskedasticity, common in cross-sectional IPO data. The coefficient of primary interest is β_2 where a statistically significant positive coefficient confirms a U-shaped relationship, indicating that moderate literacy levels minimize underpricing, while both low and high literacy levels exacerbate it. Our coefficients capture conditional cross-country associations, not causal effects of literacy on underpricing. Endogeneity from omitted institutional or investor-composition variables cannot be fully ruled out, and a credible instrument for population-level literacy is not yet available in the literature.

3. Results and discussion

3.1. Preliminary analysis

Table 1 presents IPO activity and literacy levels by country for our working sample of 856 European IPOs, primarily from the United Kingdom (17.4%), Turkey (15%), Sweden (13.4%), Italy (13.1%), and France (10.5%). First-day underpricing averages 12.16%, aligning with Ritter (2003) benchmarks for comparable European markets such as France (11.6%), Norway (12.5%), Finland (10.1%), Spain (10.7%), Netherlands (10.2%), Belgium (14.6%), and Portugal (10.6%).

Table 1
IPO activity and literacy levels by country.

Country	# IPOs	%	Financial literacy (0–100)	Digital literacy (0–100)	Avg initial return (%)
United Kingdom	149	17.4	67	65.620	14.819
Turkey	128	15.0	24	42.080	15.303
Sweden	115	13.4	71	77.780	10.444
Italy	112	13.1	37	52.880	14.870
France	90	10.5	52	58.190	4.003
Germany	44	5.1	66	67.760	9.912
Denmark	36	4.2	71	73.590	22.396
Norway	33	3.9	71	71.580	7.000
Finland	29	3.4	63	80.530	9.587
Poland	23	2.7	42	54.520	15.473
Spain	22	2.6	49	55.690	12.499
Netherlands	12	1.4	66	77.110	11.199
Russia	12	1.4	38	65.830	5.850
Belgium	10	1.2	55	63.840	5.513
Switzerland	10	1.2	57	74.430	16.778
Ireland	8	0.9	55	66.490	10.912
Romania	6	0.7	22	58.200	6.371
Czech Republic	4	0.5	58	62.960	10.660
Austria	3	0.4	53	63.000	3.619
Luxembourg	2	0.2	53	69.820	−2.727
Latvia	2	0.2	48	63.100	0.358
Greece	2	0.2	45	51.830	2.104
Bulgaria	1	0.1	35	60.910	0.000
Slovakia	1	0.1	48	59.770	8.870
Portugal	1	0.1	26	58.710	12.941
Hungary	1	0.1	54	49.530	2.040

Notes: This table reports the number and percentage of sample IPOs, country-level financial literacy (S&P Global Financial Literacy Survey, 0–100), digital literacy (World Economic Forum Global Competitiveness Index, Digital Skills Among Active Population, 0–100), and the average first-day return (%), by country. Sample: 856 European IPOs, 2015–2024.

Table 2 presents summary statistics for our sample of 856 European IPOs. First-day underpricing averages 12.16%, close to the levels reported in prior European IPO studies (e.g., Ritter, 2003), and shows substantial cross-sectional variation (median = 5.78%, SD = 28.32 pp). The distribution is strongly right-skewed (skewness = 3.34) and leptokurtic (kurtosis = 17.04), consistent with the well-documented "lottery-like" payoff structure of IPO investments where occasional extreme winners drive mean returns above medians. Financial literacy across European countries ranges from 22% to 71%, with Nordic countries (Sweden, Norway, Denmark) clustering near the upper bound and Southern/Eastern European nations (Romania, Turkey, Portugal) toward the lower range. Digital literacy displays narrower dispersion (mean = 62.03, SD = 11.78, range [42.08, 80.53]), consistent with EU-wide digital infrastructure convergence initiatives.

Table 3 reports the pairwise correlation matrix. The high correlation between financial and digital literacy ($\rho = 0.918$) suggests both measures capture related dimensions of national human capital, which justifies estimating them in separate specifications. Variance inflation factors remain below 10, indicating that multicollinearity is not a concern within each specification. Specifications entering both literacy dimensions jointly are uninformative, the two measures share over 80% of their variance, explanatory power is unchanged relative to the separate models, and neither variable's orthogonalised unique component is statistically significant, so the data cannot attribute the effect to one dimension over the other; these specifications are not reported but are available upon request.

3.2. Non-linear results: U-shaped literacy effects

Table 4 reports our main findings. Column 1, Financial Literacy, reveals a statistically significant U-shaped relationship with first-day underpricing. The linear coefficient is negative ($\beta_1 = -1.565$, SE = 0.640, p = 0.015), while the quadratic term is positive ($\beta_2 = 0.015$, SE = 0.006, p = 0.015), yielding an interior minimum at 52.2 (calculated as $-\beta_1/(2\beta_2)$), strictly inside the observed financial-literacy range [22, 71]. This pattern confirms our central hypothesis: underpricing first decreases as literacy rises from low levels, reaches a minimum at intermediate literacy, then increases again at high literacy levels.

The interior minimum of 52.2 lies within the observed financial-literacy range [22, 71] and close to the sample median (57), providing strong internal validity. Fig. 1, Panel A, shows that within the observed range, predicted first-day underpricing falls by approximately 13.7 pp when moving from the lowest score (22) to the interior minimum, and rises by approximately 5.3 pp when moving from the interior minimum to the highest score (71). Column 2 results for Digital Literacy, mirrored in Panel B of Fig. 1, confirm a similar U-shaped pattern with comparable statistical strength. The linear coefficient ($\beta_1 = -2.552$, SE = 1.168, p = 0.029) and the quadratic term ($\beta_2 = 0.020$, SE = 0.009, p = 0.029) are both significant at the 5% level, yielding an interior minimum at 63.6, close to the sample median (65.6) and well inside the observed digital-literacy range [42.08, 80.53]. The shape of the digital-literacy U-curve (Fig. 1, Panel B) is broadly comparable in steepness to that of financial literacy, with both exhibiting asymmetric arms. On a per-point basis the rent-extraction (right) arm is the steeper of the two, whereas the adverse-selection (left) arm operates over the wider portion of the observed literacy range and therefore produces the larger cumulative change in underpricing. This differential sensitivity aligns with theoretical and empirical evidence, financial literacy directly reduces IPO underpricing by enhancing investors' valuation capabilities and mitigating information asymmetry (Jia et al., 2024), as well as with Lusardi and Mitchell's (2014), findings that financial literacy—encompassing numeracy, risk diversification, and market understanding—directly enhances complex financial decision-making and retirement planning efficiency, whereas digital literacy likely amplifies these effects indirectly by facilitating information access in modern markets. Across both specifications (Columns 1–2), control variables conform to established IPO pricing regularities. Larger offer sizes reduce underpricing, consistent with certification by prestigious underwriters (Akyol et al., 2014). For

Table 2
Summary statistics.

	N	Mean	Median	SD	Min	Max	Skewness	Kurtosis
Underpricing	856	12.16	5.78	28.32	−33.56	164.12	3.34	17.04
FinLit	856	53.16	57	17.13	22	71	−0.55	1.82
FinLit^2	856	3118.81	3249	1674.09	484	5041	−0.29	1.51
DigLit	856	62.03	65.62	11.78	42.08	80.53	−0.24	2.04
DigLit^2	856	3985.81	4305.98	1435.46	1770.73	6485.08	0.05	1.94
Offersize	856	3.33	3.32	1.85	−5.12	8.44	0.07	3.08
Firmage	856	3	3.01	0.7	0.85	4.81	-.14	3.04
Overallotment	856	0.36	0	0.48	0	1	0.58	1.34
Multibookrunner	856	0.12	0	0.33	0	1	2.33	6.45
VCbacked	856	0.09	0	0.29	0	1	2.87	9.22
Hotmarket	856	0.49	0	0.5	0	1	0.04	1
FDI	856	2.6	1.77	6.63	−71.72	74.75	0.88	50.32
GDPgrowth	856	2.79	2.21	3.78	−10.94	24.62	-.27	6.52
GDP	856	8.06	7.81	1.16	3.5	12.27	0.48	5.19
Anti-self-dealing	856	0.49	0.42	0.22	0.18	0.95	1.38	3.37

Notes: Summary statistics for the 856 European IPOs (2015–2024). Underpricing is the winsorised first-day return (%). FinLit and DigLit are country-level financial and digital literacy scores (0–100); squared terms are denoted ^{2}. Offersize is log gross proceeds (€m); Firmage is log years since founding; Overallotment, Multibookrunner, VCbacked and Hotmarket are 0/1 indicators; FDI is net inflows (% of GDP); GDPgrowth is real GDP growth (%); GDP is log nominal GDP; Anti-self-dealing is the Djankov et al. (2008) index. All continuous variables are winsorised at the 1st and 99th percentiles.

Table 3
Pairwise correlation matrix.

Variables	VIF	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) FinLit	9.76	1.00											
(2) DigLit	8.97	0.918*	1.00										
(3) Offersize	1.33	0.110*	0.105*	1.00									
(4) Firmage	1.21	−0.202*	−0.123*	0.203*	1.00								
(5) Overallotment	1.51	0.192*	0.224*	0.435*	0.198*	1.00							
(6) Multibookrunner	1.05	0.139*	0.110*	0.01	−0.125*	0.081*	1.00						
(7) VCbacked	1.09	0.089*	0.06	0.107*	−0.05	0.146*	0.06	1.00					
(8) Hotmarket	1.15	0.181*	0.173*	0.153*	0.04	0.106*	0.069*	0.04	1.00				
(9) FDI	1.06	0.121*	0.121*	−0.03	−0.01	0.05	−0.04	0.084*	0.06	1.00			
(10) GDPgrowth	1.22	−0.200*	−0.200*	0.02	−0.07	−0.124*	−0.06	0.05	0.216*	0.135*	1.00		
(11) GDP	1.29	−0.346*	−0.372*	0.00	0.04	−0.202*	−0.125*	−0.145*	−0.117*	−0.06	0.133*	1.00	
(12) Anti-self-dealing	1.66	0.257*	0.05	−0.04	−0.250*	−0.246*	0.04	−0.05	0.03	0.02	0.06	−0.131*	1.00

Notes: Pairwise Pearson correlations for the 856-IPO sample (2015–2024); VIF is the variance inflation factor from the underpricing regression. All variables are defined in the notes to Table 2. * denotes significance at the 5% level.

Table 4
Estimations result on IPO underpricing: financial literacy and digital literacy.

	(1) Underpricing	(2) Underpricing
FinLit	−1.565**	
	(0.640)	
FinLit^2	0.015**	
	(0.006)	
DigLit		−2.552**
		(1.168)
DigLit^2		0.020**
		(0.009)
Offersize	−2.189***	−2.184***
	(0.752)	(0.750)
Firmage	−4.049***	−4.070***
	(1.381)	(1.391)
Overallotment	7.910***	8.155***
	(2.287)	(2.266)
Multibookrunner	−1.622	−2.203
	(3.148)	(3.161)
VCbacked	−4.868	−5.423*
	(3.145)	(3.108)
Hotmarket	−1.077	−0.779
	(2.087)	(2.084)
FDI	−0.226*	−0.236**
	(0.118)	(0.117)
GDPgrowth	−0.739***	−0.757***
	(0.257)	(0.258)
GDP	−1.476	−0.762
	(1.026)	(0.949)
Anti-self-dealing	9.536**	13.801***
	(4.724)	(4.800)
Intercept	80.791***	116.130***
	(22.496)	(39.300)
Adjusted R^2	0.045	0.044
F-statistic	2.25	2.25
p-value	0.000	0.000
Observations	856	856

Notes: The dependent variable is the winsorized IPO first-day return (1st–99th percentile) measured on the listing day. FinLit is the country-level percentage of financially literate adults from the S&P Global Financial Literacy Survey; FinLit^2 is its squared term to capture non-linear effects. DigLit is the country-level digital literacy score from the Global Competitiveness Index (World Economic Forum); DigLit^2 is its squared term. The quadratic specifications allow for a non-monotonic U-shaped relationship between literacy and IPO first-day returns. Offer Size is the natural logarithm of gross proceeds in million euros. Firm Age is the natural logarithm of years since company founding. Overallotment is an indicator equal to one if the IPO includes an over-allotment (greenshoe) option, zero otherwise. Multibookrunner is an indicator equal to one if the IPO is managed by multiple bookrunners, zero otherwise. VCbacked is an indicator equal to one if the issuing firm is venture capital-backed, zero otherwise. Hot Market is an indicator equal to one if the IPO is issued during a period of above-average issuance volume, zero otherwise. FDI is foreign direct investment net inflows as a percentage of GDP. GDP Growth is the annual real GDP growth rate of the issuer's home country. GDP is the natural logarithm of the issuer's home country nominal GDP in current USD. Anti-self-dealing is the country-level anti-self-dealing index from Djankov et al. (2008), capturing legal protection of minority shareholders. Reference categories are: Western Europe (regional); January (month); Consumer Products and Services (macro industry). All specifications include regional, month-of-issuance and macro industry fixed effects. Heteroskedasticity-robust standard errors (White, 1980) are employed throughout and are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively (* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$).

example, in column 1, older firms experience approximately 4.05 pp lower underpricing per unit increase in log FirmAge, supporting the information asymmetry hypothesis wherein mature firms face less ex-ante valuation uncertainty (e.g., Akyol et al., 2014; Ljungqvist, 1997; Ritter, 1984). Older firms have longer track records which lowers uncertainty and thus underpricing, aligning with established findings in the literature (Ritter, 2003). Overallotment options associate positively with underpricing, likely reflecting endogenous selection for anticipated high-demand issues. Greater capital openness (higher FDI) and higher GDP growth correlates with lower underpricing, consistent with increased investor sophistication and competitive pricing in globalized markets. The

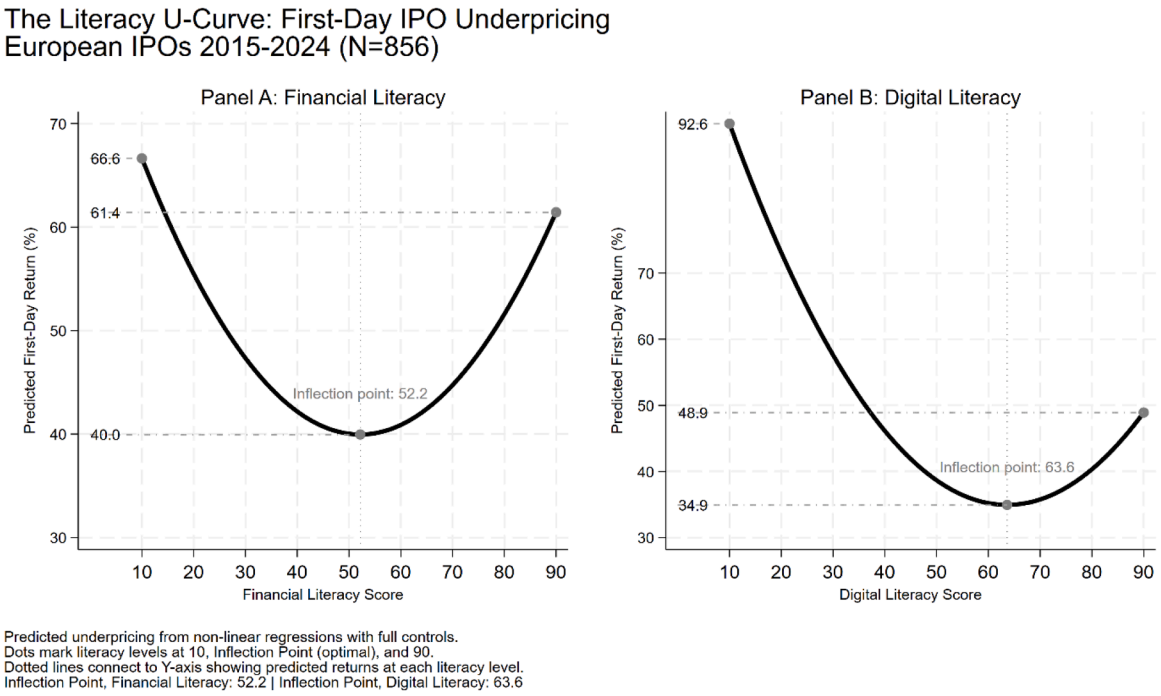


Fig. 1. U-shape relationship between literacy and underpricing of European IPOs.

remainer covariates have little or nonsignificant impact in our European IPO sample. This aligns with the inherent unpredictability of IPO first-day returns, where idiosyncratic factors (media coverage, retail investor sentiment, allocation mechanisms) dominate systematic determinants. The F-statistics (2.25 and 2.25, both Prob > F = 0.0001) confirm joint significance of all regressors, validating model specification, and visual representation of the turning points is shown in Fig. 1.

To address concerns regarding the temporal stability of literacy measures—both of which are effectively time-invariant in our panel—we perform a sub-period robustness check splitting the sample into two windows: 2015–2019 and 2020–2024. Table 5 reports results across these restricted periods. The U-shaped pattern for Financial Literacy persists in both sub-periods (e.g., 2015–2019: $\beta_1 = -3.114$, SE = 1.496, p = 0.038; $\beta_2 = +0.029$, SE = 0.014, p = 0.038), confirming that the non-linear relationship is not an artefact of pooling across structurally distinct market regimes or of applying a single cross-sectional literacy measure to a long panel. Digital Literacy coefficients retain the expected signs across both windows, though precision is reduced as expected given the smaller sub-period samples, consistent with the weaker and more marginal role of digital literacy documented in the full-sample analysis (Table 4). These findings suggest the literacy effects identified in Table 4 reflect persistent cross-country structural differences in investor sophistication that remain economically meaningful across different market conditions, including the COVID-19 disruption period, rather than being driven by spurious time-series variation in a statically measured regressor.

3.3. *Visual evidence and robustness*

Fig. 1 plots the U-shaped relationships from fitted quadratic regressions. Panel A (Financial Literacy) exhibits a pronounced valley at score 52.2, with predicted underpricing approximately 13.7 pp higher at the lower bound of the observed range (score 22) and 5.3 pp higher at the upper bound (score 71). The steeper curvature in Panel A, relative to Panel B (Digital Literacy), underscores financial literacy's dominant role. Confidence bands widen at distribution tails, particularly below 30% literacy, where only Romania (22), Turkey (24), and Portugal (26) provide data, reflecting increased estimation uncertainty.

Fig. 2 decomposes the U-curves into marginal effects. For financial literacy (Panel A), marginal effects transition from −9.1 pp at the bottom of the observed range (score 22) to +5.7 pp at the top (score 71), crossing zero at the interior minimum (52.2). The piecewise-linear test (with a knot at the FinLit median) confirms the asymmetry: the left-arm slope is −0.42 (SE 0.16, p = 0.010), the right-arm slope is +0.67 (SE 0.27, p = 0.013), and the test of slope equality is rejected (F(1, 822) = 7.58, p = 0.006). Although the rent-extraction (right) arm is steeper on a per-point basis, the adverse-selection (left) arm spans the wider literacy range and thus carries the larger cumulative welfare cost, so the burden of insufficient literacy exceeds that of excessive literacy; the F-test rejects the equality of the two slopes, not a particular ordering of their magnitudes. For instance, a 10-point rise from 22 to 32 reduces predicted underpricing by approximately 7.6 pp, whereas a comparable rise in the upper tail (61 to 71) raises it by approximately 4.1 pp as sophisticated investors extract rents. Digital literacy (Panel B) shows a similarly asymmetric pattern: the left-arm slope is −0.38 (p = 0.053) and the right-arm slope is +0.51 (p = 0.049), with the equality of slopes rejected at F(1, 822) = 4.88, p = 0.027.

Fig. 3 provides non-parametric corroboration. For financial literacy (Panel A), residualised underpricing within deciles traces a

Table 5
Estimations result on IPO underpricing: sub-period analysis (2015–2019 and 2020–2024).

	(1) FinLit 2015–19	(2) FinLit 2020–24	(3) DigLit 2015–19	(4) DigLit 2020–24
FinLit	−3.114**	−1.388*		
	(1.496)	(0.772)		
FinLit^2	0.029**	0.013*		
	(0.014)	(0.008)		
DigLit			−5.848*	−2.568*
			(3.052)	(1.391)
DigLit^2			0.045*	0.020*
			(0.023)	(0.011)
Offersize	−2.217*	−2.079**	−1.951	−2.164***
	(1.289)	(0.837)	(1.290)	(0.829)
Firmage	−3.867*	−4.110**	−3.741*	−4.224**
	(2.130)	(1.822)	(2.106)	(1.810)
Overallotment	9.024***	8.316**	8.631***	8.851***
	(3.306)	(3.217)	(3.316)	(3.135)
Multibookrunner	10.756	−5.845*	9.395	−6.386*
	(7.701)	(3.499)	(7.753)	(3.458)
VCbacked	−5.306	−2.833	−6.452	−3.037
	(4.054)	(5.806)	(4.065)	(5.718)
Hotmarket	0.453	−3.565	−0.048	−3.044
	(2.785)	(2.987)	(2.817)	(2.866)
FDI	−0.317	−0.298*	−0.359*	−0.295*
	(0.209)	(0.178)	(0.211)	(0.174)
GDPgrowth	0.983	−0.787***	1.135	−0.820***
	(0.965)	(0.287)	(0.954)	(0.291)
GDP	−0.778	−1.213	1.786	−0.876
	(1.537)	(1.089)	(1.703)	(1.081)
Anti-self-dealing	7.275	12.022*	14.404**	16.603**
	(6.228)	(6.981)	(6.598)	(7.208)
Intercept	98.587**	69.884***	181.531**	112.109**
	(45.545)	(21.617)	(89.223)	(44.399)
Adjusted R^2	0.051	0.035	0.048	0.035
F-statistic	1.57	1.82	1.56	1.90
p-value	0.051	0.013	0.053	0.009
Observations	379	477	379	477

Notes: The dependent variable is the winsorized IPO first-day return (1st–99th percentile) measured on the listing day. FinLit is the country-level percentage of financially literate adults from the S&P Global Financial Literacy Survey; FinLit^2 is its squared term to capture non-linear effects. DigLit is the country-level digital literacy score from the Global Competitiveness Index (World Economic Forum); DigLit^2 is its squared term. The quadratic specifications allow for a non-monotonic U-shaped relationship between literacy and IPO first-day returns. Offer Size is the natural logarithm of gross proceeds in million euros. Firm Age is the natural logarithm of years since company founding. Overallotment is an indicator equal to one if the IPO includes an over-allotment (greenshoe) option, zero otherwise. Multibookrunner is an indicator equal to one if the IPO is managed by multiple bookrunners, zero otherwise. VCbacked is an indicator equal to one if the issuing firm is venture capital-backed, zero otherwise. Hot Market is an indicator equal to one if the IPO is issued during a period of above-average issuance volume, zero otherwise. FDI is foreign direct investment net inflows as a percentage of GDP. GDP Growth is the annual real GDP growth rate of the issuer's home country. GDP is the natural logarithm of the issuer's home country nominal GDP in current USD. Anti-self-dealing is the country-level anti-self-dealing index from Djankov et al. (2008), capturing legal protection of minority shareholders. Reference categories are: Western Europe (regional); Consumer Products and Services (macro industry). All specifications include regional, and macro industry fixed effects. Heteroskedasticity-robust standard errors (White, 1980) are employed throughout, and are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively (* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$).

clear U-pattern. A bin-size-weighted quadratic fit through the decile means reaches its minimum at financial literacy = 48.7, close to the parametric estimate of 52.2 from Fig. 1. The 3.5-point gap reflects the discreteness of country-level literacy scores: because each country contributes its IPOs to a single decile, small national clusters exert disproportionate leverage on the binned regression. The weighted fit explains 54.8% of cross-bin variation ($R^2 = 0.548$), confirming that our parametric specification captures the data-generating process rather than imposing it. Panel B (Digital Literacy) shows the same U-shape with a binned vertex at 62.6 — essentially identical to the parametric inflection of 63.6 — and a lower R^2 of 0.141, reflecting the weaker but still significant role of digital literacy.

3.4. Robustness and theoretical interpretation

The appendix robustness checks—piecewise-linear asymmetry in Table A.1, the Sasabuchi–Lind–Mehlum U-shape test in Table A.2, and the quartile-based predicted-underpricing pattern in Table A.3—jointly corroborate the U-shaped literacy–underpricing relation and show the result is robust to alternative functional forms and non-parametric inspection. The U-shaped literacy-underpricing

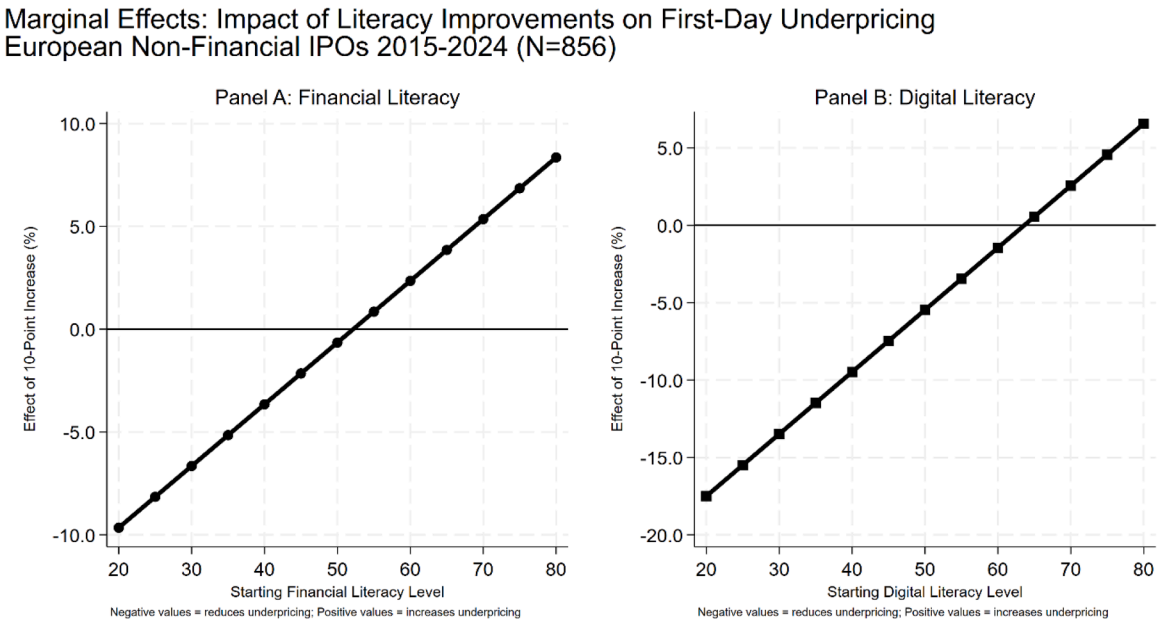


Fig. 2. Marginal effects impact on underpricing of European IPOs.

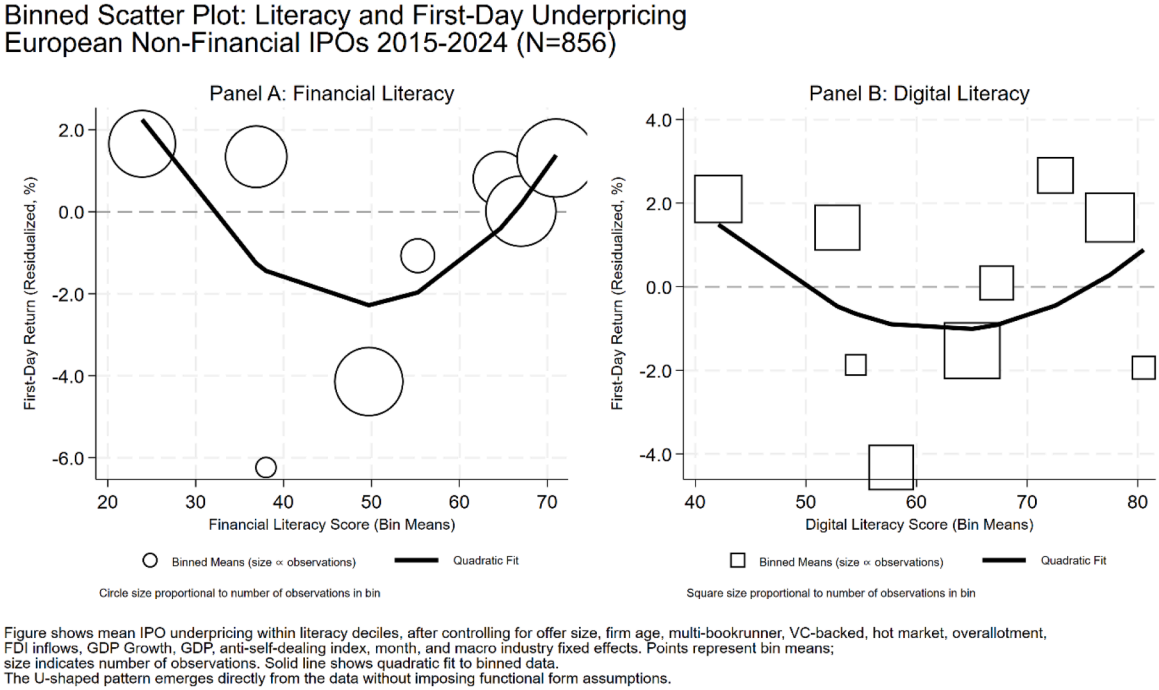


Fig. 3. Binned scatter plot: literacy and underpricing of European IPOs.

relationship reconciles competing theoretical narratives operating at different literacy levels. At low literacy (left arm), retail investors struggle to differentiate IPO quality, amplifying adverse selection and forcing issuers to underprice severely to compensate for "lemon" risk (Akerlof, 1970; Rock, 1986). Consistent with Rock's (1986) foundational analysis, retail investors in markets with limited financial sophistication cannot reliably differentiate between high-quality and low-quality IPO issuances. Conversely, at high levels of financial literacy, sophisticated investors strategically extract rents, demanding greater underpricing in exchange for participation and

favorable analyst coverage (Loughran and Ritter, 2002). At intermediate financial literacy, information asymmetry is sufficiently reduced, yet investors lack concentrated bargaining power to extract rents. This represents the unique equilibrium where both frictions are simultaneously minimized. At this literacy threshold, retail investors might possess sufficient financial knowledge to reduce information risk (thereby lowering adverse selection premiums), yet no investor cohort maintains concentrated bargaining power (thereby limiting rent extraction). Rock's and Loughran & Ritter's models are not mutually exclusive but rather operate across different literacy regimes, with the non-linear structure revealing that both adverse selection and rent extraction are economically significant but regime-dependent phenomena. This "Inflection Point zone" minimizes underpricing, minimizing wealth transfers from issuers to first-day investors. A definitive test of the rent-extraction channel would require data on individual institutional allocations and broker commissions (Reuter, 2006). We interpret our country-level results as consistent with, but not uniquely identifying, the Loughran and Ritter (2002) mechanism. We note that underpricing is a primary-market phenomenon — the offer-price discount compensates uninformed investors for adverse selection in allocation (Rock, 1986) — and does not presume that first-day secondary-market prices equal fundamental value.

4. Conclusions

This study contributed to address a fundamental puzzle in IPO pricing: why do highly literate markets exhibit substantial underpricing despite superior information processing capabilities? Across 856 European IPOs (2015–2024) from 26 countries, we document a U-shaped relationship between country-level literacy and first-day returns, with predicted underpricing minimised at financial-literacy score 52.2 and digital-literacy score 63.6, both interior to their observed ranges. The mechanisms underlying this non-linear pattern reconcile competing theoretical frameworks. At low literacy levels, information asymmetry dominates, forcing issuers to underprice by approximately 13.7 pp at the bottom of the observed financial-literacy range (score 22) to offset adverse-selection costs (Rock, 1986). At high literacy levels, sophisticated institutional investors extract rents, raising underpricing by approximately 5.3 pp at the top of the observed financial-literacy range (score 71). While Jia et al. (2024) demonstrate that greater country-level financial literacy is generally associated with *lower* IPO underpricing—an effect that intensifies in less transparent information environments —our finding refines this aggregate relationship by identifying a threshold effect: at very high literacy levels, informed institutional investors re-assert bargaining power, thereby reversing the downward pressure on underpricing. This pattern is consistent with the agency hypothesis that underwriters underprice IPOs to secure commission business from institutional investors (Loughran and Ritter, 2002), and aligns with theoretical frameworks emphasizing the role of informed institutions in mitigating information asymmetry and capturing rent-extraction opportunities (Chemmanur et al., 2010; Hanley and Wilhelm Jr, 1995). Together, these results suggest that the beneficial impact of financial literacy on reducing underpricing diminishes once investor sophistication reaches a level that enables strategic rent extraction by institutions through underwriter-allocation mechanisms. Critically, the asymmetric magnitude—adverse selection effects exceed rent extraction effects—indicates that information asymmetry, not investor sophistication, is the primary driver of underpricing across our sample. At intermediate financial literacy levels (the Inflection point zone), both mechanisms are minimized, yielding the lowest predicted underpricing in the sample (Q2 mean $\approx$ 6.1 pp; see Table A.3).

These findings complement the linear cross-country evidence of Jia et al. (2024) by isolating the regime in which the financial-literacy effect reverses sign and extend the recent corruption-and-IPO evidence of Khiar and Kooli (2026) by adding human-capital sophistication to the institutional-quality story. From a policy perspective, our results suggest that one-size-fits-all financial literacy initiatives may be suboptimal; heterogeneity in investor sophistication across markets requires tailored approaches. Regulators in high-literacy markets might consider pricing mechanisms (e.g., auction-based pricing) to constrain rent extraction, while those in low-literacy markets should prioritize investor education to reduce adverse selection costs.

Our results are consistent with, but do not uniquely identify, the Loughran and Ritter (2002) coalition mechanism. Future research with deal-level allocation data—such as Reuter (2006) for U.S. IPOs—could provide direct identification of the broker–institution channel in European markets. Future research should also explore multiple dimensions of this literacy-underpricing relationship. First, whether Inflection Point thresholds generalize across alternative security types—corporate bonds, seasoned equity offerings—remains an open question, particularly in emerging markets. Second, longitudinal studies examining literacy effects on long-run IPO performance would clarify whether underpricing reflects pure pricing inefficiency or rational compensation for undiversifiable risk. Third, cross-sectional analysis of whether literacy thresholds vary with institutional features (banking regulations, investor protection standards) would reveal how human capital and formal institutions jointly determine market outcomes. Finally, the construction of time-varying, panel-compatible measures of financial and digital literacy at the country level — with sufficient cross-European coverage — represents a pressing data infrastructure priority; as such measures become available, future work can disentangle the within-country dynamic evolution of literacy from the cross-country structural differences documented here.

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CRediT authorship contribution statement

Ricardo Emanuel-Correia: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft. **Sónia R. Bentes:** Conceptualization, Data curation, Formal analysis, Funding acquisition,

Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A.1
Piecewise-linear tests of asymmetric literacy effects on IPO underpricing.

	Financial literacy	Digital literacy
Panel A: piecewise-linear slope tests		
Left-arm slope	−0.417	−0.375
	(0.161)	*(0.194)*
Right-arm slope	+0.670	+0.514
	(0.269)	*(0.260)*
Panel B: F-test of slope equality		
F-statistic	7.58	4.88
p-value	0.006	0.027

Notes: Standard errors in parentheses. The piecewise-linear specification splits each literacy index at its estimated optimal point and estimates separate slopes below (left-arm) and above (right-arm) that threshold. The F-test evaluates the null hypothesis that the two arm slopes are equal. Rejection of this null confirms the asymmetric (U-shaped) relationship between literacy and IPO underpricing. Sample: N = 856 European IPOs, 2015–2024.

Table A.2
Sasabuchi–Lind–Mehlum U-shape test: slopes at bounds for literacy measures.

	Financial literacy	Digital literacy
Panel A: Variable range		
Sample range	[22; 71]	[42.08; 80.53]
Panel B: Slopes at bounds (Sasabuchi–Lind–Mehlum Test)		
Slope at minimum	−0.905	−0.864
	[−2.427]	*[−2.129]*
	(0.008)	(0.017)
Slope at maximum	+0.565	+0.679
	[2.241]	*[2.062]*
	(0.013)	(0.020)
Panel C: Joint Sasabuchi Test (H₀: monotone)		
Joint p-value	0.013	0.020

Notes: t-statistics in square brackets; one-tailed p-values in parentheses. The Sasabuchi (1980) test, as operationalized by Lind and Mehlum (2010), requires a statistically significant negative slope at the lower bound of the literacy variable and a statistically significant positive slope at the upper bound. Rejection of the joint null of monotonicity confirms a U-shaped relationship within the observed data range. Financial literacy range: 22–71 (S&P Global FinLit Survey). Digital literacy range: 42.08–80.53 (WEF Global Competitiveness Index). Sample: N = 856 European IPOs, 2015–2024.

Table A.3
Predicted IPO underpricing by literacy quartile.

Quartile	Predicted UP (pp)	Std. Err.	*t*	*p*	95% CI
Panel A: Financial literacy quartiles					
Q1 (Lowest)	13.99	1.980	7.06	0.000	[10.10, 17.88]
Q2	6.13	2.155	2.84	0.005	[1.90, 10.36]
Q3	14.14	2.833	4.99	0.000	[8.58, 19.70]
Q4 (Highest)	14.14	2.658	5.32	0.000	[8.92, 19.36]
Panel B: Digital literacy quartiles					
Q1 (Lowest)	14.81	2.001	7.40	0.000	[10.88, 18.74]
Q2	5.89	2.212	2.66	0.008	[1.55, 10.23]
Q3	11.30	2.384	4.74	0.000	[6.62, 15.98]
Q4 (Highest)	15.07	2.403	6.27	0.000	[10.35, 19.79]

Notes: Adjusted predictions (margins) evaluated at the mean of all covariates (atmeans). Dependent variable is IPO first-day return (underpricing, percentage points). Quartiles are constructed from the country-level literacy score distributions: Financial Literacy Q1 ≤ Q2 ≤ Q3 ≤ Q4 (S&P Global FinLit Survey); Digital Literacy Q1 ≤ Q2 ≤ Q3 ≤ Q4 (WEF Global Competitiveness Index). Bold rows indicate the global minimum (Q2) in each panel. Standard errors are delta-method robust. The pronounced V-shape with interior minimum at Q2 — not at the distributional mean — corroborates the U-shaped quadratic specification and confirms the adverse-selection regime dissipates rapidly once a country exits the lowest-literacy quartile. N = 856 European IPOs, 2015–2024.

Data availability

Data will be made available on request.

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