“Nonlinear determinants of listing day returns: Evidence from spline regression analysis”

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NONLINEAR DETERMINANTS OF LISTING DAY RETURNS: EVIDENCE FROM SPLINE REGRESSION ANALYSIS

Abstract

This study aims to identify the nonlinear determinants of listing day returns globally using a comprehensive dataset. It further examines the regional distinctions and complexities in the international context using spline regression analysis. It also assesses variation in the linear and nonlinear relationships of listing day returns and their determinants across various geographical regions worldwide. Using a set of 8,914 initial public offerings issued across the globe from January 2011 to October 2024, this study employs a restricted cubic spline methodology. Spline knots for each determinant under study were identified to examine the nonlinear influence of the already studied determinant variables. The results of the analysis depict the offer price and listing delay as major non-linear determinants, whereas issue size and market timing significantly influence listing day returns based on linear analysis. In addition, it was found that the Asia-Pacific market substantially differs from other markets geographically, based on splines. The findings of this study provide valuable insights for associated stakeholders by focusing on issue performance, predictions, and market understanding. There is a substantial presence of nonlinear relations among listing day returns and their determinants worldwide.

Keywords initial public offerings, spline, listing

JEL Classification G01, G10, G15

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INTRODUCTION

The listing price is the most extensively researched anomaly in initial public offering (IPOs) research. After decades of research on IPO pricing, varied opinions prevail in the context of IPO listing, success, and uncertainty. IPOs and their associated pricing hold significant essence, as they not only provide various financing opportunities but also lead to brand enhancement, capital acquisition through subsequent offerings, growth initiatives, and sustained liquidity for issuers. Many investors invest in IPOs because they perceive them as one of the safest investment options in the stock market. Researchers worldwide have discussed theories based on determinants such as issue size, offer price, market timing, and listing delay as proxies for the associated listing price anomalies. These theories are intrinsically based on factors or determinants associated with company-, issue-, market-, and country (institution)-specific aspects. However, studies on nonlinear calculations and associated concepts have not received sufficient attention. This study is relevant as it not only uncovers the non-linear determinants of IPO listing day returns but also compares them to linear analysis across global markets using advanced statistical methods on a comprehensive dataset.

1. LITERATURE REVIEW

Research around listing day returns had matured considerably over a period of more than five decades. Various perspectives on listing day returns for initial public offerings (IPOs) have been studied in detail across the globe (Figure 1). However, the available literature primarily discusses the linear determinants of listing day returns, as prior studies primarily focus on linear analysis. Since the inception of research on listing day returns, they have been illustrated as a function of premarket trading activity, quality of disclosed information, analyst reports, media reports, information revelation in book-building, and local information networks (Zhang et al., 2023; Boulton et al., 2020; Chang et al., 2024; Wadhwa & Sahoo, 2024).

Various theories have been proposed (Allen & Faulhaber, 1989; Carter & Manster, 1990; Rock, 1986; Welch, 1992) that illustrate and substantially contribute to the relevance of the determinants of listing day returns. Linear analysis has established that these theories have a collective influence and are not mutually exclusive (Ritter, 1991). To examine the role of determinants in predicting listing day returns, a nonlinear analysis discussion associated with the linear prediction of determinants needs to be studied. Focusing on the size of the issue, as illustrated by issue size, indicates the amount of capital expected to be raised through the public sale of shares. Existing research (Ritter, 1987; Ritter, 1991; Hanley, 1993; Lee et al., 1996; Hansen, 2001; Lowry & Schwert, 2004; Kirkulak & Davis, 2005) discusses the relevance of size in determining listing-day returns and offers mixed evidence on issue sizes with listing-day returns. It has been illustrated that issue size may generate high listing day returns beyond a certain point (Arora & Singh, 2025; Albada et al., 2019; Lin et al., 2013; Low & Yong, 2011; Mehmood et al., 2020). Aligned with the existing literature, the present study also uses the natural logarithm of the issue amount for issue-size determination (Liu et al., 2023; Lizinska & Czapiewski, 2018). Similarly, the relevance of offer prices to IPO research is formalized in Welch (1992). It is the price at which IPO shares are issued and reflects a firm's intrinsic value. It provides an overview of the information available in public and private domains. Various studies (Chowdhry & Sherman, 1996; Bradley & Jordan, 2002; Low & Yong, 2011; Badru & Ahmad-Zaluki, 2018; Arora & Singh, 2025; Mehmood et al., 2020) have offered insights into the relevance of offer prices to investor demand based on the context of demand derivation. For further analysis, the natural logarithm of the offer price was used to study its influence. In addition, the listing delay, which is studied based on the time interval between the issue-closing date and the listing date, is considered for its influence. The share market situations and regulatory norms vary across countries on listing days (Chen et al., 2022; Low & Yong, 2011). Findings based on linear analysis in the existing literature illustrate that a higher listing lag results in lower demand, as investors have time to process the information. In addition, the opportunity cost of jamming capital prevents investors from investing (Chowdhry & Sherman, 1996; Zouari et al., 2009; Low & Yong, 2011; Arora & Singh, 2025). Furthermore, delays in listing may decrease stock liquidity. Similarly, market timing significantly predicts the level of listing day returns in the linear analysis (Baker & Wurgler, 2007). Increased

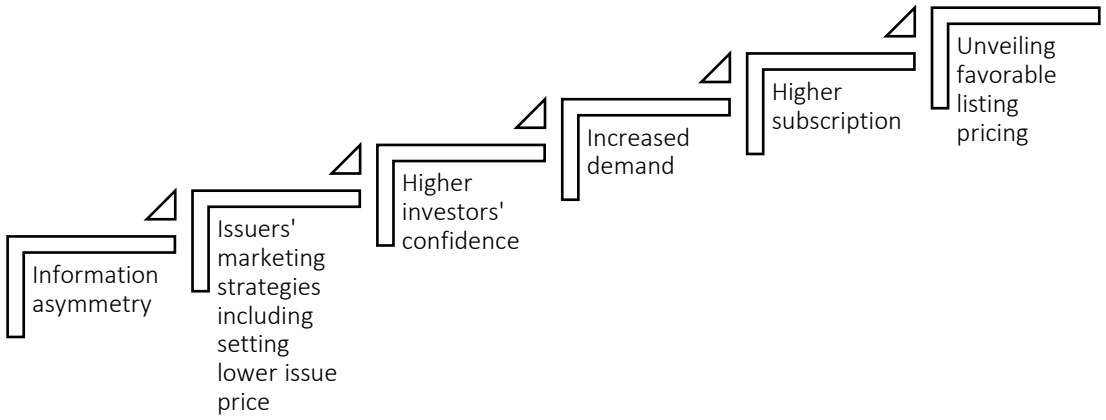

Figure 1. Evolution of listing day returns

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investor confidence and participation propensity correlate with increased growth multiples and demand for issues that ultimately result in elevated early returns (Gounopoulos. 2023; Arora & Singh, 2025; Kaustia & Knupfer, 2012; Low & Yong, 2011; Rathnayake et al. 2022) because of market timing. Recently, Zhang (2024), Obrimah (2023), Liu et al. (2023), Arora and Singh (2025), Ichev (2023), Ma et al. (2022), Rossovski (2025), Suresha et al. (2023), Li and Aumeboonsuke (2025), and Barrett et al. (2025) illustrated varied perspectives of listing day returns in a contemporary setting. The findings in the existing literature demonstrate how listing day returns vary across nations in the context of issue determinants. Informed investors exploit superior knowledge, also known as the winner's curse (Rock, 1986). If studied in the context of nonlinearity, it symbolizes extreme intensification, such as high-uncertainty firms ultimately creating threshold effects where under-pricing jumps (Żyła, 2021). Similarly, under the Adverse Selection theory, issuers holding private information influence firm quality. The spline depicts concave relationships in this context as underpricing rises and then plateaus with R&D intensity, a proxy for opacity (Hoque, 2014). Signaling, in a nonlinear scenario, shows that the optimal signal strengthens nonlinearly with dispersion quality (Korsten, 2018). In the context of Information Revelation Models, nonlinearity emerges from partial pooling (Korsten, 2018), further amplified by underwriters as underpricing compensates for demand uncertainty revelation based on nonlinear effects from oligopoly power (local markets) (Boeh & Dunbar, 2016). In the context of Behavioral Extensions, focuses on investor sentiment, overoptimism cascades, and the amplification and reversal of fear (Michel et al., 2021).

Issuer and managerial biases, as part of prospect theory loss aversion, illustrate nonlinear interactions with asymmetry with respect to splines that reveal regime shifts (Deepak & Gowda, 2014). However, Obrimah (2023) provided dynamic and game theory-based integration around systemic uncertainty driving nonlinear evolution based on knot-like transitions. It provided a unified idea using splines while operationalizing flexible tests of threshold regression equivalents, advancing linear OLS by endogenizing interactions. These findings illustrate the influence of determinants in predicting the level of listing day returns; however, the nonlinear perspective of this influence remains unexplored. Thus, this study aims to identify the nonlinear determinants of listing day returns globally using a comprehensive dataset. The conventional IPO research framework is predominantly based on linear analysis to identify drivers. However, the idea that IPO determinants behave nonlinearly has its roots in multifaceted strategic interactions, psychological thresholds, and institutional rigidities, usually visualized in thresholds, diminishing returns, or reversals. (Karlis & Stumph, 2000). The central idea of nonlinearity in IPO studies is that the marginal impact of any determinant is not constant across the distribution of initial returns. The strategic environment of an IPO is a classic application of game theory, where issuers, underwriters, and investors act rationally to maximize benefits or mitigate losses. Spline analysis was used to identify these nonlinear dynamics. The transition from linear to nonlinear in IPO research represents evaluations from simplistic to a deeper understanding of market reality.

This study aims to study the nonlinear determinants of listing day returns globally using nonlinearity-based spline regression, and hypothesizes that:

H_1: *There is no significant relation between issue determinants and listing day returns.*

H_2: *There is no significant difference between the type of relation issue determinants and listing day returns across varied geographic regions.*

2. METHOD

The present study used secondary data derived from Bloomberg. As we focus on companies with initial public issues worldwide, an initial sample set of 15,347 issuers across the world database for the period 2011–2024 was created. From this initial sample, 2,145 financial issuers and 4,288 issuers with insufficient data were excluded to obtain a final sample of 8,914 issuers across the world.

Table 1. Sample derivation

Sampling Criteria	Number
Panel I: Selection Criteria	
Initial Sample	15347
Less: Financial issuers	2145
Less: Unavailable data	4288
Final Sample	8914
Panel II: Area-wise Division	
Asia Pacific (Developed)	1565
Asia Pacific (Emerging)	5825
Eastern Europe	192
Latin America and the Caribbean	96
Middle East and Africa	175
North America	146
Western Europe	914

As presented in Table 1, the majority of the data were contributed by the Asia Pacific (emerging), followed by the Asia Pacific (developed), illustrating the contribution of Asian nations worldwide. This sample set was contributed by 88 nations and segregated into six geographical regions based on Bloomberg's data segregation. We use the offer to 1st open as a proxy for listing day returns. The calculated percentages are directly available in the Bloomberg database. To evaluate the factors predicting listing day price, offer size, offer price, listing delay, market timing (both issue size-based and number-based), debt-to-equity, profitability, return on assets, and revenue per share were used as the independent variables. The description of the same is illustrated in Table 2. In addition, industry, time, and nation dummies were used to control for their effects.

Based on the literature, ordinary linear square regression is used to evaluate the influence of issue characteristics on the listing day returns. Prior to conducting the regression analysis, basic regression assumptions were made. The presence of multicollinearity, heteroscedasticity, serial correlation, and outliers was studied and controlled for using winsorization and the robust data function available in STATA. Equation (1) depicts the relationship between listing day returns and possible determinants, assuming a linear function.

Table 2. Variable description

Type	Variable name	Description	Source and Calculation
Dependent variable	Listing Day returns (%)	Offer to1st open	Used as available on Bloomberg
Independent variables	Issue size (million $)	Total issue amount	Natural log of Issue size
	Offer price ($)	Price at which shares are offered	Natural log of the offer price as on the date of issue
	Listing delay	Difference between the first open on listing and the offer date	Natural log of the difference
	Market timing (issue size)	Presents favorable market conditions for issuers	Dummy = 1 if the monthly issue amount > 3-month moving average of total IPO proceeds per calendar month
	Market timing (issue number)	Presents favorable market conditions for issuers	Dummy = 1 if the monthly number of issues > 3-month moving average of the number of IPOs per calendar month
	Debt to Equity (ratio)	Predicts the presence of leverage in an organization at the time of issue	Used as available on Bloomberg
	Profitability (%)	Profit margin	Used as available on Bloomberg
	Return on assets	Return generated over the total assets of the issuer	Used as available on Bloomberg
	Revenue per share	Income generated per share	Used as available on Bloomberg
	Industry dummy	Dummy variable for the industry the company belongs to	Used as available on Bloomberg
	Year dummy	Dummy variable for year	Used as available on Bloomberg
	Nation dummy	Dummy variable for the nation a company belongs to	Used as available on Bloomberg

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$$\begin{aligned} &Listing\ day\ returns_{i,t} = \beta_1 + \beta_2 Issue\ size_{i,t} \\ &+\beta_3 Offer\ price_{i,t} + \beta_4 Listing\ delay_{i,t} \\ &+\beta_5 Market\ timing\ \left(issue\ size\right)_{i,t} \\ &+\beta_6 Market\ timing\ \left(issue\ number\right)_{i,t} \\ &+\beta_7 Debt\ to\ equity_{i,t} + \beta_8 Return\ on\ assets_{i,t} \\ &+\beta_9 Revenue\ per\ share_{i,t} \\ &+\beta_{10} Year\ dummy_{i,t} + \beta_{11} Industry\ dummy_{i,t} \\ &+\beta_{12} Nation\ dummy_{i,t} + \varepsilon_{i,t}. \end{aligned} \quad (1)$$

Splines facilitate the visualization of interactions between variables without considering linearity or alternative functional forms. The details of the variable mentioned in the equation are illustrated in Table 2. In this study, we used both linear and nonlinear analyses. This can be achieved by dividing the independent variable under study into one or more parts and presenting it in the form of a separate polynomial for each part. Therefore, splines are created as piecewise polynomials whose segments are slickly joined together at knots (Eubank, 2002). Here, a knot is the point at which one-part ends, and the other begins (Shao, 2000). This provided greater flexibility by effectively adjusting the local characteristics of the data. Based on this concept, we used a restricted cubic spline. An automatic spline function is used with STATA based on quantile bifurcation for the offer price and listing delay spline. The variables under study are segmented based on knots, thus creating a set of multiple sub-variables for each variable in accordance with the knot. The analysis was conducted from various perspectives. Equation (2) depicts the formulation of the spline regression.

$$\begin{aligned} &Listing\ day\ returns_{i,t} = \beta_1 + \beta_2 Issue\ size_{i,t} \\ &+\beta_3 Offer\ price\ spline_{i1,t} \\ &+\beta_4 Offer\ price\ spline_{i2,t} \\ &+\beta_5 Offer\ price\ spline_{i3,t} + \beta_6 Listing\ delay_{i1,t} \\ &+\beta_7 Listing\ delay_{i2,t} + \beta_8 Listing\ delay_{i3,t} \\ &+\beta_9 Market\ timing\ \left(issue\ size\right)_{i,t} \\ &+\beta_{10} Market\ timing\ \left(issue\ number\right)_{i,t} \\ &+\beta_{11} Debt\ to\ equity_{i,t} + \beta_{12} Return\ on\ assets_{i,t} \\ &+\beta_{13} Revenue\ per\ share_{i,t} + \beta_{14} Year\ dummy_{i,t} \\ &+\beta_{15} Industry\ dummy_{i,t} \\ &+\beta_{16} Nation\ dummy_{i,t} + \varepsilon_{i,t}. \end{aligned} \quad (2)$$

3. RESULTS

Further insight into the LDR level around prominent regions is considered when conducting a descriptive analysis of listing day returns. As shown in Figure 3, the highest level of the amount left by issuers is from developed Asia-Pacific issuers, followed by emerging Asia-Pacific issuers, whereas the lowest level of LDR is reported in Europe, contributed by both Eastern and Western Europe. The results show that the Asia-Pacific markets are largely responsible for the listing day-return trends. These findings support the view that listing day returns or LDR are low for countries that are well-integrated with the global economy (Marcato et al., 2018; Baker et al., 2021; Ichev, 2023; Ma et al., 2022; Rossovski, 2025; Suresha et al.,2023)

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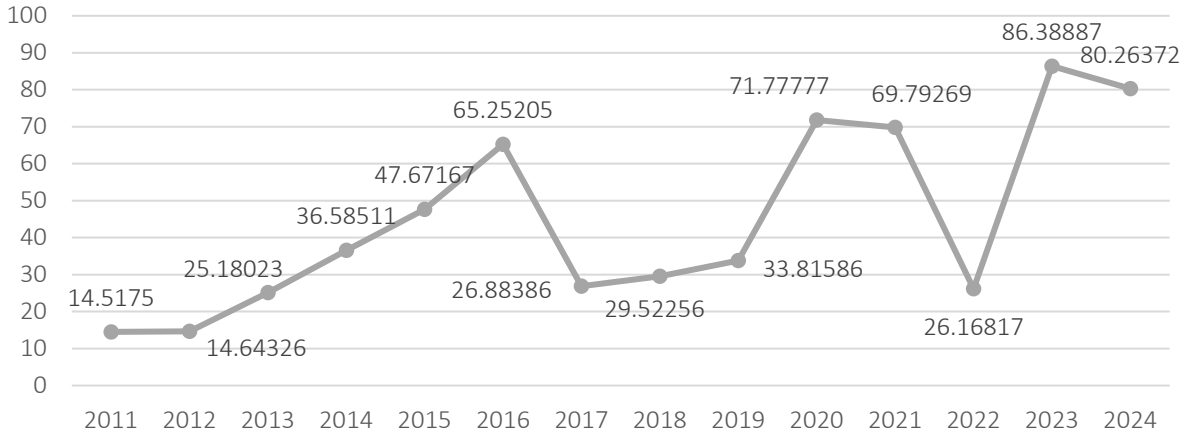

Figure 2. Listing day returns across the globe

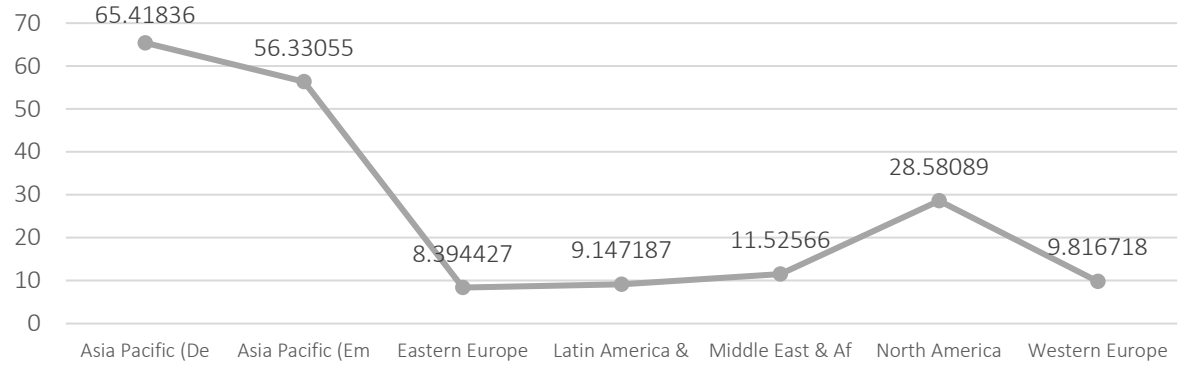

Figure 3. Regional listing day returns across the globe

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After analyzing the descriptive statistics, Table 3 presents a correlation analysis to depict the possible relationships between the variables. In addition, the analysis aimed to study the possible presence of multicollinearity among the variables. This table presents issue size and profitability as the major variables that significantly predict variations in the listing day returns. This demonstrates that there is a relationship between listing day returns and their determinants. However, the negative correlation coefficients for both variables, issue size (–0.040) and profitability (–0.094), indicate that issuers with large issue sizes and high profitability do not underprice their shares or leave money on the table on listing days to attract investor interest. In addition, no variable had a coefficient greater than 0.8 (Gujarati & Porter, 2004), indicating the absence of considerable multicollinearity in the data. The results with no multicollinearity are also supported by the figures presented in the Variance Inflation Factor in Table 4.

Table 4. Variance inflation factor

	VIF	1/VIF
Issue size	1.067	.937
Listing delay	1.098	.911
Offer price	1.183	.845
Debt to Equity	1.076	.93
Profitability	1.384	.722
Return on assets	1.448	.691
Revenue per share	1.164	.859
Market timing (issue amount)	1.107	.904
Market timing (number of IPOs)	1.097	.912
Mean VIF	1.18	.

Table 3. Correlation matrix

Variables	LDR	Issue size	Offer price	Listing delay	Debt to Equity	Profitability	Return on assets	Revenue per share
LDR	1.000							
Issue size	–0.040***	1.000						
Offer price	–0.004	0.041***	1.000					
Listing delay	0.000	0.016	0.011	1.000				
Debt to Equity	–0.009	–0.021**	–0.011	0.002	1.000			
Profitability	–0.094***	0.024**	–0.006	–0.003	0.005	1.000		
Return on assets	–0.003	0.124***	–0.003	0.008	–0.096***	0.108***	1.000	
Revenue per share	–0.003	–0.002	0.003	–0.008	0.020*	0.001	–0.005	1.000

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

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In the context of regression analysis, initially, a cross-sectional ordinary least squares (OLS) analysis is conducted to study the determinants of listing day returns worldwide. This is presented for both the normal and robust standard errors. Table 5 presents a statistically significant coefficient for the issue size. However, a negative value indicates that large issuers avoid underpricing because they do not need to attract investors. Lin et al. (2013), Albada et al. (2019), Mehmood et al. (2020), Arora and Singh (2025), and Boulton et al. (2020) anticipated that large issuers are less prone to information asymmetry than smaller ones. In addition, large issuers usually belong to large companies with strong financials and reputations, which attract investors. In addition, the coefficient symbolizing market timing is found to be significant. Market timing, evaluated based on the number of issuers hitting the market and the amount raised during the study period, has positive and negative coefficients. The negative coefficient (–21.79) for market timing, as calculated based on the amount raised, has an adverse influence on listing day returns.

To gain further insight into the determinants of listing day returns worldwide, an analysis was conducted based on regions. Table 5 shows the results of the robust regression for determining the factors that predict listing day returns. Consistent with the overall results, issue size is found to be adversely associated with listing day returns for all regions, except Western Europe, indicating that small issuers have higher listing day returns. The coefficient for market timing based on issue amount shows significant negative coefficients for emerging Asia-Pacific (–26.714), Latin America and the Caribbean (–91.418), and Western Europe (7.053). These findings support the overall results in the context of market timing, as large issuers do not need to leave money on the table to attract investors. They are interested in investing in larger issuers.

Observing market timing based on the number of issuers during the study period shows significant positive coefficient values of 37.786, 37.28, and 97.686 for Asia-Pacific-Emerging, Eastern Europe, Latin America, and the Caribbean, respectively, consistent with the overall results. However, Asia-Pacific – Developed has a significant negative coefficient value of –31.1, illustrating that LDR is not a function of a hot market. In addition, listing delay is found to be adversely associated with listing day returns in the case of Asia Pacific – Developed (–33.812), Eastern Europe

Table 5. Regression analysis

Listing day returns	OLS Regression		Robust Regression	
Listing day returns	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Issue size	–7.437***	0.00	–7.437***	0.00
Offer price	0.134	0.88	0.134	0.959
Listing delay	–0.536	0.705	–0.536	0.803
Market timing (issue amount)	–21.791***	0.00	–21.791***	0.00
Market timing (number of IPOs)	31.986***	0.00	31.986***	0.00
Debt to Equity	0.004	0.661	0.004	0.572
Profitability	0.007	0.148	0.007	0.197
Return on assets	0.151**	0.029	0.151***	0.08
Revenue per share	0.04	0.779	0.04	0.864
Constant	147.123***	0.004	147.123***	0.00
Industry dummy	Yes		Yes	
Year dummy	Yes		Yes	
Nation dummy	Yes		Yes	
Adj R-squared	0.179		0.179	
Akaike crit. (AIC)	98620.63		98607.887	
Bayesian crit. (BIC)	99808.135		99802.899	
F-test	11.222		.	
Number of obs	8700		8700	
Prob > F	0		.	

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

(–2.455), and the Middle East and Africa region (–9.283). Further, observing model strength on the basis of the Akaike Information Criterion and Bayesian Information Criterion, the values for the robust regression (98607.887 and 99802.899) in Table 5 are lower than those illustrated in the OLS regression (98620.63 and 99808.135). Lower Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) values indicate a balance between goodness-of-fit and model complexity to identify model efficiency (Penny, 2012). Thus, robust regression is considered better for illustrating the model's effectiveness. The negative coefficient value for listing delay indicates that the greater the time gap between the offer and listing dates, the lower the listing day returns. This can be attributed to the fact that, with time, information asymmetry and investor excitement become steady, thus lowering the listing day price and returns. Not only does this offer price illustrate (–2.44) an adverse effect on listing returns in Western Europe. This is the only evidence of price's direct impact on listing returns in the analysis. This shows that the higher the offer price in Western Europe, the lower the listing day returns. The findings presented in Tables 5 and 6 illustrate that there is a significant relationship between determinants and listing day returns, rejecting both hypotheses based on a linear relationship.

As discussed in the preceding sections, OLS analysis focuses only on the linear perspective of the variables under study. Although knots are installed for all variables under study, the results are presented based on the efficacy of the results. Listing day returns for other variables, in line with the linear analysis, are found to be indifferent to the event.

Thus, this study focuses on spline-based results, specifically for offer prices and listing delays. As in the case of the OLS regression, we find no significant prediction (see Table 5) of listing day returns for these two variables. To conduct a restricted cubic spline, also known as a natural spline, the knots were initially identified automatically across the data in accordance with the cubic spline. As with STATA, it is easy to identify potential knots. Table 9 shows the spline regression coefficients.

Table 6. Regional regression analysis

Listing day returns	Asia Pacific – Developed	Asia Pacific – Emerging	Eastern Europe	Latin America and the Caribbean	Middle East and Africa	North America	Westen Europe
Issue size	–24.25***	–7.055***	–1.628*	2.965**	–2.227	–3.809*	0.008
Offer price	–0.79	–0.222	0.32	–3.161	–4.763	–3.224	–2.444***
Listing delay	–33.812***	–0.093	–2.455*	1.389	–9.283**	5.125	–0.682
Market timing (issue amount)	–2.785	–26.714***	–4.763	–91.418**	–6.409	–1.94	–7.053***
Market timing (number of IPOs)	–31.1**	37.786***	37.28***	97.686***	29.229	32.137	5.137
Debt to Equity	0.039***	0.00	–0.02***	0.038	–0.045*	–0.006	–0.007*
Profitability	0.01	0.018	0.014	–0.018	0.236	–0.001	–0.006**
Return on assets	0.07	0.071	–0.047	0.595	–0.449	0.277	0.116***
Revenue per share	–0.892**	0.535	–0.402	–0.737	–0.104	0.478	0.021
Constant	542.04***	270.27***	21.396	–110.907**	118.03*	18.983	14.662**
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nation dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Akaike crit. (AIC)	16696.67	65757.41	1402.394	695.301	1599.048	1347.563	7715.951
Bayesian crit. (BIC)	17138.79	65680.09	1437.578	712.642	1633.798	1377.05	7778.208
R-squared	0.293	0.205	0.608	0.765	0.584	0.514	0.139
Number of obs	1427	5801	181	88	174	141	888

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

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Table 7. Restricted cubic spline regression analysis

Listing day returns	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
	Both		Offer price		Listing Delay	
Issue size	–18.862***	0.00	–7.617***	0.00	–7.396***	0.00
Offer price					–0.093	0.917
Offer price (k1)	–3.409**	0.047	–2.778**	.036		
Offer price (k2)	13.526***	0.007	10.442**	.04		
Offer price (k3)	–28.157*	0.065	–20.607	.176		
Listing delay (k1)	–7.047**	0.017			–6.695	0.209
Listing delay (k2)	39.444***	0.00			36.482***	0.008
Listing delay (k3)	–128.17***	0.00			–116.763***	0.001
Listing delay			–.869	.541		
Market timing (issue amount)	–21.547***	0.00	–21.495***	0.00	–21.867***	0.00
Market timing (number of IPOs)	27.983***	0.00	31.835***	0.00	28.666***	0.00
Debt to Equity	0.005	0.37	.005	0.577	0.004	0.661
Profitability	0.007***	0.009	.007	0.123	0.006	0.17
Return on assets	0.16**	0.023	.165**	0.018	0.143**	0.039
Revenue per share	–0.018	0.889	–.004	0.978	0.033	0.818
Constant	62.627***	0.00	156.014	0.003	155.155***	0.003
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Nation dummy	Yes		Yes		Yes	
R-squared	0.183		0.180		0.181	
Akaike crit. (AIC)	98366.426		98611.123		98316.63	
Bayesian crit. (BIC)	98797.761		99801.5		98422.7	
Number of observations	8700		8700		8700	

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

The panel with both offers price and listing delay was combined to illustrate a statistically significant prediction. In addition, the variation within knots is significantly different, illustrating the issuer's behavior. The synchronization between the negative coefficient value for lower offer price and listing delay to positive for the second knot, and then again negative for the knot at the higher end, depicts the non-linear behavior of listing day returns, as visualized in graphs focusing solely on offer price splines –2.778 and 10.442, indicating that price significantly determines the disparity in listing returns, in line with Low and Yong (2011), Arora and Singh (2025), and Mehmood et al. (2020).

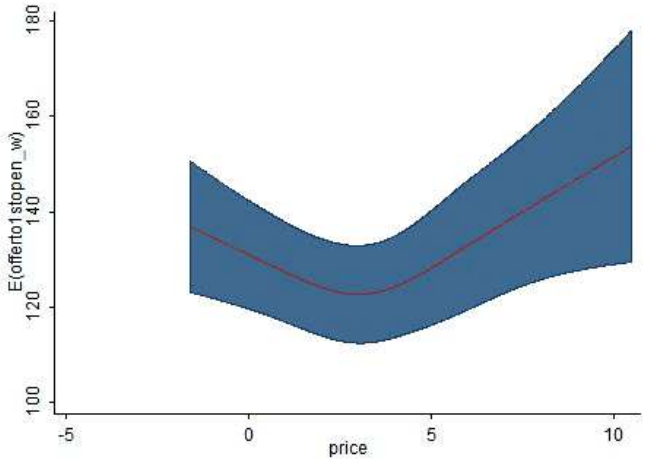

Figure 4. Spline graph: Adjusted (price)

Figure 5. Spline graph: Marginal difference (price)

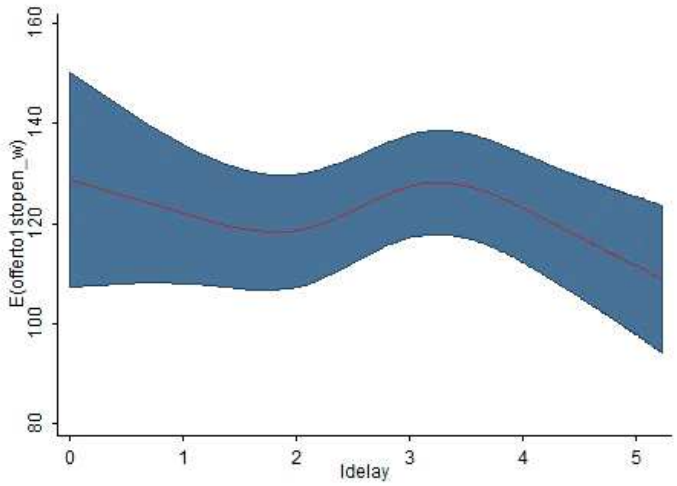

Figure 6. Spline graph: Adjusted (listing delay)

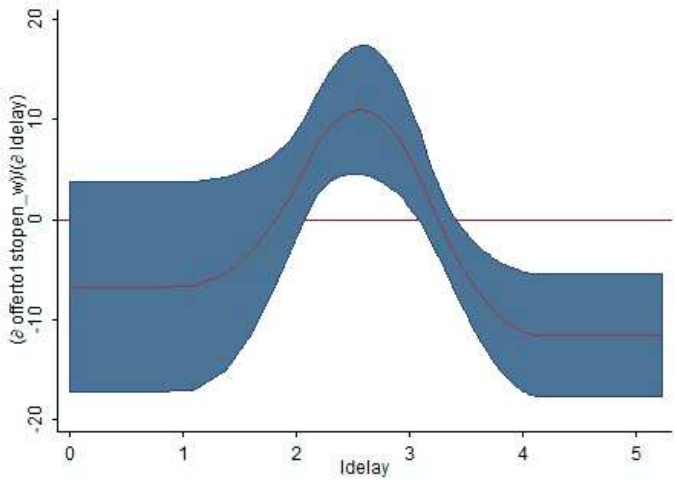

Figure 7. Spline graph: Marginal difference (listing delay)

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Issuers priced at the lower end (k1) have an adverse influence on listing day returns, whereas offers priced in the middle(k2) significantly induce listing day returns. This result indicates that the middle knot (k2), which illustrates moderate price issues, is positively associated with listing returns. Higher first-open returns in moderate price regimes (k2 knot) are consistent with underpricing compensation, although unobserved issuer intent limits causality. However, the non-significant coefficient for the higher end (k3) indicates that highly priced issuers have nothing to do with listing day returns based on nonlinearity. This illustrates that IPOs expected to be reasonably priced, instead of inexpensive and expensive issuers, predict higher listing returns, as studied using the offer to first open across the world. This is illustrated in Figures 4, 5, 6, and 7, respectively. Similarly, studying listing delays illustrates that reducing listing and offer day differences is significantly related to the listing day return. An increase in this gap significantly induces listing day returns, as shown by 36.482, which is consistent with Low and Yong (2011). If this gap is studied at the higher end based on spline knot segregation, it adversely (-116.763) influences the listing day returns. This indicates that the listing day return is significantly lower with a higher listing delay. However, reducing listing delays does not influence the listing day return. Furthermore, the AIC and BIC values in the context of spline-based models are lower than those of the OLS and Robust models in Table 5, illustrating the greater effectiveness of modelling using spline-based analysis. This confirms the non-linear behavior of the predictors under study, that is, the offer price and listing delay. Similarly, Tables 8 and 9 present the regional results for the offer price and listing delay splines, respectively. If the coefficients in Table 8 are observed, the offer price knot coefficients are found to be statistically significant for Asia-Pacific – Developed, Asia-Pacific – Emerging, Middle East and Africa, and Western Europe, which contribute close to 90 percent of the sample. This was consistent with the overall results of the spline, as discussed in Table 8. The results show that highly priced IPO issuers in de-

Table 8. Restricted cubic spline regression: Regional analysis

Listing day returns	Asia Pacific – Developed	Asia Pacific – Emerging	Eastern Europe	Latin America and the Caribbean	Middle East and Africa	North America	Westen Europe
Issue size	–22.566***	–6.771***	–1.675*	2.557**	–2.708	–3.011	–0.026
Listing delay	–38.693***	–0.424	–2.441*	0.302	–9.903*	4.757	–0.705
Offer price (k1)	–8.292**	1.233	2.471	–7.237	–10.867*	–5.578	–7.13***
Offer price (k2)	88.755***	–12.387*	–10.812	11.432	7.551	3.18	11.592**
Offer price (k3)	–268.79***	44.064**	30.624				–22.551
Debt to equity	0.039*	0	–0.025**	0.033	–0.045	–0.006	–0.007*
Profit margin	0.01	0.018**	0.013	–0.097	0.217	0	–0.006***
ROA	0.113	0.07	–0.045	0.763	–0.418	0.262	0.106***
Revenue per share	–0.81**	0.425*	–0.401	–0.804	–0.151	0.466	0.043
Market timing (issue amount)	–2.976	–26.659***	–5.289	–93.878**	–6.623	1.737	–6.414***
Market timing (number of IPOs)	–33.911	38.29***	36.92***	98.053***	28.143*	27.526	6.871**
Constant	530.341***	266.982***	21.187	–87.126**	122.742	1.917	19.083***
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nation dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Akaike crit. (AIC)	16564.09	65593.43	1400.524	694.614	1599.04	1347.336	7707.652
Bayesian crit. (BIC)	16632.51	66417.33	1435.708	711.955	1633.79	1376.823	7769.908
R-squared	0.297	0.206	0.612	0.767	0.591	0.515	0.147
Number of obs	1427	5801	181	88	174	141	888

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 9. Restricted cubic spline regression: Regional analysis

Listing day returns	Asia Pacific – Developed	Asia Pacific – Emerging	Eastern Europe	Latin America and the Caribbean	Middle East and Africa	North America	Westen Europe
Issue size	–22.84***	–6.759**	–1.698*	2.86**	–2.082	–1.966	–0.129
Offer Price	–1.412	–0.776	–0.537	–2.506	–4.432	–3.001	–2.689***
Listing delay spline 1	–135.715**	–12.944*	–1.926	0.612	–2.994	–6.036	0.341
Listing delay spline 2	244.414**	76.493**	8.511	1.509	–5.846	10.643	6.519
Listing delay spline 3	–588.063**	–242.24**	–46.484			4.966	–36.92
Debt to equity	0.034*	0.001	–0.025**	0.037	–0.044	–0.006	–7.793***
Profit margin	0.01	0.017	0.015	–0.023	0.233*	–0.003	4.441
ROA	0.109	0.033	–0.015	0.604	–0.448	0.286	–0.007*
Revenue per share	–0.906**	0.525	–0.474	–0.731	–0.11	0.528	–0.006**
Market timing (issue amount)	–3.88	–26.60***	–6.602**	–88.283**	–6.371	–0.102	0.112***
Market timing (number of IPOs)	–32.872**	29.488***	42.337***	100.157***	27.077	31.579	0.016
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nation dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	733.413***	298.73***	31.086	–113.959**	104.926	4.076	13.587**
Akaike crit. (AIC)	16544.05	65551.31	1395.782	695.258	1598.584	1343.038	7704.002
Bayesian crit. (BIC)	16612.48	65637.97	1430.966	712.599	1633.334	1372.526	7766.259
R-squared	0.303	0.211	0.622	0.765	0.586	0.53	0.15
Number of obs	1427	5801	181	88	174	141	888

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

veloping Asia-Pacific nations fear losses from unpredictable investment behavior. The coefficients for the panel with both the offer price and listing delay are combined to illustrate a statistically significant prediction. In addition, the variation within knots is significantly different, illustrating the variation in the prediction of listing-day returns based on splines.

The synchronization between the negative coefficient value for lower offer price and listing delay to positive for the second knot, and then again negative for the knot at the higher end, depicts the non-linear behaviour of listing day returns, as visualized in graphs focusing solely on offer price splines –2.778 and 10.442, depicting that price significantly determines the variation in listing day returns, in line with Low and Yong (2011), Arora and Singh, (2025), and Mehmood et al. (2020).

Likewise, observing listing delays based on spline knots illustrates that only the Asia-Pacific developed and emerging countries were significant (Table 10). The regression coefficients for both regions (–135.715, 244.414, –588.063, 0.034, –12.944, 76.493, –242.24) are similar to the overall figures in Table 8. However, the only major differentiation evident is the coefficient value, which is higher for developed nations and lower for emerging ones. This observational design identifies associations rather than causation. Spline improvements reflect a better nonparametric fit to nonlinear data patterns, not necessarily policy implications without experimental validation. In addition, there is a significant difference in the prediction by determinants for listing day returns. These results of nonlinear determinants illustrate the relevance of the discussion away from linearity. Whenever the determinants of listing day returns are discussed, only linear patterns are assumed; however, the results of this study illustrate the influence of nonlinear ideas in predicting listing day returns. Altogether, the result illustrates significant prediction for listing day returns by issue determinants

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not just based on linear analysis but also on the basis of non-linear analysis, thus rejecting both null hypotheses.

4. DISCUSSION

While IPO listing day returns have been researched extensively, they remain shrouded in uncertainty and unpredictability. This study advocates for a shift toward greater informational efficiency by adopting nonlinear predictors to model stock behavior across global listings. Moving beyond the constraints of linear models is essential, as real-world market conditions seldom mirror the "perfect" assumptions of linearity; instead, empirical data often exhibit complex, non-linear patterns that require more sophisticated analytical frameworks. Consequently, making investment decisions and return predictions based on nonlinear analysis offers a more grounded and realistic approach to market dynamics. The current study provides critical insights into the multifaceted determinants of listing day returns, specifically highlighting how these factors interact through nonlinear relationships. While traditional linear regression – consistent with existing literature (Lin et al., 2013; Albada et al., 2019; Rossovski, 2025) – identifies issue size and market timing as primary drivers, our restricted cubic spline analysis uncovers hidden non-linearities. Specifically, it captures significant nuances in offer price and listing delays, alongside identifying critical spline knots for issue size and timing that linear specifications overlook. From a theoretical standpoint, these findings extend asymmetric information theories (Rock, 1986; Welch, 1989) by demonstrating empirical shifts that remain invisible in rigid models. The identified spline knots reveal regime shifts consistent with partial pooling equilibria, where underpricing serves as a quality signal only up to specific threshold points, illustrating clear threshold effects. Furthermore, this study demonstrates a methodological advancement by utilizing restricted cubic splines, evidenced by marked improvements in AIC and BIC values. This aligns with Obrimah's (2023) emphasis on nonlinearity, allowing for flexible empirics without the burden of restrictive functional form assumptions. Such a transition represents a leap in efficiency, bridging the gap between theoretical constructs and complex market realities. Our regional analysis further enriches this discussion, highlighting the outsized influence of Asia-Pacific markets, where the time gap between offer and listing dates critically dictates investor enthusiasm. These dynamics are regionally concentrated, suggesting that local market mechanisms and behavioral biases play a decisive role in pricing. Given that the IPO environment is a strategic arena of game theory, the use of spline analysis is vital for identifying the rational, yet non-linear, maneuvers of issuers and investors. Ultimately, the shift from linear to nonlinear evaluation represents an evolution from simplistic modelling to a deeper, more robust understanding of market reality, providing investors and policymakers with the empirical tools necessary to strategically manage IPO pricing.

CONCLUSION

This study advances understanding of the global primary market by pivoting from traditional linear frameworks to a nonlinear perspective of IPO listing day returns. Using restricted cubic spline (RCS) analysis on a comprehensive dataset of 8,914 IPOs (2011–2024), we demonstrate that the determinants of initial performance (offer prices and listing delays) do not follow simple proportional paths. This is done to illustrate that there exist nonlinear influences, and if studied in greater depth, there can be a substantial presence of non-linearity in relation to underpricing and its determinants. The positioning of RCS regression uncovers critical market nuances that linear models frequently obscure. Most notably, the identification of a "sweet spot" in moderate offer prices, which yield the highest initial returns, suggests a deliberate strategic pricing mechanism employed by underwriters to optimize market reception. By capturing these nonlinear dynamics, this study provides a more authentic reflection of real-world market volatility and the interplay between pricing and timing strategies. The insights from this study are instrumental for a broad spectrum of market participants, issuers, and analysts in developing pricing strategies, investors in predicting volatility, and regulators and policymakers in improving market

stability by understanding the non-proportional impact of listing delays on price discovery. Though this study bridges a significant gap in the literature, it is constrained by data availability. Also, the study just illustrates the presence of a nonlinear relation, which can be further researched with greater detail and comprehensive variables. Subsequent research can re-test established theories within nonlinear scenarios. Ultimately, by moving beyond the linear horizon, this study offers a more robust foundation for navigating the inherent complexities of the global IPO landscape.

AUTHOR CONTRIBUTIONS

Conceptualization: Mamta Dhanda.
Data curation: Mamta Dhanda.
Formal analysis: Mamta Dhanda.
Investigation: Amit Kumar Singh, Mamta Dhanda.
Methodology: Amit Kumar Singh.
Project administration: Amit Kumar Singh.
Resources: Amit Kumar Singh.
Software: Amit Kumar Singh, Mamta Dhanda.
Supervision: Amit Kumar Singh.
Validation: Amit Kumar Singh.
Visualization: Amit Kumar Singh.
Writing – original draft: Mamta Dhanda.
Writing – review & editing: Amit Kumar Singh.

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