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The determinants of capital structure: Evidence from the high-tech and low-tech Spanish start-ups between the non-crisis and crisis periods

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Abstract. This study explores the changes of capital structure (the proportion of external debt) of start-ups and the influential factors respectively for high-tech and low-tech start-ups in Spain with considering the impacts of intellectual capital elements. In particular, the start-ups founded from 2008 to 2022 are analyzed with separating the crisis years and non-crisis years in accordance with the macro-economic environment. The observations show a decreasing trend of the average leverage since the 2008 global financial crisis especially for low-tech start-ups, which demonstrates the discreetness regarding external debt finance for start-ups. The results also confirm that the importance of financial factors outweighs that of intellectual capital factors. Specifically, the significant impacts of profitability and size (based on assets) are observed in nearly all the regressions in both the crisis and non-crisis periods, whereas the negative effects of intellectual capital on leverage are mainly shown in structural capital during the non-crisis period. Therefore, the findings manifest the negative signaling effect on obtaining external debt finance when investing largely in intellectual capital. This paper enriches the related empirical research regarding start-up capital structure through considering technology features for a long period covering the two important crises in the 21st century.

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1. INTRODUCTION

Entrepreneurship and start-ups have been studied by scholars for a long time, because of the importance of start-ups to economy, such as creating new jobs, stabilizing employment, driving economic growth, and bringing innovation to market (Chmelíková & Somerlíková, 2014; Ferrucci et al., 2021). For start-ups, financial capital plays an important role in their future development; in particular, the choice of financing types is closely related to the problems of information asymmetry and moral hazard with potential investors and can influence the value and future growth of start-ups (Hechavarría et al., 2016; Venâncio & Jorge, 2022). Therefore, the topic of capital structure and its influential factors deserve to be investigated in depth.

Although the research on capital structure started at the time of 1950s from the irrelevance theory of Modigliani and Miller (1958) between capital structure and firm's market value in a perfect market, no consensus has been reached regarding the debt-equity choice (Myers, 2001; Duguleană et al., 2024). After the seminal study in 1958, a series of theories were proposed: the trade-off theory stresses the balance between the benefit of tax shield and the risk of default; the agency theory proposed by Jensen and Meckling (1976) highlights the impact of the costs generated between ownership and control; the pecking order theory proposed by Myers (1984) and Myers and Majluf (1984) demonstrates an order (internal funds, external debt and then equity finance) of funding (Nicodano & Regis, 2019; De Lima & Da Silva, 2024).

Following the above theories, there are a large number of empirical studies that try to test these theories in a variety of types of firms, industry sectors, geographical regions, and macro-economic environments. Using the data of Turkish companies, the trade-off theory and the pecking order theory are compared by the research of Güner (2016), and both theories are supported by the empirical data. Furthermore, the research results of Khan et al. (2024) partially support the trade-off, pecking order, agency, and signaling theories with using the data of non-financial listed companies in Gulf Cooperation Council countries. Similarly, the research findings of Toshinori et al. (2023) also support a series of theories, including the trade-off theory, agency theory, and particularly pecking order theory as well as supply-related theories. Hence, the theories of capital structure are not contradictory, as nearly each theory can be supported by empirical studies.

For the European Union areas, the impacts of the 2008 global financial crisis on capital structure have attracted many researchers, such as Proença et al. (2014) on Portuguese small and medium-sized enterprises (SMEs), Balios et al. (2016) on Greek SMEs, and Yazdanfar et al. (2019) on Swedish SMEs; by contrast, the research on the influence of the COVID crisis is limited. Hence, a long-term observation is necessary. In addition to macro-economic environment, the impacts of firm-specific characteristics on capital structure have been investigated in depth, with focusing on some specific sectors (such as, Jaworski and Czerwonka (2021) on energy industry sector, Neykov et al. (2022) on forestry sector, and Gostkowska-Drzewicka and Koralun-Bereźnicka (2024) on agricultural business sector) or with considering a series of sectors (for example) the studies of Moradi and Paulet (2019) and Heckenbergerová and Honková (2023).

This paper expands the study of Neville and Lucey (2022) on high-tech firms to both high-tech and low-tech firms. Here, we focus on start-ups. This is because: although there are some studies examining the explanatory power of some theories and practical factors about start-up capital structure (Cassar (2004); Colombo et al. (2023)), the research on the capital structure of start-ups and financing options of

entrepreneurs is still incomplete with questions to be answered (Hechavarría et al., 2016; Venâncio & Jorge, 2022). In this study, the founding years of start-ups span from 2008 to 2022 covering both the 2008 global financial crisis and the COVID crisis; thus, the findings should be more reliable. Additionally, following the study of D'Amato (2021), we take intellectual capital elements into account because intellectual capital plays an important role in high-tech firms. The findings of this paper not only enrich the studies of capital structure with differentiating high-tech and low-tech start-ups but also provide the evidence about the changes of capital structure and its influential factors between the crisis and non-crisis periods. The followings of this paper are organized in this order: methodology, empirical results, discussion, and conclusion.

2. METHODOLOGY

The sample is composed of the Spanish start-ups with the founding year from 2008 to 2022 in the Iberian Balance sheet Analysis System (SABI) database which is developed by Bureau Van Dijk. In particular, given that only a few start-ups report financial data in their founding year due to the scattered date of incorporation, we choose the start-ups that report financial data in the year after their founding year and take these data as the research target. In addition, the firms with missing data and outliers are excluded from the sample. Finally, the sample contains 26405 start-ups within which there are 3412 high-tech and 22993 low-tech firms.

With regard to investigating economic crisis, according to the research of La Rocca et al. (2025), Gross Domestic Product (GDP) growth is used to identify the differences in national economic development and as an important indicator to classify crisis and post-crisis periods. In terms of the global financial crisis, though the collapse of Lehman Brothers happened in 2008, the economic recession started in 2009 (Martínez-Sola et al., 2024); this is in accordance with the change of GDP growth from positive in 2008 to negative in 2009. Hence, we use the GDP growth as the classifying standard to differentiate the crisis and non-crisis periods. The annual growth rates of GDP in Spain are shown in Table 1. Because we do research on the data after the founding years (for instance observing the data in 2009 for the start-ups founded in 2008), the classification of crisis and non-crisis is on the basis of the GDP growth from 2009 to 2023. Considering that the annual growth rates of GDP in 2009, 2011, 2012, 2013, and 2020 are negative, these years are classified as crisis years containing 8548 start-ups; while the other years are classified as non-crisis years including 17857 start-ups.

Table 1

The annual growth rates of GDP in Spain

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
GDP growth	0.767%	-3.768%	0.094%	-0.640%	-2.865%	-1.427%	1.520%	4.061%
Economic situation	Non-crisis	Crisis	Non-crisis	Crisis	Crisis	Crisis	Non-crisis	Non-crisis
Year	2016	2017	2018	2019	2020	2021	2022	2023
GDP growth	2.915%	2.896%	2.395%	1.961%	-10.940%	6.683%	6.179%	2.676%
Economic situation	Non-crisis	Non-crisis	Non-crisis	Non-crisis	Crisis	Non-crisis	Non-crisis	Non-crisis

Source: World Bank national accounts data, and OECD National Accounts data files.
https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2023&locations=ES&start=1961&view=chart

Referring to the research of De Lima and Da Silva (2024), we use the total liabilities (total asset minus equity) divided by total assets to represent capital structure as the dependent variable. In terms of the

independent variables (shown in Table 2), following the research of Cassar (2004), Franck and Huyghebaert (2010), Demirgüç-Kunt et al. (2020), Amore et al. (2025) and especially D'Amato (2021), we use both the traditional influential factors (such as, firm size, profitability, asset structure, and group background) and the intellectual capital factors.

Regarding how to measure intellectual capital, the model proposed by Pulic (2004) is popularly utilized in academic research. Pulic model decomposes the value-added intellectual coefficient (VAIC) into two parts (intellectual capital efficiency and capital employed efficiency), where intellectual capital efficiency is calculated as the sum of human capital efficiency and structural capital efficiency (Szklarz, 2023). As noted by Buenaño et al. (2025), human capital includes the knowledge, skills, talents, and experiences of employees, whereas structural capital contains the systems, processes, and organizational structures of a company in stead of its employees; capital employed represents physical and financial assets of a company to generate value.

Table 2

The definitions of variables

Dependent variable	**Measurement**
Leverage	(Total shareholders' funds and liabilities －Shareholders' equity)/Total shareholders funds and liabilities
Independent variables	**Measurements**
Human capital efficiency (HCE)	Human Capital Efficiency = Value Added / Employee Cost; Value Added = Operating Profit + Employee Cost + Depreciation + Amortization
Structural capital efficiency (SCE)	Structural Capital Efficiency = (Value Added － Employee Cost) / Value Added
Capital employed efficiency (CEE)	Capital Employed Efficiency = Value Added / Capital Employed; Capital Employed = Total Assets － Intangible Assets
Size	Natural logarithm of total assets in thousands of Euros
Profitability	The ratio of earnings before interests and tax (EBIT) to total asset
Tangibility	The ratio of tangible fixed assets to total asset
Group dummy	Dummy variable: if the number of companies in corporate group is more than zero, it takes the value of 1; if the number of companies in corporate group is zero, it takes the value of 0.
High-tech dummy	Dummy variable: if a firm belongs to high-tech and medium-high-tech categories, it takes the value of 1; if a firm belongs to low-tech and medium-low-tech categories, it takes the value of 0.

Note: Value-Added Intellectual Coefficient (VAIC) is the sum of Intellectual Capital Efficiency (ICE) and Capital Employed Efficiency (CEE); Intellectual Capital Efficiency (ICE) is the sum of Human Capital Efficiency (HCE) and Structural Capital Efficiency (SCE).

According to the classification of European Commission in 2008 (NACE Rev. 2 2-digit level), high-technology manufacturing sectors include: manufacture of basic pharmaceutical products and pharmaceutical preparations (21); manufacture of computer, electronic and optical products (26). Medium-high-technology manufacturing sectors include: manufacture of chemicals and chemical products (20); manufacture of electrical equipment (27); manufacture of machinery and equipment n.e.c. (28); manufacture of motor vehicles, trailers and semi-trailers (29); manufacture of other transport equipment (30). Medium-low-technology manufacturing sectors include: manufacture of coke and refined petroleum products (19); manufacture of rubber and plastic products (22); manufacture of other non-metallic mineral products (23); manufacture of basic metals (24); manufacture of fabricated metal products, except machinery and equipment (25); repair and installation of machinery and equipment (33). Low-technology manufacturing

sectors include: manufacture of food products (10); manufacture of beverages (11); manufacture of tobacco products (12); manufacture of textiles (13); manufacture of wearing apparel (14); manufacture of leather and related products (15); manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (16); manufacture of paper and paper products (17); printing and reproduction of recorded media (18); manufacture of furniture (31); other manufacturing (32). In this study, high-tech includes both high-technology and medium-high-technology sectors; low-tech contains both low-technology and medium-low-technology sectors.

Following the research of Cassar (2004), Cribari-Neto and Lima (2014), and Bortoluzzo et al. (2024), we use the ordinary least squares regression (OLS) model with the method of heteroskedasticity-robust standard errors to deal with the issue of homoskedasticity as well as the quantile regression model to observe the proportion of external debt financing at different debt levels. Because the sample size used here is quite large, the normality assumption is not necessary to be fulfilled strictly (Schmidt and Finan, 2018). Specifically, the empirical analysis is classified into three steps. The first step is to observe the change of the mean values of leverage year by year and results of the independent samples tests separately for the high-tech and low-tech start-ups. The second step is to use the OLS and quantile regression models to regress the start-ups separately in the non-crisis and crisis periods. The third step is to further regress the high-tech and low-tech start-ups separately in the non-crisis and crisis periods as well as to observe the interacting effects of the high-tech dummy.

3. EMPIRICAL RESULTS

3.1. The trends of leverage change

Table 3 shows the mean values of the leverage separately for the high-tech and low-tech start-ups year by year. Compared to high-tech start-ups, low-tech start-ups show an obviously decreasing trend of leverage from 2008 to 2022. In particular, the average leverage of high-tech start-ups is lower than that of low-tech start-ups in each observed year (no matter in the crisis or non-crisis periods), which should be explained by the problems of information asymmetry for the external finance to high-tech start-ups. Therefore, start-ups (especially low-tech start-ups) generally tend to reduce external debt finance since the 2008 global financial crisis.

Table 4 shows the results of the independent samples tests. The first is to classify the total sample into the start-ups separately in the non-crisis and crisis periods. The difference of the mean values of leverage between the non-crisis and crisis periods is statistically significant in the total sample. The second and third are separately to classify the start-ups in the non-crisis period and in the crisis period in accordance with the technology feature. The differences of the mean values of leverage between the high-tech and low-tech start-ups are statistically significant in both the crisis and non-crisis periods. Therefore, the mean values between the crisis and non-crisis periods as well as between the high-tech and low-tech sectors when considering the macro-economic environment are different with statistical significance. It is meaningful to investigate the leverage and its influential factors on the basis of the above classifications. Table 5 shows the results of Pearson correlation of the independent variables for the total sample as well as separately for the non-crisis and crisis periods. Because the absolute values of all the correlation coefficients are less than 0.7, multi-collinearity is not serious here (Dwivedi and Pawsey, 2023).

Table 3

The mean values of the leverage separately for the high-tech and low-tech start-ups

	High-tech start-ups		Low-tech start-ups	
Founding year	**Mean of leverage**	**Number of observation**	**Mean of leverage**	**Number of observation**
2008	0.802	253	0.860	1625
2009	0.825	217	0.847	1328
2010	0.776	260	0.835	1387
2011	0.788	211	0.822	1320
2012	0.771	242	0.819	1571
2013	0.773	268	0.799	1867
2014	0.730	324	0.807	1838
2015	0.773	273	0.777	1912
2016	0.708	281	0.771	2296
2017	0.738	229	0.757	1825
2018	0.732	216	0.745	1783
2019	0.694	219	0.758	1460
2020	0.674	184	0.740	1213
2021	0.693	170	0.721	1029
2022	0.585	65	0.745	539
Total	0.747	3412	0.789	22993

Source: Authors' own calculation.

Table 4

Independent samples tests for the start-ups between the crisis and non-crisis periods and between high-tech and low-tech sectors

Variable: Leverage	**Classification**	**Number of observations**	**Mean**	**Standard deviation**	**Standard error mean**	**t**	**Significance**
Total sample	Non-crisis	17857	0.770	0.312	0.002	-10.323	0.000
	Crisis	8548	0.812	0.317	0.003		
Start-ups in non-crisis	Low-tech	15630	0.775	0.309	0.002	5.170	0.000
	High-tech	2227	0.736	0.331	0.007		
Start-ups in crisis	Low-tech	7363	0.820	0.317	0.004	5.239	0.000
	High-tech	1185	0.768	0.316	0.009		

Source: Authors' own calculation.

Table 5

Pearson correlation of the independent variables for the total sample as well as separately for the non-crisis and crisis periods

Pearson correlation for the total sample with 26405 observations								
Variable	HCE	SCE	CEE	Size	Profitability	Tangibility	Group dummy	High-tech dummy
HCE	1.000	0.002	0.047	0.034	0.280	-0.048	0.022	0.008
SCE	0.002	1.000	-0.031	0.024	0.015	0.010	0.003	0.012
CEE	0.047	-0.031	1.000	-0.297	0.207	-0.120	-0.005	-0.067
Size	0.034	0.024	-0.297	1.000	0.089	0.072	0.106	0.142
Profitability	0.280	0.015	0.207	0.089	1.000	-0.148	0.035	-0.012
Tangibility	-0.048	0.010	-0.120	0.072	-0.148	1.000	-0.032	-0.082
Group dummy	0.022	0.003	-0.005	0.106	0.035	-0.032	1.000	0.033
High-tech dummy	0.008	0.012	-0.067	0.142	-0.012	-0.082	0.033	1.000

Pearson correlation for the non-crisis period with 17857 observations								
Variable	HCE	SCE	CEE	Size	Profitability	Tangibility	Group dummy	High-tech dummy
HCE	1.000	0.002	0.044	0.027	0.280	-0.046	0.015	0.004
SCE	0.002	1.000	-0.035	0.024	0.004	0.003	0.001	0.006
CEE	0.044	-0.035	1.000	-0.304	0.205	-0.118	-0.002	-0.074
Size	0.027	0.024	-0.304	1.000	0.081	0.064	0.104	0.142
Profitability	0.280	0.004	0.205	0.081	1.000	-0.160	0.020	-0.021
Tangibility	-0.046	0.003	-0.118	0.064	-0.160	1.000	-0.030	-0.079
Group dummy	0.015	0.001	-0.002	0.104	0.020	-0.030	1.000	0.034
High-tech dummy	0.004	0.006	-0.074	0.142	-0.021	-0.079	0.034	1.000
Pearson correlation for the crisis period with 8548 observations								
Variable	HCE	SCE	CEE	Size	Profitability	Tangibility	Group dummy	High-tech dummy
HCE	1.000	0.004	0.053	0.051	0.280	-0.053	0.038	0.017
SCE	0.004	1.000	-0.026	0.024	0.035	0.024	0.004	0.022
CEE	0.053	-0.026	1.000	-0.285	0.202	-0.123	-0.016	-0.050
Size	0.051	0.024	-0.285	1.000	0.110	0.086	0.112	0.142
Profitability	0.280	0.035	0.202	0.110	1.000	-0.119	0.062	0.012
Tangibility	-0.053	0.024	-0.123	0.086	-0.119	1.000	-0.036	-0.088
Group dummy	0.038	0.004	-0.016	0.112	0.062	-0.036	1.000	0.034
High-tech dummy	0.017	0.022	-0.050	0.142	0.012	-0.088	0.034	1.000

Source: Authors' own calculation.

3.2. The regressions of the start-ups founding separately in the non-crisis and crisis periods

Following the fact of the existence of difference of the mean values between the start-ups in the non-crisis and crisis periods, OLS (heteroskedasticity-robust standard errors) model is run separately for the start-ups founding in the non-crisis and crisis periods. As is shown in Table 6, HCE is statistically insignificant in both the non-crisis and crisis periods. SCE and CEE are statistically significant in the non-crisis period separately with a negative and a positive effect on leverage, while they are non-significant in the crisis period. For other variables, size, profitability, tangibility and high-tech dummy are statistically significant in both the non-crisis and crisis periods; all being negatively related to leverage with large absolute values in coefficients. Group dummy shows statistically significant and positive effect on leverage only in the non-crisis period. Compared to the crisis period, there are more statistically significant variables in the regression for the non-crisis period.

Table 6

The results of the OLS (heteroskedasticity-robust standard errors) model separately for the non-crisis and crisis periods

	Non-crisis period		**Crisis period**	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	-00000239	0.998	-0.001	0.356
SCE	-0.002***	0.003	-0.001	0.660
CEE	0.006**	0.032	-0.000369	0.951
Size	-0.011***	0.000	-0.018***	0.000
Profitability	-0.528***	0.000	-0.542***	0.000
Tangibility	-0.027**	0.013	-0.063***	0.000
Group dummy	0.013***	0.002	0.007	0.241
High-tech dummy	-0.042***	0.000	-0.040***	0.000
Constant	0.853***	0.000	0.928***	0.000
R-Square	0.248		0.242	
F-statistic	87.38		76.20	
Significance	0.000		0.000	
Number of observation	17857		8548	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

In order to further observe the impacts of independent variables separately for the non-crisis and crisis periods, quantile regressions are run in the 25th, 50th and 75th quantiles (shown in Table 7 and 8). HCE is non-significant in all the regressions in both the non-crisis and crisis periods. SCE is significant and negatively related to leverage in all the regressions in the non-crisis period but is significant only in the 0.25 quantile regression with a negative effect in the crisis period. CEE is non-significant in the non-crisis period but shows significantly negative effects on leverage in the crisis period. Profitability and high-tech dummy are statistically significant and negatively related to leverage in all the regressions in both the non-crisis and crisis periods. Tangibility is statistically significant and negatively related to leverage in the 0.25 and 0.5 quantile regressions in both the non-crisis and crisis periods. Group dummy shows significantly positive effects on leverage in the 0.25 and 0.5 quantile regressions in the non-crisis period and in the 0.25 quantile regression in the crisis period. Size shows significantly negative effects in the 0.25 quantile regressions but significantly positive effects in the 0.75 quantile regressions in both the non-crisis and crisis periods.

Table 7

The results of the quantile regressions for the start-ups in the non-crisis period

	Quantile 0.25		**Quantile 0.5**		**Quantile 0.75**	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	0.001	0.412	-0.000125	0.816	-0.000146	0.446
SCE	-0.002**	0.038	-0.001**	0.010	-0.000492**	0.015
CEE	0.005	0.166	-0.003	0.185	-0.000468	0.501
Size	-0.011***	0.000	0.001	0.519	0.006***	0.000
Profitability	-0.538***	0.000	-0.767***	0.000	-0.834***	0.000
Tangibility	-0.127***	0.000	-0.067***	0.000	-0.002	0.497
Group dummy	0.022***	0.003	0.009**	0.025	-0.000126	0.929
High-tech dummy	-0.074***	0.000	-0.037***	0.000	-0.006***	0.002
Constant	0.743***	0.000	0.903***	0.000	0.951***	0.000
Pseudo R-square	0.097		0.200		0.311	
Number of observation	17857		17857		17857	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

Table 8

The results of the quantile regressions for the start-ups in the crisis period

	Quantile 0.25		Quantile 0.5		Quantile 0.75	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	0.0000242	0.989	-0.001	0.116	-0.000430	0.152
SCE	-0.003*	0.051	-0.001	0.117	-0.000268	0.338
CEE	-0.011*	0.086	-0.008***	0.009	-0.002**	0.041
Size	-0.023***	0.000	-0.007***	0.000	0.002***	0.001
Profitability	-0.502***	0.000	-0.729***	0.000	-0.809***	0.000
Tangibility	-0.177***	0.000	-0.085***	0.000	-0.002	0.631
Group dummy	0.024**	0.037	0.002	0.669	-0.002	0.362
High-tech dummy	-0.069***	0.000	-0.028***	0.000	-0.005*	0.060
Constant	0.854***	0.000	0.971***	0.000	0.979***	0.000
Pseudo R-square	0.079		0.163		0.290	
Number of observation	8548		8548		8548	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

In summary, the effects of most variables tend to be stable in both the OLS (heteroskedasticity-robust standard errors) model and the quantile regressions when observing separately in the non-crisis and crisis periods. The results of both models confirm the strong and negative effect of profitability, because of being statistically significant at the 1 percent level in all the regressions and the highest absolute values of coefficient. Following profitability, size and tangibility as important financial factors also exert strong impacts on leverage because of their high absolute values of coefficients. Regarding intellectual capital factors, their impacts are much less than the above financial factors: HCE is non-significant in all the regressions; SCE shows low absolute values of coefficient when being statistically significant.

3.3. Regressions for the high-tech and low-tech start-ups respectively in the non-crisis and crisis periods

In the non-crisis period (Table 9), HCE is non-significant for both high-tech and low -tech start-ups, while SCE shows significant and negative effect only for the low-tech start-ups. On the other hand, CEE is statistically significant and positively related to leverage for both high-tech and low-tech start-ups. Size and profitability show a significantly negative effect on leverage for both high-tech and low-tech start-ups. The negative effect of profitability on leverage is also supported by the findings of Bvirindi and Inalegwu (2024). The effect of tangibility on leverage is significantly negative for low-tech start-ups (which is similar to the findings of D'Amato (2020)), while it shows no explanatory power for the high-tech start-ups. Group dummy positively and significantly affects leverage for low-tech start-ups. Here, three variables (SCE, tangibility and group dummy) change their impacts on leverage in magnitude between high-tech and low-tech start-ups in the non-crisis period.

Table 9

The results of the OLS (heteroskedasticity-robust standard errors) model separately for high-tech and low-tech start-ups in the non-crisis period

	High-tech start-ups		**Low-tech start-ups**	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	0.002	0.352	-0.001	0.129
SCE	-0.005	0.117	-0.002**	0.012
CEE	0.021**	0.043	0.005*	0.081
Size	-0.016***	0.000	-0.008***	0.000
Profitability	-0.338***	0.000	-0.564***	0.000
Tangibility	0.039	0.244	-0.042***	0.001
Group dummy	-0.017	0.212	0.017***	0.000
Constant	0.824***	0.000	0.848***	0.000
R-square	0.121		0.277	
F-statistic	13.42		109.64	
Significance	0.000		0.000	
Number of observation	2227		15630	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

In the crisis period (Table 10), all the VAIC variables (HCE, SCE and CEE) are non-significant except for the statistically significant and negative effect of SCE for high-tech start-ups. Size and profitability are negatively related to leverage for both high-tech and low-tech start-ups. Tangibility only shows statistically significant and negative effect on leverage for low-tech start-ups, whereas it shows non-significant effect for high-tech start-ups. Group dummy shows non-significant effect on leverage for both high-tech and low-tech start-ups. Thus, there are only two variables (SCE and tangibility) with obvious changes of the impacts on leverage between high-tech and low-tech start-ups in the crisis period.

Table 10

The results of the OLS (heteroskedasticity-robust standard errors) model separately for high-tech and low-tech start-ups in the crisis period

	High-tech start-ups		**Low-tech start-ups**	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	0.001	0.660	-0.002	0.190
SCE	-0.003**	0.034	0.000141	0.930
CEE	0.010	0.471	-0.001	0.887
Size	-0.025***	0.000	-0.015***	0.000
Profitability	-0.457***	0.000	-0.556***	0.000
Tangibility	0.062	0.143	-0.080***	0.000
Group dummy	0.022	0.226	0.005	0.422
Constant	0.887***	0.000	0.924***	0.000
R-square	0.162		0.255	
F-statistic	17.29		68.78	
Significance	0.000		0.000	
Number of observation	1185		7363	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

Table 11 shows the interacting effects of the high-tech dummy (for identifying the high-tech from the low-tech start-ups) on the independent variables separately for the non-crisis and crisis periods. The

interacting effects between the non-crisis and crisis periods are generally similar: the interacting effects of financial variables (size, profitability and tangibility) with the high-tech dummy are statistically significant, which indicate strong impacts of technology sector on the effects of financial factors; by contrast, the interacting effects of the VAIC variables (HCE, SCE, and CEE) are non-significant, which demonstrate little impact of technology sector on the effects of intellectual capital factors. In particular, the negative effects of profitability and tangibility are reduced due to the different signs of the direct variables and their interacting variables, whereas the negative effects of size are strengthened thanks to the same signs of direct variable and its interacting variable. In the non-crisis period, the positive effect of group dummy is reduced due to the different signs. Here the results of the interacting model generally support the differences in financial factors observed separately for the non-crisis and crisis periods. Specifically, the increasing effect on size as well as the decreasing effects on profitability, tangibility, and group dummy confirmed by the interacting model are observed as the change of the coefficient and the change of significant level in the separate regressions in the non-crisis and crisis periods.

Table 11

The results of the OLS (heteroskedasticity-robust standard errors) model for the interacting effects with the high-tech dummy

	Non-crisis period		**Crisis period**	
Variable	**Coefficient**	**Significance**	**Coefficient**	**Significance**
HCE	-0.001	0.134	-0.002	0.197
HCE × High-tech dummy	0.003	0.142	0.002	0.365
SCE	-0.002**	0.012	0.000144	0.929
SCE × High-tech dummy	-0.003	0.356	-0.003	0.125
CEE	0.006*	0.057	-0.000237	0.970
CEE × High-tech dummy	0.012	0.178	0.004	0.720
Size	-0.008***	0.000	-0.015***	0.000
Size × High-tech dummy	-0.011***	0.000	-0.014***	0.000
Profitability	-0.564***	0.000	-0.557***	0.000
Profitability × High-tech dummy	0.230***	0.000	0.106*	0.095
Tangibility	-0.041***	0.001	-0.079***	0.000
Tangibility × High-tech dummy	0.074**	0.031	0.132***	0.002
Group dummy	0.017***	0.000	0.005	0.396
Group dummy × High-tech dummy	-0.035**	0.016	0.017	0.373
Constant	0.844***	0.000	0.918***	0.000
R-square	0.256		0.244	
F-statistic	63.45		46.31	
Significance	0.000		0.000	
Number of observation	17857		8548	

Note: the dependent variable is leverage; ***Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Source: Authors' own calculation.

4. DISCUSSION

Through the regression analysis, we find that the effects of financial factors (especially profitability as the most powerful factor) on leverage are stronger than the effects of intellectual capital elements. For intellectual capital elements, obvious differences are observed about the effect of structural capital on leverage separately for the high-tech and low-tech start-ups. Specifically, we observe a non-significant effect of human capital efficiency on leverage for both high-tech and low-tech start-ups; structural capital efficiency shows the significant and negative effects on leverage for high-tech start-ups in the crisis period

and low-tech start-ups in the non-crisis period. The negative effects of structural capital efficiency as an important part of intellectual capital elements are to some extent in accordance with the finding of D'Amato (2021) about the negative effect of intellectual capital on financial leverage. The negative effects of intangible assets or intangible capital on leverage can be interpreted by the feature of being not suitable to work as collateral for obtaining bank debt (Van Hoang et al., 2018).

The findings here tend to support the pessimistic expect of the effect of intellectual capital elements from the perspective of potential lender for debt finance. According to Ferrucci et al. (2021), due to the risk of financing of innovation, innovative firms often face hurdles when financing externally. Given that research and development (R&D) and innovation activities are the main features of high-tech manufacturing industry sectors, high-tech firms especially start-ups are riskier than low-tech firms. During the crisis period, new firms especially high-tech start-ups often suffer serious financial constraints and are difficult to get access to external finance because of their high riskiness. For instance, though databases and intellectual property rights are important parts of structural capital (Ali et al., 2021), large amount of R&D investments and innovation activities on these areas may seriously impede the willingness of potential lenders such as banks to provide funds. On the other hand, low-tech firms generally do not heavily rely on R&D and innovation activities. Considering that start-ups usually suffer financial constraints (Schäfer et al., 2011), potential lenders should believe it is risky for low-tech firms to do large investments in intellectual capital particularly structural capital even if in the economic upturn period.

With regard to human capital as the core of intellectual capital, the no explanatory power of human capital efficiency on leverage found here generally confirms the difficulties for financial lenders as external stakeholders to evaluate the credit worthiness of start-ups. This means that the value created by human capital is hard to be measured by external lenders. Differently enough, capital employed efficiency shows the significant and positive effects on leverage for both high-tech and low-tech start-ups in the non-crisis period, which confirms the benefits of physical and financial assets on obtaining external debt finance during economic upturn period with sufficient funds.

According to Margolis and Tzabbar (2020), the initial target of start-ups is survival; and, because of a lack of track record, potential investors are reluctant to lend funds to start-ups. This situation should be especially true during the crisis period, as economic crises usually cause a large drop of demand, macro-economic uncertainty, and then more problems of information asymmetry between borrowers and lenders. Here, the indicators of intellectual capital elements that are calculated on the basis of the efficiency of generating value added are to some extent not directly related to start-up survival; thereby, it is not surprising that VAIC variables generally show non-significant effect on leverage during the crisis period in comparison to the non-crisis period.

In terms of the other financial variables, the negative effects of size and profitability on leverage are strongly observed for both high-tech and low-tech start-ups during both the non-crisis and crisis periods, notwithstanding the positive effects observed in the quantile regressions for high leverage start-ups. The findings here manifest the importance of internally generated funds compared to external debt finance, since both larger firm size and higher profitability mean greater production capacity. This is in accordance with the pecking order theory of Myers and Majluf (1984) and Myers (1984). The significant and negative effects of tangibility on leverage for low-tech start-ups show the crucial role of machine and equipment on production and then on generating internal funds. The benefits of signaling effect of group background for start-ups to finance externally in debt are shown in the non-crisis period under loose economic environment for low-tech sectors with the feature of lower risk in comparison with high-tech sectors.

5. CONCLUSION

Entrepreneurship finance is a crucial academic topic, which stands at the shoes of the financial theories. Though the financial theories are examined under a variety of environments and by different types of firms, start-ups are relatively less studied due to a lack of information compared to the mature firms. This paper investigates the capital structure of Spanish start-ups as well as the influential factors with a long time span from 2008 to 2022, which helps to explore the changes of the capital structure since the 2008 global financial crisis and the differences between the crisis and non-crisis periods. Additionally, the high-tech and low-tech start-ups are separately observed with considering the impacts of intellectual capital elements.

The research results confirm a decreasing trend of leverage from 2008 to 2022 especially for low-tech start-ups as well as the change regarding the impacts of intellectual capital elements (particularly structural capital) on leverage between the crisis and non-crisis periods. For both the high-tech and low-tech start-ups, intellectual capital elements exert limited impact on leverage; there are more statistically significant variables for low-tech start-ups than for high-tech start-ups in the non-crisis period, which means the easiness to predict the capital structure during economic upturn period for the low-tech start-ups with less risk. The impacts of financial factors especially size and profitability are quite strong in comparison with intellectual capital elements. The significant and negative effects of size and profitability on leverage tend to support the pecking order theory of Myers and Majluf (1984) and Myers (1984). Therefore, the findings of this study support the weakness of the impacts of intellectual capital factors compared to financial factors on the external debt finance especially in the crisis period, which is less explored in the past literature. Due to the limitation of the available data, this research only investigates the start-ups in Spain; future research should develop comparison studies among different regions.

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