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Real options as a component of the market value of stocks: evidence from the Spanish Stock Market

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This paper aims to examine how investors' expectations about the value of a firm's real options are reflected in the price of its stocks. If the real-option approach is correct, then the efficient-market hypothesis predicts that stock prices will reflect the available information relative to the real options held by firms and their ability to identify, acquire, maintain and exercise them. The role of investment irreversibility, operating and financial flexibility, business and geographical diversification, and size are examined as indicators of a firm's real option strategy. The empirical analysis of a panel of 101 companies listed on the Spanish Stock Exchange during the period 1991–1997 provides evidence consistent with predictions. The market value of the real option portfolio is significantly and positively related to business diversification, asset irreversibility and operating leverage, and negatively related to size. In addition, financial leverage and geographical diversification are not significantly related to our proxies for the market value of real options. These results are robust even after controlling for industry, and alternative measures of investment flexibility and business diversification.

I. Introduction

The recent technological bubble coupled with the increase of volatility in major stock exchanges, has re-opened the debate about the reliability of stock prices and financial models of valuation. The confidence that almost all Corporate Finance textbooks place in the traditional approach of 'discounted cash-flow' (DCF) is in sharp contrast with its limited accuracy in practical valuation.

One of the possible explanations for the problems of empirical accuracy of traditional DCF valuation has recently been attributed to the influence of a firm's real options on its ability to generate future cash-flow. Estimates such as those of Kester (1984 and 1986) point in this direction: the capitalized value of current cash-flow streams hardly accounts for 50% of the market value of many companies and, in some cases – like those characterized by high volatility in demand and important growth opportunities – the estimate in question fails to cover 20% of their market value.

The aim of this paper is to examine in greater depth the idea that stock prices reflect investor expectation regarding the value of real options. To this end, we analyse the relation between the proportion of a firm's market value accounted for by its real options and a series of variables that should disclose the value

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of its real options. In contrast to the case of financial options, the majority of the variables affecting the value of real options are not directly observable.

Given these restrictions, the market value of a firm's real option portfolio will reflect the investors' expectations based on the publicly available information. Hence, data contained both in a company's balance sheet and in its income statement will reveal information concerning the possession and exercise of real options and, thereby, influencing their own market value. Additionally, other particular characteristics of a firm, providing information regarding its ability to identify, acquire and efficiently exercise the real options critical to its success, will also affect the market value of its real option portfolio. Among those variables that are usually expected to be related to the market value of a firm's real options, our interest has focused on the analysis of asset irreversibility, operating and financial flexibility, business and geographical diversification, and size.

The market value of a firm's real option portfolio is defined as the difference between its total market value and the value of its assets-in-place, and approximated by subtracting the present value of its expected cash-flow to equity (under a no-growth assumption) from the market value of equity. We estimate the proportion of a firm's market value unaccounted for by its assets-in-place using a panel of 101 companies listed on the Spanish Stock Exchange during the period 1991–1997. This market value estimate is then regressed on the aforementioned real-option related factors.

Our results are consistent with predictions derived from the real option framework. The market value of the real options portfolio is significantly and positively related to business diversification, irreversibility and operating leverage, and negatively related to size. Financial leverage and internationalization are not significantly related to real option measures. These results are robust even after controlling for industry, and alternative measures of investment flexibility and diversification.

The paper is organized as follows. Section II examines the problem of estimating the value of the real option portfolio. Section III studies the theoretical link between that fraction of a firm's market value accounted for by its real options and several variables that could inform about the characteristics of the real options portfolio of the firm. Section IV reviews various methodological issues, while Section V presents our empirical findings. Finally, Section VI offers conclusions.

II. The Real Options Portfolio as a Component of Stock Prices

Since Myers (1977) suggested using Options Pricing Theory to value growth opportunities and discretional decisions available to companies, an increasing number of studies have been trying to propose and develop contingent models adapted to the valuation of different decision rights (options) embedded in corporate investments.[1]

Underlying all such studies is the conviction that a significant part of the market value of many firms is accounted for by their real options, that is, by decisions which have yet to be made, but for whose execution the company is particularly well resourced. However, there are virtually no available studies offering empirical evidence about the effect of real options on stock prices, except the estimates in Kester (1984 and 1986), Smit (2000) and Danbolt *et al.* (2002), or the industry-specific analyses provided in Paddock *et al.* (1988), Quigg (1993) and Adam and Goyal (2002).[2]

According to the real options approach, a company's assets are composed of two elements: assets-in-place and real options, and as such, the market value of a firm is the sum of the market value of these two components. Assets-in-place refers to particular allocations of a firm's resources already made. The value of this component is derived from the stream of cash-flow generated over time, and equals what the traditional DCF model attributes to the company as a whole. However, the value of a firm's liabilities comes not only from the ownership of cash-flow as generated by a given resource allocation, but rather from the ownership of the resources themselves, and hence, from cash-flow as generated by any other alternative allocation. Rights to decide the allocation of resources, have value to the extent

[1] A survey of the real options approach can be found in Dixit and Pindyck (1994) and Trigeorgis (1996). See also Amram and Kulatilaka (1999) and Copeland and Antikarov (2001) for a practical perspective.

[2] Empirical evidence has basically concentrated on the analysis of specific investment projects with the aim of verifying the relevance of their embedded options and, thus, of demonstrating the suitability of the options pricing models for their valuation. For an interesting collection of similar case studies, see Trigeorgis (1999).

In addition to these studies, mention must be made of the statistical analysis of 'option reasoning' propositions in explaining investment decisions adopted in practice by managers. Some good examples include Kogut (1991) and Hurry *et al.* (1992).

that they affect future cash-flow, and their valuation is the principal object of the real options approach.

If real options principles are correct, then the efficient-market theory predicts that a firm's market value will reflect not only the present value of future cash-flow to be generated by its current resource allocation, but also that derived from future resource allocation opportunities. This implies that in judging decisions undertaken by managers, investors consider not only the effects of managerial decisions on the amount, time and risk of a firm's expected cash-flow, but also on the variables that determine the value of its real option portfolio.

The problem is that there is neither one generalized way to estimate the market value of the real options portfolio, nor a theory to explain how investors construe public information to assess the effects of managerial decisions on the portion of a firm's market value accounted for by its real options.

The nature and composition of the real options portfolio will be determined by both tangible and intangible assets accumulated by a firm in the course of its existence, which are not always adequately recorded in its financial statements. Furthermore, the value of each real option will depend on factors such as its time to expiration, its strike price or on the specific characteristics of its underlying asset, variables to whose identification only managers have access.

Under such circumstances, quantifying this component of a firm's market value inevitably becomes a complex task. It is easier to estimate the value of the real options portfolio by indirect means, that is, as based on the difference between the market value of a company and the estimated value of its assets-in-place, computed as the present value of the stream of net cash-flow expected from already made investments.

If this estimate is accurate, it should be related not only to the indicators of the presence and relevance of real options into a firm's assets, but also to those factors which reflect a firm's ability to efficiently manage its options. In fact, differences in the market value of the real options portfolios of companies belonging to the same industry – and therefore co-owners of the same shared options – reveal different perceptions on the part of investors relative to the mechanisms adopted by each firm for their identification, acquisition, maintenance and subsequent optimal exercise.[3]

Acquisition of the most valuable options, avoidance of the destruction of 'hidden options', their expensive duplication or the failure to take advantage of them, depend on the establishment of efficient systems for obtaining relevant information (Sharp, 1991; Bowman and Hurry, 1993). Moreover, in order that the process of recognizing these options comes to fruition in a company's investment structure, there must be an adequate allocation of decision rights throughout the company hierarchy, in addition to the establishment of incentives and control mechanisms in line with its objectives.

Finally, the market value of real options will reflect a firm's ability to carry out the maintenance and subsequent optimal exercise of the real options previously identified and acquired. The successful execution of both tasks – though more the latter than the former – depends on the availability of sufficient financial resources or, in their absence, enough financial flexibility. Yet, for the management of these options to take place optimally, the correct mechanisms for incentives and control must be in place. These mechanisms should guarantee the efficient allocation of financial and organisational resources necessary for maintaining the options until such time as their optimal exercise date and avoiding their fruitless expiration.

III. Variables Related to the Market Value of the Real Options Portfolio

If it were necessary to choose, from among all the available alternatives, one single variable as the main gauge of the relevance of real options in a firm's assets, it would undoubtedly be the industry in which it operates. Factors such as consumer needs and purchasing power within a given market, degree of liberalization and competition in product and factor markets, level of globalization, state of technology in the production systems, or efficiency level of corporate asset markets, are sources both of investment and disinvestment opportunities shared simultaneously by all companies operating in a particular industry and/or region.

Nevertheless, operating in a particular industry does not by itself determine the composition or the market value of a company's real options portfolio. What are commonly referred to as real options are not latent market opportunities, but rather, the

[3] On the analysis of a firm's strategy as a sequence of options see, for example, Sharp (1991) and Bowman and Hurry (1993).

individual rights to access in an efficient manner these opportunities. In turn, these rights originate from specific resources and competences held by the firm. It follows that if one's purpose is to determine the variables which best approximate the market value of the options portfolio of each firm, it is necessary to resort to factors providing information relative to the specific ability of the firm in question to take advantage of the mentioned opportunities and to exploit them efficiently. Some of these factors are: business diversification, geographical expansion, size, financial leverage, irreversibility of investment and operating flexibility. The study proceeds to discuss the role played by these variables in the market value of a firm's real options.

The degree of business and geographical diversification are frequently suggested in real options literature as reliable indicators of the relevance of real options in a firm's assets. It is well known that a principal way a firm has for obtaining knowledge is by undertaking real investments. In turn, this particularly specific knowledge is a key source of a firm's growth options. Thus, participating in different businesses and markets provides a firm with new knowledge about those resources relevant to success in its current and potential businesses and markets and, as a consequence, it acquires new options to grow.

At the same time, simultaneous participation in different businesses and regions gives the company the option to switch resources between them, depending on the evolution of products and markets, thus increasing its flexibility. Furthermore, as far as the underlying assets of these options to invest are not correlated, the value of the portfolio of real options associated with the diversification strategy will be greater than the corresponding value of the specialization strategy, as the value of a set of financial options exceeds the value of an option on a set of assets.

However, the validity of this hypothesis depends on the effective positive influence of diversification on a company's capacity to acquire and manage its options. In this regard, it has also been noted that a strategy aimed at obtaining an excessive number of options may lead to an inefficient exercise of these options as a result of the restrictions on the acquisition and use of necessary resources, or even to the loss of previously acquired rights as a result of the lack of resources needed for their conservation. Thus, some authors (Bowman and Hurry, 1993 or Sanchez, 1995, among others) have defended the position that the optimal strategy is a concentric expansion based on the acquisition of those real options for whose acquisition and subsequent exercise the company is best equipped.

In summary, to the extent that managerial efficiency is not reduced by diversification, a company's simultaneous participation in different businesses and markets broadens the scope of growth opportunities and increases its flexibility. If this premise were correct, it would be possible to predict a positive relational influence between a company's degree of diversification and the market value of its real options.

Another variable commonly referred to as a main determinant of a firm's ability to manage its options in an efficient way is corporate debt. It is well known that corporate debt could discourage the efficient exercise of options to invest expiring before the liquidation date of debt (Myers, 1977). This is explained by the agency problems arising from the divergence of interests of equityholders and debtholders, induced by the asymmetric distribution of costs and benefits of exercising a firm's real options (Mauer and Ott, 2000).

In addition, financial leverage, together with the size of a firm, are sources of information regarding a company's possibilities for raising funding (through additional borrowing or profit retention) for the acquisition, maintenance and exercise of its real options. This argument reinforces the aforementioned hypothesis on the negative relation between a firm's corporate debt and the market value of its real options, and suggests a positive relation between a firm's size and its real option value.

However, the latter positive relation is not so clear. To the extent that size could be considered a manifestation of the logical evolution of a firm's portfolio of investments, Bernardo *et al.* (2000) predict a negative relation between real options relevance and corporate size. According to this point of view, size would be a signal of the situation of a firm as it grows in the process of sequential substitution of its options to invest with assets-in-place, and thus, an increase in size (and age) should be associated with a decrease in the proportion of total market value accounted for by growth options.

Asset irreversibility is another variable affecting the value of options to invest as it increases the opportunity cost associated with exercising postponable growth options. To the extent to which commitment of resources can be postponed, the optimal moment for investment will be when the underlying value exceeds the sum of the value of exercise plus the present value of exercising the option at a later moment in time. Thus, greater irreversibility of a company's assets will postpone the optimal date for exercising its options to invest, implying greater value for postponement options, and thus, a higher proportion of

Table 1. Descriptive statistics by industry

		Assets			Sales			Capitalization		
	No. %	Mean	Median	Var. coef.	Mean	Median	Var. coef.	Mean	Median	Var. coef.
Food	13.58	55 438	31 802	1.190	100 056	40 796	2.050	41 197	17 099	1.642
Construction	23.46	70 967	43 500	1.164	50 284	17 617	1.553	51 546	26 916	1.299
Real estates	9.88	45 333	15 564	1.193	8272	2369	1.496	21 453	6430	1.738
Communications	11.11	527 422	42 794	2.353	163 566	12 075	2.619	284 549	38 157	2.532
Trade & retailing	3.70	109 397	26 986	1.264	171 750	39 954	1.303	135 936	17 343	1.365
Utilities	16.05	613 886	256 317	1.256	188 883	105 231	1.061	351 476	154 934	1.561
Oil-chemicals	11.11	217 743	23 280	1.972	260 041	11 019	2.316	186 157	12 067	2.198
Other services	4.94	10 033	6166	0.730	8086	3981	0.744	12 990	4263	1.645
Metal-working	6.17	20 066	22 045	0.724	17 275	9540	0.863	10 220	6291	1.214
Mining	9.88	37 556	27 553	0.997	27 983	16 017	1.285	28 884	7076	1.831
Automobiles	3.70	139 731	153 775	0.559	303 091	353 973	0.740	37 735	32 063	0.733
Paper and textiles	11.11	26 240	13 240	1.068	15 632	10 619	0.885	10 972	7353	1.131

the total market value accounted for by its options to invest *vis-à-vis* that accounted for by assets-in-place.[4]

Finally, whether or not a company holds operating options – related to the modification of the scale of operations and the substitution of factors and products – is reflected in its profit volatility. The successive exercise of these rights reduces the impact of changes in demand, product prices and costs of inputs on a company's operating profits, and reduces the volatility of its gross profit while increasing the correlation between sales and operating costs (Myers, 1977).

Furthermore, the market value of its real options increases with a company's operating leverage. The more the fixed costs exceed the variable costs, the greater the sensitivity of a company's gross profit to changes in the product and factor markets, so that the value of assets-in-place become lower and the utility and value of the flexibility options greater. On the other hand, greater operating leverage implies greater risk of the assets that underlie growth options, and consequently, also a greater proportion of the total market value of a company accounted for by these options (Micalizzi and Trigeorgis, 1999).

IV. Sample and Regressions

Data and definitions

The sample universe includes 101 non-financial companies listed on the Spanish Stock Exchange during the period 1991–1997. The sample selection criterion is defined according to the frequency with which each company's securities are quoted, so that prices can be considered the result of efficient valuations. Accordingly, the study chose all the non-financial companies listed on the electronic market, and those with the most frequent quotation on the auction market during the period analysed. The selected sample comprises blue-chip companies widely held by both individual and institutional investors.

The combination of 101 companies in the sample together with the seven years analysed provides a balanced panel with 707 firm–year observations subject to panel data analysis. These companies represent slightly more than half the companies listed on the Spanish Stock Exchange and account for approximately 80% of the total market capitalization and around 66% of the total value of the companies' assets. The information is taken from the *Registro de Empresas de la Comisión Nacional del Mercado de Valores* (*CNMV*) and from the *Madrid Stock Exchange Database*.

Table 1 offers a general description of the companies in the sample. According to their nature, firms belong to 12 activity sectors and can be regarded as of medium-to-large in size within the context of Spanish businesses. Nevertheless, there is a high degree of heterogeneity with respect to their average size and turnover, so that size bias in the elaboration of the sample may only be apparent. Table 1 also shows the different weighting

[4] Besides, investments such as those dedicated to new-products R&D are usually of a highly irreversible nature while constituting at the same time one of the principal mechanisms for the identification and acquisition of new growth options. Moreover, the value of these growth options generally depends positively on their exclusivity, which in turn depends on the specificity of the assets supporting them.

of the various businesses relative to the number and volume of the listed companies, highlighting the large contribution of industries such as Construction, Utilities, and Paper and Textiles compared to Trade and Retailing, and the Automobile industry.

The market value of a firm's real options portfolio was approximated by indirect means as stated in Section I. Assuming that the market value of a company is equal to the sum of the value of its assets-in-place and of its real options, the value of any two of these three elements will automatically determine the third one. Hence, the market value of a firm's real options has been computed as the difference between its equity market value and the estimated value of the assets-in-place corresponding to its stocks. This last estimation is not straightforward. In addition to problems associated with the estimation of the expectations relative to future net cash-flow, there is the near impossibility of obtaining an appropriate measure of risk for this stream of cash-flow. Estimates normally used in measuring this risk, e.g. CAPM beta, are linked to the whole of the company's assets and thus reflect not only risk associated with its assets-in-place, but also risk derived from its real options.[5]

The method chosen to solve the problem of determining the future cash-flow that assets-in-place are expected to generate consists in assuming that they provide constant and perpetual income, identical to that recorded in the current year. Regarding the approximation of the discount rate, it was opted to employ two different criteria. Firstly, the cost of capital is estimated using CAPM, taking as a proxy of the systematic risk of equity cash-flow as provided by assets-in-place, the simple average beta of the stocks belonging to the same industry. Secondly, the discount rate is identified with the risk-free rate of return.[6]

This way, one obtains, for each company-year, a first proxy of the assets-in-place value ($AIP1$) computed as the quotient between the expected perpetual equity cash-flow and the industry-risk adjusted cost of equity. A second estimate ($AIP2$) is obtained discounting the aforementioned expected cash-flow at the risk-free interest rate. The combination of these two estimates with the equity market value gives two other proxies for the proportion of a firm's total market value accounted for by its real options. More specifically, the relevance of a firm's real options in its total market value is measured by the ratio of the market value of its stocks (S) to the both previous estimates of its assets-in-place value ($AIP1$ and $AIP2$). The use of these two proxies for the real options ratio ($ROR1$ and $ROR2$) makes it possible to compare the robustness of the proposed hypotheses depending on the proxy selection.[7]

Table 2 reports descriptive statistics on real options value estimates sorted by year. Columns 1 and 2 present descriptive statistics for the full sample, while Columns 3 and 4 provide information regarding the sub-sample that results from excluding the observations giving negative values for its assets-in-place or which record extreme values in the ratios $ROR1$ or $ROR2$.[8] It may be observed that the mean of the most demanding valuation ratio ($ROR2$) is nearly half the mean of the valuation ratio estimated using the industry-risk adjusted cost of equity ($ROR1$). The values recorded describe an upward tendency over time, further accentuated in the estimates made for the full sample.

A comparison of these two valuation ratios, as representative of the relevance of the real options

[5] See Chung and Charoenwong (1991) and Chung and Kim (1997).

[6] Using the average beta of the industry instead of a company's beta permits to reduce the problems derived from the influence of real options on stock beta. The industry average beta selected in each exercise to estimate the first proxy of the discount rate is that published annually by the *Revista de la Bolsa de Madrid*, and is obtained on the basis of the last 36 monthly returns of each industry index. Annual risk-free rate of returns are approximated on the basis of the returns recorded at the end of each year for long-term government bonds (*Main Economic Indicators*, OECD), and the risk premium is considered constant during the 1991–1997 period and approximated as the average spread of the General Index of the Madrid Stock Exchange on the risk-free rate of return during this period (8.35%).

[7] Logically,

$$AIP1 < AIP2$$

and, hence,

$$ROR1 > ROR2$$

In this respect, the real options ratio that is approximated on the basis of the risk-free interest rate is more exacting than that obtained through the industry average beta.

[8] Extreme values are those that exceed the mean of the full sample plus twice its standard deviation. Of the total of 707 observations that make up the data panel, 90 observations were found with negative values and six extreme values for $ROR1$; and 90 observations with negative values and five with extreme values for $ROR2$.

Table 2. Descriptive statistics on real option value estimates

		$ROR1$	$ROR2$	$ROR1$	$ROR2$
1991	Mean	1.4681	0.8838	1.6743	1.0106
	Median	1.1262	0.6842	1.2342	0.7263
	SD	1.7861	1.0754	1.6969	1.0172
	Max	11.7144	7.1694	11.7144	7.1694
	Min	−2.8856	−1.7792	0.1173	0.0728
	Var. coef.	1.2166	1.2168	1.0135	1.0065
1992	Mean	0.8929	0.5370	1.3967	0.8374
	Median	0.8268	0.5056	0.9651	0.6016
	SD	1.9911	1.1894	1.4348	0.8674
	Max	8.2903	5.1144	8.2903	5.1144
	Min	−8.4023	−5.1378	0.0807	0.0497
	Var. coef.	2.2301	2.2150	1.0273	1.0358
1993	Mean	1.1257	0.5869	2.0293	1.1106
	Median	1.1084	0.6529	1.6295	0.9177
	SD	4.3637	2.3146	1.8172	0.9963
	Max	29.7253	14.5395	9.9409	5.7119
	Min	−16.7640	−9.6324	0.3789	0.1990
	Var. coef.	3.8766	3.9440	0.8955	0.8971
1994	Mean	1.9421	1.0517	2.0759	1.1117
	Median	1.5370	0.8318	1.6638	0.8883
	SD	7.0839	4.2933	1.9527	1.0545
	Max	64.7807	39.5598	13.2115	6.9999
	Min	−15.6778	−8.5659	0.2662	0.1650
	Var. coef.	3.6476	4.0824	0.9406	0.9485
1995	Mean	1.7768	1.0141	2.0738	1.1857
	Median	1.3971	0.7953	1.5166	0.8512
	SD	2.3157	1.3609	2.1776	1.2835
	Max	12.7296	7.4786	12.7296	7.4786
	Min	−3.8174	−2.3127	0.1054	0.0699
	Var. coef.	1.3033	1.3419	1.0501	1.0824
1996	Mean	4.2088	2.2377	2.4731	1.2723
	Median	1.4615	0.7439	1.5660	0.7899
	SD	18.8393	10.4600	3.3045	1.7576
	Max	186.1115	103.6191	23.4451	12.5539
	Min	−3.3098	−1.6055	0.2011	0.1166
	Var. coef.	4.4762	4.6745	1.3362	1.3814
1997	Mean	4.2905	1.8571	2.1606	1.0153
	Median	1.5596	0.6731	1.5978	0.6895
	SD	20.9697	9.5081	1.9499	1.3606
	Max	209.0914	95.0149	11.9547	11.4649
	Min	−4.1737	−1.8966	0.0891	0.0363
	Var. coef.	4.8875	5.1200	0.9025	1.3401

portfolio in total market value, against the factors that are theoretically related to a firm's real options value is made using the proxies described below.

Industry ascription of companies in the sample is done by means of dummy variables which classify them in the aforementioned 12 segments. The level of corporate diversification is measured with the Herfindahl Index (*HERF*) as defined by the expression:

$$HERF = 1 - \sum_{i}^{n} P_i \cdot W_i$$

where n is the number of the company's lines of business, P_i is the sales contribution of activity i, and W_i a weighting coefficient which, following Hirschman's original formulation (1964), is estimated by P_i. Therefore, index values close to 1 reflect a high degree of diversification and vice versa.

By way of complementation, and in order to evaluate the robustness of this diversification estimate, we incorporate in the analysis the Rumelt's index (*RUM*), which measures the degree of specialization or focus (Rumelt, 1974). By relating the sales of a company's principal activity to its total sales, this ratio indicates the extent to which a company

Table 3. Descriptive statistics on corporate diversification and specialization

	[91–97]	[91]	[92]	[93]	[94]	[95]	[96]	[97]
HERF								
Mean	0.1494	0.1387	0.1401	0.1498	0.1531	0.1456	0.1433	0.1769
SD	0.1838	0.1874	0.1879	0.2009	0.2107	0.2063	0.2039	0.2353
Max	0.7755	0.6686	0.6686	0.7675	0.8291	0.8380	0.8313	0.8257
Min	0	0	0	0	0	0	0	0
Median	0.0595	0	0	0.0155	0.0006	0	0	0.0003
ESP								
Mean	0.8911	0.9053	0.9044	0.8847	0.8797	0.8963	0.8992	0.8672
SD	0.1442	0.1410	0.1414	0.1824	0.1914	0.1613	0.1586	0.1917
Max	1	1	1	1	1	1	1	1
Min	0.3465	0.4899	0.4899	0.3303	0.2359	0.2777	0.3085	0.2933
Median	0.9636	1	1	0.9899	0.9887	1	1	0.9999

concentrates its resources in its principal business[9]:

$$RUM = \frac{\text{Main Business Sales}}{\sum_i \text{Sales in Business}_i}$$

Table 3 reports descriptive statistics on corporate diversification and specialization variables for the sample. Roughly speaking, it shows a high degree of specialization for the Spanish non-financial company, detected in terms both of Herfindahl's index and of Rumelt's ratio. Approximately 56% of the companies manifest a specialization ratio greater than 0.9 and only about 25.8% maintain a diversified business portfolio. This result is consistent with those found in previous studies on the diversification strategies of Spanish firms (Suárez, 1994). Regarding the evolution of these ratios during the period 1991–1997, a moderate increase in the level of diversification is observed.

To approximate the variable of globalization, the quotient between a company's exports and its total sales (*EXP*) is used. In the case of investment irreversibility, the index chosen is the ratio of book value of fixed asset to total assets (*FATA*), given that companies with a greater structural burden tend to exhibit a higher degree of investment irreversibility.

In addition, investment irreversibility is also approximated by the sensitivity of a company's investments to changes in demand for its products, which in turn is measured as a contemporaneous correlation between growth in sales and investments (*FLEX*). A firm can be expected to have greater flexibility as the extent to which this correlation approaches 1, while values close to zero are indicative of a high level of asset irreversibility.[10]

A company's financial leverage is estimated on the basis of the ratio of its book value of debt with cost to its book value of total assets (*DTA*). The logarithm of the book value of assets (*LTA*) and of sales (*LSAL*) is used to calculate a firm's size. The level of operating flexibility is approximated by the correlation coefficient between sales and costs (*SCCC*),[11] while operating leverage (*OPLEV*) is defined as the ratio of fixed costs to variable costs; taking labour, selling and goods expenses as variable costs, and general and administrative expenses and depreciation as fixed costs. Table 4 provides some summary statistics

[9] The source of information used to estimate Herfindahl's Index (*HERF*) and Rumelt's ratio (*RUM*) is the *Registro de Actividades de la CNMV*. The analysis would certainly have benefited from considering the exact type of diversification followed by the companies, but the lack of sufficient and reliable information regarding their business lines made this impossible. Data in the *Registro de Actividades de las Empresas de la CNMV* only refers to the numbers of business lines and their sales.

[10] The inconvenience of this variable lies in the fact that it is only possible to obtain an observation per company for the period as a whole. Hence this cannot be introduced into the analysis of panel data, but can still be used as a discriminating variable for comparing the average real options values. In the sample, 25% of the companies have a correlation coefficient of more than 0.70, and one third present values between 0.55 and 1.

[11] As in the case of the correlation coefficient between growth in sales and investments, the multi-periodic nature of this variable prevents its inclusion in the panel data analysis. Moreover, the limited discriminating power exhibited by the values obtained by this measure in the sample (see Table 4) render it of limited use in the formation of subsamples and the consequent comparison of their influence on the market value of the real option portfolio. In the majority of observations, the correlation between sales and costs reveals values close to 1, and its mean is 0.95.

Table 4. Descriptive statistics

	Mean	Median	SD	Max.	Min.	Var. coef.
*ROR*1	1.9865	1.4497	2.1438	23.4450	0.081	1.0792
*ROR*2	1.0787	0.7594	1.2315	12.5538	0.0362	1.1417
HERF	0.1559	0.0006	0.2115	0.8313	0	1.3566
RUM	0.8849	0.9995	0.1755	1	0	0.1983
EXP	0.1402	0.0242	0.2210	1	0	1.5763
FATA	0.5871	0.5967	0.2402	0.9959	0.0248	0.4091
OPLEV	0.7642	0.4631	1.6944	32.00	0.0482	2.2172
FLEX	0.2939	0.3556	0.4848	0.9987	−0.8437	1.6495
SCCC	0.8407	0.9539	0.3057	0.9997	−0.9310	0.3636
DTA	0.2733	0.2664	0.1645	0.7580	0.0001	0.6019
LTA	10.5800	10.4017	1.6521	15.2592	7.5923	0.1545

on these variables for the observations in the restricted panel.[12]

Model specification

The regression models to be estimated follow a progressive and cumulative sequence, so that the first model includes the independent variables of business and geographical diversification, together with financial leverage and size (1). The model which includes factors indicating investment and operating flexibility together with financial leverage and size as independent variables is the second to be estimated (2). And finally, the third model includes all independent variables (3). The three models are estimated for each of the two dependent variables (*ROR*1 and *ROR*2).

Analytically, they are expressed as follows:

$$RORit = \alpha_i + \beta_1\, HERF_{it} + \beta_2\, EXP_{it} + \beta_3\, DTA_{it} + \beta_4\, SIZE_{it} + \varepsilon_{it} \quad (1)$$

$$RORit = \alpha_i + \beta_1\, FATA_{it} + \beta_2\, OPLEV_{it} + \beta_3\, DTA_{it} + \beta_4\, SIZE_{it} + \varepsilon_{it} \quad (2)$$

$$RORit = \alpha_i + \beta_1\, HERF_{it} + \beta_2\, EXP_{it} + \beta_3\, FATA_{it} + \beta_4\, OPLEV_{it} + \beta_5\, DTA_{it} + \beta_6\, SIZE_{it} + \varepsilon_{it} \quad (3)$$

where i represents each company ($i = 1, \ldots, 101$), t indicates the observation's year ($t = 1, \ldots, 7$), the coefficients α_i and β_j are those to be estimated, and ε_{it} are the random errors. Subsequently, these models are re-estimated with the aim of testing the robustness of our results against different specifications of the model and different subsamples.[13]

V. Empirical Results

The following results refer to the restricted panel of 611 firm–year observations for the period 1991 though 1997, obtained by removing from the full panel of 707 observations, those with negative values for their cash-flow or extreme values in the ratios *ROR*1 or *ROR*2.[14] Table 5 presents the results from the regression of the real option ratios on the independent variables included in Model 1. Irrespective of the valuation ratio, estimates of the coefficients from this regression are consistent with predictions, although only business diversification and size are significant at the 1% level or lower.

Table 5 shows that real option ratios are increasing in business and geographical diversification, supporting the idea that diversification is a source of growth options and flexibility. It also shows that real options ratios are negatively related to size, suggesting that most of the total market value of large firms derives from the ability of its assets-in-place to generate cash-flow, while for the small firms comes mainly from their future opportunities. This result confirms size as a good indicator of the situation of a firm as it grows in the logical process of substituting growth options with assets-in-place. Finally, the regression

[12] The restricted panel is obtained by removing those observations with negative values for its assets-in-place or which record extreme values in the ratios *ROR*1 or *ROR*2.

[13] One variable of special importance in arriving at the value of real options is Research and Development expenditures. Unfortunately, the lack of information regarding R&D expenditures of the companies in the sample prevents its inclusion in the empirical analysis.

[14] Both the fixed effects models (within) and the random effects model (random) are presented together with the Hausman test, which evaluates the null hypothesis relative to the absence of correlation between fixed effects and the remaining regressors.

Table 5. Regression results of Model 1

$$ROR_{it} = \alpha + \beta_1\, HERF_{it} + \beta_2\, EXP_{it} + \beta_3\, DTA_{it} + \beta_4\, SIZE_{it} + \varepsilon_{it}$$

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
HERF	2.952***	[0.001]	2.51149***	[0.000]	*HERF*	1.40570***	[0.008]	1.1763***	[0.000]
EXP	3.053***	[0.009]	0.658866	[0.257]	*EXP*	1.41015**	[0.043]	0.26721	[0.410]
DTA	−0.9087	[0.263]	−0.52261	[0.409]	*DTA*	−0.75434	[0.122]	−0.40971	[0.263]
LSAL	−0.5067***	[0.000]	−0.27010***	[0.000]	*LSAL*	−0.23648***	[0.003]	−0.13322***	[0.001]
C			4.44855***	[0.000]	*C*			2.3525***	[0.000]
R^2	0.48870		0.35041		R^2	0.42792		0.28370	
Adj-R^2	0.38299		0.21611		Adj-R^2	0.30988		0.13590	
F(100.503)	41.715***	[0.000]			*F*(100.504)	33.020***	[0.000]		
	Hausman $\chi^2(4) = 11.771$			[0.0191]		Hausman $\chi^2(4) = 7.667$			[0.1046]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The first four columns show regression results using *ROR*1 as dependent variable; while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

results indicate that real option measures are decreasing in financial leverage, suggesting the negative influence of debt on a firm's ability to manage efficiently its real options as a result of the under-investment problems (Myers, 1977).[15]

Model 1 is re-estimated incorporating a set of dummies corresponding to the firms' industry description. The results of these new regressions (Table 6) allow one to corroborate the sign of all the coefficients, and the statistical significance of business diversification and size in explaining the relevance of a firm's real options value. Furthermore, it is found that the industry dummies are not statistically significant, which suggests that real options reflected in the market value of firms are not shared with the rest of the industry, but firm-owned exclusively.

Estimates for the coefficients from Model 2 are presented in Table 7. The result of this regression shows that valuation ratios are positively related to investment irreversibility and operating leverage, with coefficients statistically significant at the 1% and 5% level respectively.

The positive sign of the irreversibility coefficient confirms its influence in postponing a firm's investments, and therefore, its explanatory power regarding the weight of growth options not yet exercised in a firm's total assets. With regard to the operating leverage, the positive sign of its regression coefficient is consistent with its positive influence on the risk of a firm's investments, and consequently, on the value of the real options that have these investments as underlying assets.

Regression results relative to the sign of the financial leverage and size coefficients corroborate the results obtained in the estimation of Model 1, although there are differences in their statistical significance. According to the within-effect estimates (the result from Hausman tests recommends this method), the size coefficient is significant at the 10% level only when the valuation measure is $ROR1$, while financial leverage is significant at the same level only when the dependent variable is $ROR2$.

In addition, inclusion of industry dummies in the estimation of Model 2 does not modify the previous results relative to the sign of the coefficients (Table 8). The only difference concerns the statistical significance of the coefficients in the regression using $ROR2$ as the dependent variable. In this case, though asset irreversibility and operating leverage remain significant at the same level, there are several additional variables, such as the size and the industry dummies, whose coefficients are statistically significant at the 1% or lower level.

Table 9 presents the regression results of Model 3, which considers the combined influence of all the above independent variables on valuation ratios. These results are qualitative identical to those obtained in previous regressions. No changes are found for the sign of the regression coefficients, which is again consistent with the predictions derived from the real options framework. However, differences in the significance levels of the coefficients indicate the statistical superiority of the proxies for business diversification, asset irreversibility, and operating leverage in explaining the market valuation of real options.

Again, Model 3 is re-estimated by including industry dummies. The regression estimates are reported in Table 10. Consistent with the earlier estimations, these results indicate that, irrespective of the valuation measure, the proxies for the market value of real options are increasing in the variables of business diversification, asset irreversibility and operating leverage, and statistically significant at the 5% or lower level. Only one difference with respect to the results in Table 9 is detected, which is the statistical significance of the negative relation between the market value of a firm's real options and its size.[16] The statistical significance of some industry dummies in explaining the market value of real options as estimated by the ratio $ROR2$ should be noted.

Robustness analysis

Finally, the robustness of the results is checked against a number of specifications. First, the sensitivity of the results are evaluated for the subsample of companies with highest investment flexibility. The sample is divided into flexible and non-flexible firms based on the correlation coefficient between the growth of the book value of assets and the growth

[15] However, low statistical significance for this variable does not help us to confirm this prediction. The negative relation between financial leverage and real option value seems to agree with empirical findings in previous studies. See Smith and Watts (1992) and McConnell and Servaes (1995). Regarding the Spanish case, Andrés *et al.* (2000) observe a negative relation between a firm's market value and financial leverage for those companies showing a larger relevance of growth opportunities.

[16] Note that this same significance of the size coefficient was found in the result regressions of Models 1 and 2.

Table 6. Regression results of Model 1 including industry dummies

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
HERF	1.40570***	[0.008]	1.2381***	[0.000]	*HERF*	1.40570***	[0.008]	1.2381***	[0.000]
EXP	1.41015**	[0.045]	0.21910	[0.536]	*EXP*	1.41015**	[0.045]	0.21910	[0.536]
DTA	−0.75434	[0.125]	−0.40061	[0.281]	*DTA*	−0.75434	[0.125]	−0.40061	[0.281]
LSAL	−0.23648***	[0.003]	−0.13273***	[0.001]	*LSAL*	−0.23648***	[0.003]	−0.13273***	[0.001]
COMM			0.12141	[0.674]	*COMM*			0.12141	[0.674]
PAPER			−0.40716	[0.163]	*PAPER*			−0.40716	[0.163]
BUILD			−0.15634	[0.474]	*BUILD*			−0.15634	[0.474]
UTIL			−0.06855	[0.798]	*UTIL*			−0.06855	[0.798]
CHEM			−0.13551	[0.643]	*CHEM*			−0.13551	[0.643]
MET			0.24506	[0.446]	*MET*			0.24506	[0.446]
C			2.3984***	[0.000]	*C*			2.3984***	[0.000]
R^2	0.42792		0.28436		R^2	0.42792		0.28436	
Adj-R^2	0.30156		0.12629		Adj-R^2	0.30156		0.12629	
$F(100.498)$	31.707***	[0.000]			$F(100.498)$	31.707***	[0.000]		
	Hausman $\chi^2(4) = 8.4626$			[0.0706]		Hausman $\chi^2(4) = 8.4626$			[0.0706]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

Table 7. Regression results of Model 2

$$ROR_{it} = \alpha + \beta_1\, FATA_{it} + \beta_2\, OPLEV_{it} + \beta_3\, DTA_{it} + \beta_4\, SIZE_{it} + \varepsilon_{it}$$

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
FATA	3.94522***	[0.000]	1.35772***	[0.008]	*FATA*	2.13241***	[0.000]	0.65342**	[0.021]
OPLEV	0.12804**	[0.012]	0.14444***	[0.002]	*OPLEV*	0.07026**	[0.022]	0.08037***	[0.005]
DTA	−1.0894	[0.175]	−0.20213	[0.749]	*DTA*	−0.84325*	[0.082]	−0.22087	[0.545]
LSAL	−0.23486*	[0.091]	−0.27707***	[0.000]	*LSAL*	−0.09046	[289]	−0.13841***	[0.000]
C			3.98375***	[0.000]	*C*			2.1148***	[0.000]
R^2	0.48948		0.34213			R^2	0.42994	0.27635	
Adj-R^2	0.38351		0.20557			Adj-R^2	0.31185	0.12643	
F(100.501)	4.2013***	[0.000]			*F*(100.502)	3.2928***	[0.000]		
	Hausman $\chi^2(4) = 15.474$		[0.0038]			Hausman $\chi^2(4) = 12.734$			[0.0127]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

Table 8. Regression results of Model 2 including industry dummies

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
FATA	3.94522***	[0.000]	2.26231***	[0.000]	*FATA*	2.13241***	[0.000]	1.18457***	[0.000]
OPLEV	0.12804**	[0.012]	0.14480***	[0.003]	*OPLEV*	0.07026**	[0.022]	0.08069***	[0.005]
DTA	−1.0894	[0.175]	−0.30063	[0.637]	*DTA*	−0.84325*	[0.082]	−0.28746	[0.432]
LSAL	−0.23486*	[0.091]	−0.22478***	[0.002]	*LSAL*	−0.09046	[289]	−0.10675***	[0.007]
COMM			−1.3181**	[0.017]	*COMM*			−0.62005**	[0.037]
PAPER			−0.7763	[0.139]	*PAPER*			−0.46301	[0.100]
BUILD			0.5724	[0.153]	*BUILD*			−0.39675*	[0.064]
UTIL			−1.4511**	[0.005]	*UTIL*			−0.86951***	[0.002]
CHEM			−0.5111	[0.337]	*CHEM*			−0.23030	[0.419]
MET			−0.2695	[0.636]	*MET*			−0.14401	[0.638]
C			3.5183***	[0.000]	*C*			1.8279***	[0.000]
R^2	0.48948			0.34508	R^2	0.42994		0.27953	
Adj-R^2	0.37603			0.19954	Adj-R^2	0.30352		0.11975	
$F(100.495)$	3.8982***	[0.000]			$F(100.496)$	2.9974***	[0.000]		
	Hausman $\chi^2(4) = 9.7985$			[0.0440]		Hausman $\chi^2(4) = 7.7554$			[0.1010]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

Table 9. Regression results of Model 3

$$RORit = \alpha + \beta_1\, HERF_{it} + \beta_2\, EXP_{it} + \beta_3\, FATA_{it} + \beta_4\, OPLEV_{it} + \beta_5\, DTA_{it} + \beta_6\, SIZE_{it} + \varepsilon_{it}$$

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
HERF	3.06838***	[0.000]	2.97634***	[0.000]	*HERF*	1.53186***	[0.004]	1.43887***	[0.000]
EXP	2.11502	[0.249]	0.59376	[0.302]	*EXP*	0.84276	[0.249]	0.23188	[0.470]
FATA	3.98881***	[0.000]	1.95090***	[0.000]	*FATA*	2.15697***	[0.000]	0.94822***	[0.001]
OPLEV	0.11884**	[0.031]	0.14599***	[0.002]	*OPLEV*	0.06715**	[0.031]	0.08155***	[0.004]
DTA	−0.99101	[0.101]	−0.34541	[0.578]	*DTA*	−0.79789	[0.101]	−0.30013	[0.404]
LSAL	−0.27958	[0.192]	−0.27418***	[0.000]	*LSAL*	−0.11081	[0.192]	−0.13747***	[0.000]
C			3.11827***	[0.000]	*C*			1.70678***	[0.000]
R^2	0.50684		0.36894		R^2	0.44195		0.29621	
Adj-R^2	0.40208		0.23489		Adj-R^2	0.32365		0.14700	
$F(100.499)$	4.0688***	[0.000]			$F(100.500)$	3.1662***	[0.000]		
	Hausman $\chi^2(6) = 13.966$			[0.0300]		Hausman $\chi^2(6) = 10.673$			[0.0990]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

Table 10. Regression results of Model 3 including industry dummies

	*ROR*1					*ROR*2			
	Within coef.	*p*-value	Random coef.	*p*-value		Within coef.	*p*-value	Random coef.	*p*-value
HERF	3.06838***	[0.000]	2.85680***	[0.000]	*HERF*	1.53186***	[0.004]	1.34381***	[0.000]
EXP	2.11502	[0.079]	0.24690	[0.690]	*EXP*	0.84276	[0.252]	−0.01693	[0.961]
FATA	3.98881***	[0.000]	2.46687***	[0.000]	*FATA*	2.15697***	[0.000]	1.28931***	[0.000]
OPLEV	0.11884**	[0.021]	0.14777***	[0.002]	*OPLEV*	0.06715**	[0.032]	0.08243***	[0.004]
DTA	−0.99101	[0.201]	−0.39242	[0.531]	*DTA*	−0.79789	[0.103]	−0.33704	[0.352]
LSAL	−0.27958**	[0.046]	−0.24295***	[0.001]	*LSAL*	−0.11081	[0.195]	−0.11427***	[0.004]
COMM			−0.91763	[0.101]	*COMM*			−0.45810	[0.128]
PAPER			−0.73010	[0.158]	*PAPER*			−0.43424	[0.118]
BUILD			−0.50552	[0.202]	*BUILD*			−0.37861*	[0.074]
UTIL			−0.93682*	[0.080]	*UTIL*			−0.65571**	[0.023]
CHEM			−0.69977	[0.182]	*CHEM*			−0.32196	[0.253]
MET			−0.05551	[0.923]	*MET*			−0.01271	[0.967]
C			3.01731***	[0.000]	*C*			1.6033***	[0.000]
R^2	0.50684		0.36981		R^2	0.44195		0.29735	
Adj-R^2	0.39480		0.22664		Adj-R^2	0.31543		0.13805	
$F(100.493)$	3.8623***	[0.000]			$F(100.494)$	2.9458***	[0.000]		
	Hausman $\chi^2(6) = 12.073$			[0.0604]		Hausman $\chi^2(6) = 8.7956$			[0.1854]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. The table shows estimates of the coefficients from the model, its *p*-value in the *t*-Student test, the coefficients of determination for each regression, and within and random effects from Hausman tests, which contrast the null hypothesis of no correlation between those effects.

Table 11. Regression results of Model 3 for the subsample of firms with highest flexibility

	*ROR*1		*ROR*1		*ROR*2		*ROR*2	
	Coef.	*p*-value	Coef.	*p*-value	Coef.	*p*-value	Coef.	*p*-value
FATA	1.80049***	[0.007]	2.10342***	[0.002]	0.73102**	[0.040]	0.93646***	[0.009]
HERF	2.54205***	[0.000]	2.63928***	[0.000]	1.07362***	[0.005]	1.08998***	[0.005]
EXP	−0.71987	[0.164]	−1.05096*	[0.090]	−0.40924	[0.147]	−0.63366*	[0.053]
OPLEV	0.18237***	[0.006]	0.19197***	[0.004]	0.10038***	[0.004]	0.10629***	[0.002]
DTA	0.20897	[0.736]	0.12190	[0.846]	0.10000	[0.760]	0.01807	[0.956]
LSAL	−0.14569**	[0.025]	−0.12874**	[0.045]	−0.06986**	[0.047]	−0.06146*	[0.071]
PAPER			0.25838	[0.667]			0.08265	[0.795]
BUILD			−0.21855	[0.578]			−0.24295	[0.244]
UTIL			−0.47174	[0.320]			−0.39036	[0.121]
CHEM			−0.31686	[0.513]			−0.15402	[0.548]
MET			0.34972	[0.521]			0.15282	[0.597]
C	1.75163**	[0.046]	1.53180*	[0.100]	1.05077**	[0.027]	0.98499**	[0.045]
R^2	0.59368		0.58682		0.58630		0.57816	
Adj-R^2	0.48958		0.45860		0.48031		0.44724	
$F(25, 121)$	4.51***	[0.000]	3.64***	[0.000]	5.00***	[0.000]	3.76***	[0.000]
Hausman $\chi^2(6)$	6.72	[0.3467]	8.74	[0.1884]	6.45	[0.3750]	8.86	[0.1818]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level. The four first columns show regression results using *ROR*1 as dependent variable, while in the last four columns the dependent variable is *ROR*2. Columns 2 and 4 presents the results of the regressions that include industry dummies. The table shows estimates of the coefficients from the random-effects model, its *p*-value in the Student-*t* test, the coefficients of determination, and Haussman tests for each regression. The sample is divided into flexible and non-flexible firms based on the correlation coefficient between the growth of the book value of assets and the growth of sales (*FLEX*). Results refer to the subsample of firms in the highest quartile (*FLEX* > 0.7020. 153 observations), that is, for those firms with highest flexibility.

of sales, and those with a ratio greater than a breakpoint of 0.7 (153 observations of the highest quartile of the sample) were selected. It was then tested whether the estimation results of Model 3 depend on a firm's investment flexibility.

The results of this analysis are presented in Table 11. Broadly speaking, these results are consistent with the earlier findings for the full panel. Both valuation ratios are positively related to business diversification, asset irreversibility and operating leverage, and significant at the 1% level. The negative sign of the size effect on the value of options holds as well, though at the 5% or even at the 10% level, depending on the valuation ratio used as dependent variable. The only difference concerns the negative sign of geographical diversification, although the statistical significance of this variable is not high enough to indicate significant differences with previous findings, and depends on the inclusion of the industry dummies. Finally, the estimation results of the regressions that incorporate the set of industry dummies (Columns 2 and 4 in Table 11) show that industry ascription is not determinant of the market value of a firm's real option portfolio for those firms with highest flexibility.

Then the robustness of results was analysed against different measures of business diversification. Table 12 shows the estimation results of Model 3 when the previous diversification proxy (*HERF*) is replaced by the specialization ratio (*RUM*). The new results confirm those of the original estimation. As expected, the specialization ratio has a negative effect on the valuation ratios – significant at the 1% level – while asset irreversibility and operating leverage show again positive coefficients, significant at the same level. Finally, the negative and strongly significant coefficient of the size variable appearing in the estimation of this last regression indicates the need to consider size together with a firm's degree of specialization in explaining the market value of its real options. Again, this is consistent with predictions in Bernardo *et al.* (2000), that is, if a firm's evolution over time is defined as a continuous process of substituting its growth options with assets-in-place, the positive effect of business diversification on the market value of growth options will be greater in new entrants than in mature firms.

VI. Conclusions

We have used real options reasoning to predict the expected relation between the real options component of stock prices and the variables of business and geographical diversification, asset irreversibility,

Table 12. Regression results of Model 3 with the specialization ratio as independent variable

	*ROR*1		*ROR*2	
	Coef.	*p*-value	Coef.	*p*-value
RUM	−2.19656***	[0.000]	−1.01303***	[0.005]
EXP	0.43334	[0.486]	0.06694	[0.846]
FATA	2.36678***	[0.000]	1.24264***	[0.000]
OPLEV	0.15562***	[0.001]	0.08563***	[0.003]
DTA	−0.35936	[0.569]	−0.31675	[0.383]
LSAL	−0.22338***	[0.002]	−0.10499***	[0.008]
COMM	−1.05425*	[0.060]	−0.52422*	[0.081]
PAPER	−0.78090	[0.132]	−0.45797*	[0.099]
BUILD	−0.55244	[0.165]	−0.39958*	[0.060]
UTIL	−1.13746**	[0.033]	−0.75335**	[0.009]
CHEM	−0.62812	[0.232]	−0.28524	[0.311]
MET	−0.34954	[0.541]	−0.15368	[0.619]
C	5.28886***	[0.000]	2.65265***	[0.000]
R^2	0.35565	0.35565	0.28555	0.28555
Adj-R^2	0.20927	0.20927	0.12573	0.12573
	$F(100.493) = 3.8$***	[0.000]	$F(100.496) = 2.91$***	[0.000]
Hausman	$\chi^2(6) = 13.27$	[0.0389]	$\chi^2(6) = 9.64$	[0.1403]

Notes: ***Denotes significant at the 1% level. **Denotes significant at the 5% level. *Denotes significant at the 10% level.
The first column shows the regression results using as dependent variable *ROR*1; while in the second column the dependent variable is *ROR*2. The table shows estimates of the coefficients from the random-effects model, its *p*-value in the *t*-Studen test, the coefficients of determination, and Haussman tests for each regression. The diversification proxy (*HERF*) in Model 3 has been substituted with a measure of specialization (*RUM*), and industry dummies are included.

financial and operating leverage, and size. These predictions are then tested using a firm-level panel data during the period 1990 through 1996. After approximating the real options component of stock prices for the firms in the sample, some panel regressions of this valuation measure have been estimated on several proxies of the investors' expectations regarding a firm's real options portfolio.

The results are consistent with predictions. It is shown that real options contribute significantly to the stock price of the firms in the sample. They also confirm that the market value of real options is significantly and positively related to corporate diversification, asset irreversibility and operating leverage, and negatively related to size. On the other hand, financial leverage and geographical diversification are not significantly related to real options measures. These results are robust even after controlling for industry, and alternative measures of investment flexibility and business diversification.

The nature of the variables that are empirically related to a firm's market value accounted for by its real options indicates that investors pay more attention to the information about the effective holding of real options by firms than to insights about a firm's efficiency in identifying, acquiring and exercising its real options. Indeed, asset irreversibility and operating leverage are directly related to the market value of the real options already held by a firm. Moreover, the positive relation between the market value of real options and business diversification can only be explained when the latter is interpreted as a proxy for real options holding. Finally, the negative influence of size on real options value reflects its role in providing information about the weight of real options – versus assets-in-place – in a firm's total assets.

While some evidence has been provided about the valuation effects of real options, and some of their explanatory variables, future research might progress in the evaluation of broader samples of companies, and the analysis of alternative measures of investors' expectations regarding a firm's ability to acquire and exploit its options.

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