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How is corporate diversification coded into Real Options language? The interaction between growth options, diversification scope and relatedness

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Abstract

This paper investigates how corporate diversification interacts with a firm's growth options value. We adopt an options-based perspective, from which diversification is seen as both a materialization of current growth options exercise and a source of future options to expand. We focus on two dimensions of this strategy: degree of diversification and relatedness between segments. We posit that at low levels of diversification, the option exercising effect prevails, whereas the option creation effect dominates at higher diversification levels. Relatedness sparks interaction effects among growth options, which may make the value of the portfolio non-additive. This effect of relatedness may be moderated by diversification scope, which sets out the relative importance of synergies versus coordination costs. Using a panel sample of U.S. firms from 1998-2010 and accounting for endogeneity, we confirm a U-relationship between diversification and growth options. Results also reveal an inverse U-linkage between relatedness and the firm's growth options value, which is less pronounced in high diversifiers than in low ones. This study extends the applicability of the real options approach to strategy, and suggests the relevance of a multidimensional and contingent view in the diversification debate.

Key words: diversification, relatedness, real options, GMM system estimator.

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0. INTRODUCTION

The goal of this paper is to investigate the impact of corporate diversification on a firm's growth options value. With a few exceptions, the bulk of the existing literature on the value-effect of corporate diversification has mainly dealt with how this strategy may influence the stream of cash flows expected from a firm's current businesses. However, a firm's market value not only stems from the expected cash flows to be generated by a given allocation of resources –value of assets-in-place–, but also from any other possible/future allocation which ownership of the resources themselves may enable the firm to undertake –value of growth options– (Myers, 1977).[1] Overlooking such a twofold composition of a firm's value may bias both theoretical hypotheses and empirical results.[2]

The exception to this general approach is represented by a small number of works which have, directly or indirectly, linked growth options value to corporate diversification value, yet with ambiguous results. On the one hand, some empirical papers (Villalonga, 2004a; Stowe and Xing, 2006; Andrés, Fuente and Velasco, 2014; to name but a few) show differing evidence when controlling for growth options in the relation between value effect and corporate diversification, ranging from evidence that growth options fail to account for the diversification discount (Stowe and Xing, 2006) to their playing a mediating role (Andrés *et al.*, 2014). On the other hand, a number of different arguments have been used to suggest the theoretical link between growth options and diversification. For instance, Raynor (2002) considers options-based diversification as a strategic insurance which reduces firm-specific risk in a way shareholders could not replicate with a portfolio of

[1] Growth options seem to account for around half of a firm's market value (and even more in more volatile industries) according to estimations such as Kester (1984), Alessandri, Lander and Bettis (2007) or Tong, Reuer and Peng (2008), among others.
[2] Indeed, this widespread research has shaped a conflicting view about the impact of corporate diversification on performance, with evidence ranging from a negative effect ("discount effect": Berger and Ofek, 1995; Servaes, 1996; Stowe and Xing, 2006), to a positive effect ("premium effect": Campa and Kedia, 2002; Villalonga, 2004a) or a curvilinear effect (Palich, Cardinal and Miller, 2000).

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unisegment companies. Bernardo and Chowdhry (2002) argue that unisegment firms have more options to expand whereas multisegment firms may have already depleted part of them. Holder and Zhao (2015) find that diversification by above average performers mainly involves exercising growth options, whereas in the case of below average performers it aims to seek out further opportunities. In a similar vein, Yang, Narayanan and De Carolis (2014) suggest that high degrees of diversification offer firms the ability to create possible new paths of action in response to uncertainty. Overall, this research proves particularly enlightening by delving more deeply into the diversification strategy and its value-driving mechanisms through the real options (hereinafter, RO) lenses.

In this paper, we study further the effect of a firm's diversification strategy on the value of its embedded growth options by directly focusing on analysing the degree of diversification and relatedness between business segments. We adopt an RO perspective to draw potential differences in the growth option portfolio of firms based on these two diversification dimensions and their interactions.

According to the RO approach, a firm's diversification decision, by way of investing in a new business, involves replacing one of its current growth options (which is exercised) by both a share in its 'underlying' business and a number of new options to expand in future segments. Under this perspective, diversification will create value as long as the sum of the Net Present Value (NPV) of expected cash-flows from the underlying business and the value of future options to expand, is positive. This may be obtained by means of a positive NPV of expected cash-flows or a value of future growth options higher than the negative amount of NPV from cash-flows.

Negative NPV projects are exploratory investments, their value source stemming from options to expand in the future. R&D activities are a paradigm of this kind of project

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(McGrath and Nerkar, 2004). However, diversifying in a new business is primarily an exploitation investment (Penrose, 1959). It generally involves capitalizing on synergies and competitive advantages acquired in prior segments. Should this be the case, its main source of value would be cash-flows, and diversification would imply replacing a current growth option with new ones of lower value. Based on this logic, we might expect a lower growth options value, the higher the degree of diversification.

However, investments are not the only source of growth options. Day-to-day business management also creates certain capabilities which can become the seed of new growth options. Likewise, managing multiple businesses simultaneously can provide firms with unique capabilities for sensing and seizing new growth options which would increase their relevance in a firm's market value. As a consequence, we might expect a higher growth options value, the higher the degree of diversification. Taking both arguments together, we posit that at low levels of diversification, the option exercising effect prevails, whereas the option creation effect dominates at higher diversification levels.

Furthermore, the interrelationships between the businesses within a company may spark a portfolio effect, causing individual growth option values to be non-additive. Some benefits of relatedness, such as synergies, may enhance a firm's options value either by making it less costly to exercise subsequent options to invest or by increasing future project returns. However, at a certain level of relatedness, such benefits may be countered or even exceeded by the costs imposed by duplicities and diversity constraints. In addition, we posit a moderating effect of the level of diversification on the value impact of relatedness, since the scope of a conglomerate can determine the relative importance of synergies versus complexity, thus either countering or reinforcing the impact which relatedness carries individually.

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Drawing on a panel of 818 U.S. firms (5,592 firm-year observations) during the 1998-2010 period and using two-step GMM system estimations to control for unobserved heterogeneity and endogeneity, our study finds evidence of a U-relation between the degree of diversification and the firm's growth options value (GOV), suggesting that this strategy may primarily become a source of growth options after a certain level. In addition, we report an inverted U-shaped relationship between relatedness and GOV, revealing that firms exploit synergies from related diversification up to a certain level, after which relatedness becomes counterproductive. We also find that degree and relatedness interact with each other, causing the inverted U-curve of relatedness to be unexpectedly flatter in high diversifiers.

The remainder of the paper is organized as follows. Section 1 develops our theoretical background and hypotheses. The following section then describes our sample, variables, models and econometric approach. Section 3 contains our empirical findings, and Section 4 discusses the results, conclusions and contributions.

1. BACKGROUND AND HYPOTHESES

1.1. Degree of diversification

Since Myers (1984) and Kester (1984) first came up with real options (RO) as an integrative approach to bridge strategic and financial analyses over thirty years ago, a stream of research has progressively exploited the potential of such a hybrid perspective for a better understanding of the value creation process of a wide range of corporate strategies. Some relevant examples are the analysis of market development (Folta and O'Brien, 2004; Tong *et al.*, 2008), R&D (McGrath and Nerkar, 2004; Miller and Arikan, 2004; Oriani and Sobrero, 2008), strategic alliances (Kogut, 1991; Chi and McGuire, 1996) or serial acquisitions programmes (Smit and Moraitis, 2010), among others.[3] Drawing on RO logic, corporate strategies create value by generating both cash-flows and non-financial or strategic outcomes. These outcomes are valuable insofar as they grant the firm certain future choices it would not otherwise be able to make. When these choices refer to the opportunity to invest in a future business, they are known as "growth options" or options to expand, due to their conceptual analogy with financial call options (Bowman, Hurry and Miller, 1992). In the case of corporate diversification, a firm's diversification decision, by way of investing in a new business, implies replacing one of its current growth options (which is exercised) by both a share in its 'underlying' business and a number of new options to expand in future segments. Papers such as Bowman and Hurry (1993) or McGrath (1999) back up such arguments.

Both effects are captured by the definition of the Expanded Net Present Value ($ENPV_i$) of exercising the growth option value (C^*_i) on investment "i" as the sum of the Net Present Value of expected cash-flows from operating in business i (NPV_i), and the value of new emerging growth options to invest in business "j" (C_j):

$$ENPV_i \ (= C^*_i) = NPV_i + C_j$$

where the whole equation represents replacing the option to invest in business i by its underlying assets-in-place i and a new option to grow in business j. Should value creation be a firm's objective, the normative decision rule would be to invest in projects displaying an $ENPV>0$, which can be obtained through either a negative or a positive NPV of cash-flows.

In contrast to explorative projects, such as R&D investments, whose NPV is usually negative, corporate diversification is genuinely an exploitation activity (Penrose, 1959),

[3] See Reuer and Tong (2007) for a comprehensive survey.

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which implies capitalizing on synergies and competitive advantages which have been accrued in prior segments. In this case, NPV would be positive and the value of the exercised option would exceed the value of future growth options in business "*j*" ($C^*_i > C_j$). As a result of this prevailing effect of replacing growth options by assets-in-place, more diversified companies are seen to have fewer unexercised options than their undiversified counterparts (Bernardo and Chowdhry, 2002), diversification thus reducing GOV.

However, investment in a new business is not the only source of growth options. Many open-up opportunities are rooted in tangible and intangible outcomes derived from day-to-day business management such as knowledge, brand image or customer loyalty, to name but a few (Kogut, 1991; Williamson, 2001). In the case of a diversified firm, managing multiple businesses simultaneously may give rise to specific knowledge and experience which is useful for improving the exercise conditions of current growth options or identifying new paths of action from which further options to invest may flourish (Pennings, Barkema and Douma, 1994; Chang, 1995; Smit and Moraitis, 2010).

Moreover, this option value-enhancing effect may be leveraged by disseminating resources and skills emerging from each of its businesses across the whole diversified firm, thus opening up new possibilities for growth options to emerge (Bowman and Hurry, 1993). For instance, Smit and Moraitis (2010) argue that one acquisition can serve as a platform through which a company can acquire new core competences and assets that can leverage into follow-on acquisitions. Knowledge gained from new product success and failure may prove a springboard to additional growth options (McGrath, 1999). Yang *et al.* (2014) show that diversification generates knowledge, which increases managers' ability to devise novel solutions in an uncertain context such as venture capital. This reasoning suggests that the degree of diversification spreads business activity and sows the seeds for

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further options to arise. At such a level, diversification sparks multiplicative mechanisms in the options portfolio (Vassolo, Anand and Folta, 2004) and scatters its multisegment management capabilities across alternative businesses.

Taking these two effects together, we conjecture that the degree of diversification may have a U-relationship with GOV. At lower levels of diversification, replacing growth options by assets-in-place prevails, thus driving a negative impact of diversification on GOV. Conversely, at higher levels of diversification the option value-enhancing effect may be leveraged by the effect of resources and skills to emerge from multi-business management, thus driving a positive impact of diversification on GOV. Accordingly, we posit our first hypothesis:

H_1: The degree of diversification has a U-shaped relationship with GOV

1.2. Relatedness between businesses

Prior research underscores the benefits of relatedness vis-à-vis enhancing economies of scope and synergies, most empirical evidence attributing better performance to this type of diversification (Rumelt, 1982; Simmonds, 1990; Very, 1993; Markides and Williamson, 1994; Berger and Ofek, 1995; Villalonga, 2004a). Relatedness may also affect GOV. Although growth options from related diversification are less diverse, as a firm moves forward into a related diversification strategy, the interplay of connected businesses may carry value-enhancing effects on their embedded options to expand, either as a result of reducing investment cost ('option exercise price') or by enhancing project returns ('underlying asset value'). Regarding the former, related diversification enables the company to take advantage of complementarities and synergies in costs by deploying and leveraging existing resources and capabilities in multiple divisions. As a result,

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"exercising" subsequent options to expand is less costly in more closely related industries (Penrose, 1959; Vassolo *et al.*, 2004), thereby increasing the growth option value.

Furthermore, relatedness can make the firm's growth options portfolio super-additive by enhancing the value of subsequent investments. Firstly, relatedness and synergies may exhibit a parallel increase. For instance, as the firm operates in more similar businesses, accumulated knowledge and experience are more likely to display commonalities from which future businesses can benefit, the learning process thus proving more efficient (Yang *et al.*, 2014). Secondly, related diversification can boost the creation of new strategic options. Markides and Williamson (1994) argue that related diversification contributes to developing core competences as well as accumulating and renewing strategic assets more quickly and at a lower cost than competitors are able to do. Moreover, the background of connected experience enables the firm to recognize new emerging opportunities. These related investments are likely to fit into the firm's current activity and to drive further options in neighbouring business domains. Overall, these complementary effects cause the options portfolio to be super-additive, its value thus exceeding that of the sum of the call option values taken independently (Vassolo *et al*., 2004).

However, as relatedness exceeds a particular threshold, certain counter-value effects might increasingly prevail. High relatedness is likely to drive duplicities and thus give rise to mutually competitive options with an over-cost which has to be maintained. In this sense, Vassolo *et al*. (2004) provide empirical evidence that investment in multiple competing projects impacts negatively on the options portfolio, making it sub-additive. Extremely related diversification also narrows the diversity of options and restricts a firm's future behaviour when identifying and reacting to opportunities in a broader scope (Hayward, 2002). As a result, the firm may become trapped in its current competences

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(Williamson, 2001; Holmqvist, 2004) and be unable to build up potential courses of action for the future beyond its limited sphere of expertise.

Summing up, we state our second hypothesis:

H_2: The impact of relatedness among businesses of a diversified firm on GOV exhibits an inverted-U shaped function.

1.3. Degree of diversification and relatedness between businesses

Fan and Lang (2000) report a negative effect on value from vertical relatedness in more widely diversified firms. These findings suggest that relatedness has a different effect on low and high diversifiers. In a firm's options portfolio, degree of diversification and cross-business relatedness are also closely linked and may carry a joint effect.

In fact, we posit that diversification may magnify both the positive and negative effects of relatedness on GOV. As the company maintains a broader business portfolio, it is more likely to benefit from the effects of relatedness on reducing either exercise costs to invest in new businesses due to economies of scope and experience sharing (Vassolo *et al.*, 2004) or costs to maintain options alive until optimal exercise through resource sharing. Secondly, increasing relatedness in a larger portfolio of businesses is more likely to promote similarities and the spread of core skills across businesses, which may enhance investment returns (for instance, via cross-business complementarities in certain resources such as knowledge). The knowledge required and generated by related divisions may prove mutually supportive due to coexistence within a single organization, enhancing the returns of future businesses (Tanriverdi and Venkatraman, 2005), and thus increasing growth options value at a faster rate. Overall, all these arguments suggest that broader diversification accelerates the multiplicative mechanisms of relatedness in the growth

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options portfolio. Accordingly, we expect the positive relationship between low levels of relatedness and GOV predicted in Hypothesis 2 to be more pronounced in higher diversifiers.

Broader diversification can also magnify the detrimental effects of high levels of relatedness. Greater diversification makes managing interdependencies across businesses more complex (Rawley, 2010; Zhou, 2011) and may even lead to diseconomies of complexity. As a result, we expect a more rapid increase in coordination costs with relatedness, thereby increasing option exercise price and causing a more dramatic decline in option value. Moreover, the combination of a higher diversification level, which may give rise to more numerous real options in line with our Hypothesis 1, coupled with relatedness is more likely to result in redundant options. Also, shared resources can be overstretched (Gary, 2005) and prevent the firm from materializing potential synergies. Accordingly, we expect the negative relationship between high relatedness and GOV to be more pronounced in higher diversified firms compared with our baseline model.

H_3: The degree of diversification moderates the inverted U-form relationship between relatedness across businesses and GOV, in such a way that the inverted U-form effect is accentuated in firms with a higher degree of diversification.

2. DATA AND RESEARCH METHODS

2.1. Data sources and sample selection

To test our hypotheses, we examine an unbalanced panel sample of U.S. firms during the period 1998-2010.[4] We alleviate potential survivorship bias by including both active

[4] To guarantee homogeneity of data, the initial year of our sample is 1998, the year in which the new SFAS 131 reporting standard came into force. See Berger and Hann (2003) for the implications of SFAS 131 on diversification research.

and currently inactive firms in our panel.[5] We collect information from Worldscope on financial and segment data, and from Datastream on market data.[6] We also gather industry information on the U.S. Census Bureau (Statistics of U.S. Businesses), which provides annual data for U.S. business establishments by geography, industry, and enterprise size.[7]

We apply Berger and Ofek's (1995) sample selection criteria to build a dataset consistent with prior research and thereby ensure comparability of our results. First, we remove firm-years with any segment in the financial services industry (SIC codes 6000-6999). Additionally, we drop observations with missing data on total capital, total sales, and segment-level sales. We exclude observations with negative segment sales or total sales, or firms whose sum of segment sales is not within the range of 99-101% of a firm's reported total sales. We also require firms to have total sales equal to or above $20 million.

Finally, an additional restriction comes from our estimation methodology: the generalized method of moments (GMM). This requires availability of data for at least four consecutive years per firm to test for the lack of second-order residual serial correlation. The final sample for estimation purposes comprises 5,592 firm-year observations corresponding to 818 companies.

2.2. Variables

In all models, our dependent variable is the firm's growth options value (denoted by GOV). GOV is proxied by the market-to-book assets ratio (*MBAR*), calculated as:

$$MBAR = \frac{share\_price * common\_shares\_outstanding + preferred\_stock + current\_liabilities + long\_term\_debt - deferred\_taxes\_and\_investment\_tax\_credit}{total\_assets}$$

[5] Inactive firms are those ceasing activity during our window of analysis due to multiple reasons (bankruptcy, mergers, …).
[6] Worldscope and Datastream are accessed through the Thomson.One package by Thomson Reuters, which contains complete coverage of U.S. companies filing with the Securities Exchange Commission.
[7] Official website: http://www.census.gov//econ/susb/data/susb2010.html

MBAR is among the most frequently used proxy variables for growth options value.[8] The market value of assets measures both the value of assets-in-place and growth options, whereas the book value is a proxy for assets-in-place. Therefore, *MBAR* measures the relevance of growth options value relative to its assets-in-place. Other usual proxies are market-to-book equity ratio, earnings-price ratio, and capital expenditures. Adam and Goyal (2008) examine their relative performance in a sample of mining firms for which growth options are measurable by outsiders, and conclude that *MBAR* provides the highest information content, apart from being easy to calculate and depending only on publicly available data.[9]

As far as diversification is concerned, we classify a firm as diversified if it has more than one segment at the 4-digit SIC level, and otherwise as a unisegment company[10]. Degree of diversification is captured by three alternative measures: the number of businesses, the Herfindahl index (Hirschman, 1964), and the entropy measure (Jacquemin and Berry, 1979). The former is the simple count of the number of segments at the 4-digit SIC code level (*NUM_4d*). The Herfindahl index (*HERF_4d*) is computed as:

$$\text{HERF\_4d} = 1 - \sum_{s=1}^{n} P_s^2$$

where ‘n’ is the number of a firm’s segments (at the 4-digit SIC code level) and ‘P_s’ the proportion of the firm’s sales from business ‘s’. Focused firms will show a *HERF_4d*

[8] See for example Folta and O’Brien (2004); Barclay, Smith and Morellec (2006); Adam and Goyal (2008); Trigeorgis and Lambertides (2014), to name but a few.

[9] Adam and Goyal also evaluate a common factor constructed from several proxies although it does not improve the performance of *MBAR*. The ratio of capital expenditures to total assets is another common proxy (Stowe and Xing, 2006; Mansi and Reeb, 2002), which may not be the best forward-looking measure for growth options, since it captures their past exercise to a greater extent than their being held currently. To check the robustness of our results, we follow Haanappel and Smit (2007) to use the skewness return as another alternative proxy for growth options.

[10] Setting industry limits based 4-digit SIC codes is a common standard in the literature which mitigates potential drawbacks from a wider industry definition (Stimpert and Duhaime, 1997).

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equal to zero, and the closer this index is to one, the higher the degree of diversification. Finally, the entropy measure (*TENTROPY*) is calculated as follows:

$$\text{TENTROPY} = \sum_{s=1}^{n} P_s * \ln(\frac{1}{P_s})$$

where 'P_s' is the proportion of a firm's sales in business '*s*' for a corporation with '*n*' different 4-digit SIC segments. The higher the *TENTROPY*, the greater the degree of diversification, although this index has no upper boundary.

The relatedness dimension can only be defined for firms with at least two businesses (diversified firms). Generally, the literature considers a multisegment company as related diversified when its divisions belong to the same 2-digit SIC industry. Our relatedness measure is derived from the *TENTROPY* defined earlier, which is split into two components: unrelated entropy (*UNRELATED*) and related entropy (*RELATED*) (Jacquemin and Berry, 1979), *UNRELATED* being defined as:

$$\text{UNRELATED} = \sum_{r=1}^{m} P_r * \ln(\frac{1}{P_r})$$

where 'P_r' is the proportion of a firm's sales in business '*r*' for a corporation with '*m*' different 2-digit SIC segments. Next, our proxy for relatedness *RELATED* is calculated by subtracting *UNRELATED* from *TENTROPY*:

$$\text{RELATED} = \text{TENTROPY} - \text{UNRELATED}$$

Additionally, following prior literature, we employ a number of control variables which may also affect *GOV*, namely size (Andrés, Azofra and Fuente, 2005), leverage (Myers, 1977), industry, and year. Size (*LTA*) is estimated by the natural logarithm of the book value of total assets. Leverage (*DTA*) is measured by the ratio of total debt over total assets. We include a set of dummy variables to control for the industry effect[11] (*dumINDUSTRY*) and the year effect (*dumYEAR*).

Table 1 shows full-period descriptive statistics for our variables in the final sample[12]. As shown in panel A, sample firms display a moderate diversifying profile. The sample mean of *NUM_4d* (*HERF_4d*) is two segments (0.2783). As observed, the level of data disaggregation (either at the 4-digit or 2-digit SIC code level) affects the measures of the degree of diversification. *NUM_4d* and *HERF_4d* increase by about 16% and 27% (19% and 26% in the diversified firms subsample) respectively, in comparison to computation at the 2-digit SIC code level (*NUM_2d* and *HERF_2d*).

TABLE 1 ABOUT HERE

2.3. Empirical models and robustness checks

To test the U-form relationship between the level of diversification and GOV stated in Hypothesis 1, we estimate the following empirical model:

$$MBAR_{it} = \alpha + \beta_1 NUM\_4d_{it} + \beta_2 (NUM\_4d)^2_{it} + \beta_3 LTA_{it} + \beta_4 DTA_{it} + \beta_5 dumINDUSTRY_{it} + \beta_6 dumYEAR_{it} + \eta_i + \nu_{it} \quad [1]$$

where i identifies each firm, t indicates the year of observation (from 1 to 13), α and β_p are the coefficients to be estimated, η_i represents the firm-specific effect accounting for unobservable heterogeneity (time constant), and ν_{it} is the random disturbance for each observation. We perform robustness checks by approximating the degree of diversification by either *NUM_4d*, *HERF_4d* or *TENTROPY.* Additional robustness analyses are

[11] Major groups of industries as defined by the U.S. Department of Labor. The official website provides the matching of these major groups to the 2-digit SIC code classification: http://www.osha.gov/pls/imis/sic_manual.html. The industry dummy *j* takes 1 if the firm's core business operates in industry *j* and zero otherwise.
[12] Following Adam and Goyal (2008), negative values of *MBAR* have been removed.

implemented by computing the number of a firm's segments and the Herfindahl index with 2-digit SIC code business segment data (variables denoted by *NUM_2d* and *HERF_2d*).

To test Hypothesis 2 on the inverse U-relation between relatedness and GOV, our estimation model is specified as:

$$MBAR_{it} = \alpha + \beta_1 RELATED_{it} + \beta_2 RELATED^2_{it} + \beta_3 LTA_{it} + \beta_4 DTA_{it} + \beta_4 dumINDUSTRY_{it} + \beta_5 dumYEAR_{it} + \eta_i + \nu_{it} \quad [2]$$

where i identifies each firm, t indicates the year of observation (from 1 to 13), α and β_p are the coefficients to be estimated, η_i represents the firm-specific effect accounting for unobservable heterogeneity, and ν_{it} is the random disturbance for each observation.

To explore the moderating effect of the degree of diversification (Hypothesis 3) on the relationship between *RELATED* and *MBAR*, we re-specify equation [2] as follows:

$$MBAR_{it} = \alpha + \beta_1 RELATED_{it} + \beta_2 RELATED^2_{it} + \beta_3 RELATED_{it} * dumNUM_{it} + \beta_4 RELATED^2_{it} * dumNUM_{it} + \beta_5 dumNUM_{it} + \beta_6 LTA_{it} + \beta_7 DTA_{it} + \beta_8 dumINDUSTRY_{it} + \beta_9 dumYEAR_{it} + \eta_i + \nu_{it} \quad [3]$$

where i identifies each firm, t indicates the year of observation (from 1 to 13), α and β_p are the coefficients to be estimated, η_i represents the firm-specific effect accounting for unobservable heterogeneity, and ν_{it} is the random disturbance for each observation. The moderating effect of degree of diversification is estimated by interacting *dumNUM* with *RELATED* and its squared term. *dumNUM* is a dummy variable which equals 1 if *NUM_4d* is above the sample mean, and null value otherwise. As a result, the nonlinear effect of *RELATED* on *MBAR* is captured by β_2 for below-mean diversified firms (dumNUM=0), and by (β_2+ β_4) for above-mean diversified firms (dumNUM=1). As robustness checks, we replace *dumNUM* by alternative proxies for diversification: *dumHERF* and

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dumTENTROPY. *dumHERF* is a dummy variable which equals 1 if the observation shows *HERF_4d* above the sample mean, and null value otherwise. Similarly, *dumTENTROPY* equals 1 if the observation has *TENTROPY* above the sample mean, and zero otherwise.

Finally, we estimate a full model to test the three hypotheses jointly, as expressed in equation [4]:

$$MBAR_{it} = \alpha + \beta_1 NUM\_4d_{it} + \beta_2 (NUM\_4d)^2_{it} + \beta_3 RELATED_{it} + \beta_4 RELATED^2_{it} + \beta_5 RELATED_{it} * dumNUM_{it} + \beta_6 RELATED^2_{it} * dumNUM_{it} + \beta_7 dumNUM_{it} + \beta_8 LTA_{it} + \beta_9 DTA_{it} + \beta_{10} dumINDUSTRY_{it} + \beta_{11} dumYEAR_{it} + \eta_i + \varepsilon_{it} \quad [4]$$

Additionally, all models are re-estimated by using an alternative proxy for GOV as the dependent variable, return skewness (*skewness*), to evaluate the robustness of our empirical findings. Models involving *RELATED* (equations [2] to [4]) are estimated on the diversified firms subsample since relatedness can only be defined for firms with at least two segments.

Table 2 presents the correlation matrix for our variables. Degree of diversification (measured as the most disaggregated level, namely 4 digit-SIC code) and relatedness have a correlation around 0.5 (0.5045 between *RELATED* and *NUM_4d*; 0.4688 between *RELATED* and *HERF_4d*; and 0.5216 between *RELATED* and *TENTROPY*), statistically significant at 1% level[13].

TABLE 2 ABOUT HERE

2.4. Econometric approach and estimation strategy

[13] Interestingly, measures of degree of diversification at the 2-digit SIC code level display a negative correlation with relatedness, since the higher the relatedness, the more likely are a firm's businesses to be grouped into the same broad industry category.

We apply panel data methodology to address two potential problems: the unobservable individual heterogeneity effect and endogeneity. The former refers to certain firm-specific time-constant characteristics that also determine the value of the firm's growth options. For instance, characteristics such as a firm's culture or managerial team may prove a crucial factor in the sense of shadow options (Bowman and Hurry, 1993). We model such an individual effect by including the term η_i in all equations. Secondly, one widespread concern in diversification research is endogeneity (Campa and Kedia, 2002; Villalonga, 2004b). The causal relation between the diversification dimensions and GOV may not only run in the hypothesized direction but also in both directions. The firm's growth options may also influence the diversification decision since the firm is likely to build its strategy upon the type and breadth of available investment opportunities. To address this problem, we use the two-step system generalized method of moments (GMM) proposed by Blundell and Bond (1998). This is an instrumental variable estimator which uses the lags of explanatory variables as instruments.

Below all the estimations, we include the Wald test, which evaluates the joint significance of all independent variables. The GMM estimator is based on two assumptions: absence of second-order serial correlation and lack of correlation between instruments and residuals. Thus, additionally, we report two model specification tests for the validity of GMM estimations. First, Arellano and Bond's (1991) m_2 statistic[14] tests the absence of second degree serial correlations in first-difference residuals. Since the GMM estimator uses lags as instruments under the assumption of white noise errors, it would lose its consistency if the errors were serially correlated. Secondly, the Hansen J-test of overidentifying restrictions (Hansen, 1982), which is χ^2 distributed, evaluates the

[14] We also report the m_1 statistic which tests first-order residual serial correlation, although this correlation does not lead to invalid results.

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instrument exogeneity assumption. The null hypothesis is the joint validity of all the instruments, thus meaning they do not correlate with the residuals.

The conventional method for identifying curvilinear relationships draws on the inclusion of a quadratic term in the model. A nonlinear relationship is documented if that term is statistically significant and the inflection point of the curve lies on the data range. However, recent studies (Blanchflower, 2007; Lind and Mehlum, 2010) cast doubt on the sufficiency of this criterion. In cases when the true relationship is convex but monotone over relevant data values, the quadratic specification of the model can erroneously lead to an extreme point being derived and thus to the conclusion that there is a quadratic relationship (Lind and Mehlum, 2010: 110). To further assess the validity and significance of the quadratic relationships, we check the robustness of our results by performing Sasabuchi's (1980) t-test[15]. To test the presence of an inverse U-shape relationship (U-shape relationship), Sasabuchi tests the composite null hypothesis that the relationship is decreasing (increasing) at the left hand side of the interval and/or increasing (decreasing) at the right hand side[16]. Moreover, we estimate the extreme point of the curve and compute its confidence intervals based on Fieller's (1954) standard error method (Lind and Mehlum, 2010). The extreme value must fall within the limits of the data.

3. EMPIRICAL FINDINGS

Tables 3 to 5 show our empirical findings. Both the Hansen and m_2 tests reported below all the estimations support the validity of our GMM estimations. The Hansen J-statistic is not statistically significant and does not reject the null hypothesis of absence of

[15] This test was computed using the ado-file utest for STATA developed by Lind and Mehlum, available at http://econpapers.repec.org/software/bocbocode/s456874.htm
[16] Computing this test also allows us to obtain the estimated slopes for the lower bound and the upper bound of the curves so as to subsequently test the moderating effects.

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correlation between the instruments and the residuals, thus confirming the instruments are valid. Furthermore, the m_2 statistic fails to reject the null hypothesis of no second-order residual serial correlation. The statistical significance (above the 1% level) of the Wald test indicates that the variables are jointly significant. In addition, *LTA* and *DTA* are included as controls, together with industry and time dummies. When significant, their signs are robust across most estimations. Consistent with prior literature, *LTA* is positively associated with the growth options dependent variables *MBAR* and *skewness*, whereas *DTA* displays a negative relationship (Myers, 1977).

3.1. Degree of diversification and GOV

Regression results on the relationship between diversification and GOV are summarized in Table 3. Columns (1) to (5) estimate a direct effect. As shown, results reveal a negative impact of *NUM_4d* on *MBAR*, which is statistically significant at the 1% level. We conduct several robustness tests by using alternative proxies for the level of diversification (*HERF_4d* and *TENTROPY* in columns (3) and (5)) and by computing diversification proxies at the level of 2-digit SIC codes (*NUM_2d* and *HERF_2d* in columns (2) and (4)). Results again show a negative relationship with *MBAR.*

TABLE 3 ABOUT HERE

Columns (6) to (10) in Table 3 present the estimation of equation [1] in which a nonlinear relationship is tested. Our results strongly support a U-shaped effect between *NUM_4d* and *MBAR* (our Hypothesis 1) with a negative linear term (β_1=-0.9028, p-value=0.000) and a positive quadratic term (β_2=0.1021, p-value=0.000). This U-form effect persists with alternative diversification indexes such as *HERF_4d* and *TENTROPY.* Moreover, in columns (7) and (9), we assess the robustness of these empirical findings by computing the degree of diversification at the 2-digit SIC code level (measured by either *NUM_2d* or *HERF_2d*). Results remain similar.

In testing the non-linear effect, the last three rows of Table 3 contain additional robustness analyses. First, we perform Sasabuchi's test to check for the presence of a U-form relationship (H_0: Monotone or inverse U shape; H_1: U shape). Sasabuchi's test is rejected across all proxies (p-value<0.02), thus providing further evidence to support the U-effect. Results are statistically stronger when *NUM_4d* or *NUM_2d* are used (p-value=0.001 and p-value=0.000, respectively). We estimate that the inflection point occurs at approximately four segments (*NUM_4d**=4.4171 and *NUM_2d**=3.1100). Fieller's confidence interval (estimated at [3.9628; 5.3469]) for the estimated *NUM_4d* inflection point is within the limits of our data (in our sample, *NUM_4d* ranges between 1 (minimum) and 7 (maximum) as shown in Table 1).

3.2. Relatedness and GOV

Table 4 contains the estimations results of the effect of relatedness on GOV (eq. [2]). Column (1) offers a test for the linear effect. We find that *RELATED* has a positive and significant impact (above the 1% level) on *MBAR*. Subsequently, we extend the model by including the squared term of *RELATED* to test the nonlinear relationship. Evidence clearly suggests an inverted U-form relationship between *RELATED* and *MBAR*, thus supporting Hypothesis 2. As reported in column (2), the main effect of *RELATED* is positive and statistically significant (β_1=0.8590, p-value=0.000) and its squared term is negative and significant (β_2=-1.3699, p-value=0.000).

TABLE 4 ABOUT HERE

To ensure the correct interpretation of this curvilinear effect of *RELATED* on *MBAR*, we further examine the validity of the inverted U-shape relationship by conducting Sasabuchi's test (H_0: monotone or U shape; H_1: inverse U shape). Consistent with prior estimations, Sasabuchi's test is rejected (p-value=0.000), providing yet more evidence to support the inverted U-effect. Moreover, Fieller's confidence interval at 95% for the inflection point of the curve ranges between 0.2790 and 0.3443. This extreme point is within the limits of our data.

Overall, Hypothesis 2 receives strong support. Our results provide meaningful evidence that the relationship between relatedness and GOV is quadratic rather than linear, and suggest the existence of a maximum (estimated at *RELATED**=0.3135) after which relatedness proves detrimental to the value of the firm's growth options.

3.3. The interaction effect of degree of diversification and relatedness

To evaluate whether the shape of the inverted U-form between *RELATED* and *MBAR* differs at low and high levels of diversification (Hypothesis 3), we extend equation [2] to [3] with the addition of the moderating effect of the degree of diversification on said quadratic relationship. The estimation results for the moderating effects are presented in columns (3) to (5) of Table 4. Once again, these results corroborate the inverse U-form relationship between *RELATED* and *MBAR* (both *RELATED* and $RELATED^2$ have p-value=0.000). The significance of the multiplicative term $RELATED^2$x*dumNUM* supports the idea that the degree of diversification moderates the relationship between *RELATED* and *MBAR*. Results reveal a negative interaction effect of *dumNUM* and the linear term of *RELATED* (β_3=-2.5068, p-value=0.000) and a positive interaction with its quadratic term (β_4=4.7275, p-value=0.000). As a result, the absolute value of the coefficient associated with the curvilinear effect of relatedness is higher for below-mean diversifiers (β_2 = -

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7.5826) than for above-mean diversifiers (∑non linear=$\beta_2 + \beta_4$=-2.8576), suggesting that the inverted U-curve is less pronounced in firms with high levels of diversification.

Results are robust to several diversification proxies (*dumHERF* and *dumTENTROPY* estimated in columns (4) and (5)). These findings clearly run contrary to our Hypothesis 3, which predicted that the inverse U-form relationship between *MBAR* and *RELATED* would be steeper in high diversifiers. Indeed, as hypothesized, there is a difference in the shape of the curvilinear relationship, although the degree of diversification attenuates the effect of *RELATED* rather than reinforcing it. Finally, we depict these moderating effects in Figure 1, derived from equation [3]. In order to have a continuous measure of diversification, *dumHERF* is used instead of *dumNUM*. Consistent with the previous results, Figure 1 reveals that the curvilinear relation linking *MBAR* and *RELATED* is less pronounced in more extensively diversified companies.

FIGURE 1 ABOUT HERE

Finally, we estimate equation [4] which introduces all the hypothesized effects jointly to check the robustness of our empirical findings. Results are displayed in Table 5 (columns (1) to (3)). As observed, the results previously described and derived from our individual models also hold in the full estimation.

TABLE 5 ABOUT HERE

To further verify the robustness of our empirical findings, we estimate all equations taking *skewness* as an alternative proxy for GOV. As a result of the optional nature of growth options (only exercised if there are positive payoffs, and deferred or abandoned

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otherwise), an asymmetrical distribution in stock returns emerges, thus supporting the direct relation between a firm's positive return skewness and growth options value (Haanappel and Smit, 2007). The variable of *skewness* is calculated by Fisher's skewness coefficient using each firm's daily returns for the observation year. All results presented in this section prove robust to *skewness* as an alternative dependent variable to proxy for growth options.[17]

4. DISCUSSION AND CONCLUSIONS

This study investigates the effect of corporate diversification on the growth options portfolio in a dataset of U.S. firms between 1998 and 2010, our findings showing that the degree of diversification and GOV exhibit a U-shaped relation. Options exploitation dominates in early-mid diversification levels until the creation of new options gains ground at a higher degree of diversification. Not only might participation in a wider set of industries foster the generation of options, but also the interplay of these options within and across businesses is likely to give rise to further options (Vassolo *et al.*, 2004) and spark multiplicative mechanisms in the options portfolio.

Consistent with prior research (such as Rumelt, 1982; Simmonds, 1990; Markides and Williamson, 1994), we find evidence of the value-enhancing effects of related diversification. In addition, we also connect with recent papers by showing that relatedness not only has an effect on switching options (Sakhartov and Folta, 2014) but, in our case, also on growth options. Relatedness promotes the option-generating process as a result of synergies and complementarities from background connected experience. These synergies can also decrease the 'exercise price' of subsequent projects or enhance the value of the

[17] Results are available upon request.

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underlying assets. However, our findings confirm an inverted U-relationship rather than a linear one. When diversifying relatedly beyond a certain limit, the company is likely to reach a break point after which certain counter-value effects of relatedness dominate. The statistical significance of the relatedness dimension in the growth options value and our reported quadratic relationship suggest the existence of a portfolio effect based on internal interplay mechanisms across options, as pointed out in prior literature (McGrath and Nerkar, 2004; Vassolo *et al*., 2004).

Our study also complements existing work (such as Fan and Lang, 2000) by analyzing the joint effect of two diversification dimensions: scope and relatedness. We hypothesize that the degree of diversification may accentuate the inverted U-relation between relatedness and GOV, firstly because broader business activity may offer more possibilities to capitalize on relatedness (for example, via synergies and economies of scope), and secondly because interdependencies across businesses may carry a ‘domino effect’ that could heighten complexity and coordination costs. Contrary to our expectations, our results yield evidence that diversification attenuates such a curvilinear relationship. The lack of support for our Hypothesis 3 might be due to the limits imposed upon the materialization of the benefits of relatedness, which cannot be extended in their entirety to further business. This evidence concurs with prior literature such as Gary (2005). In addition, it may reduce the availability of resources to continue exploring, designing, and identifying new investment opportunities, slowing down the generation of new options and thus weakening the effect on GOV. In summary, so far, our results show that after a certain level, relatedness also comes at a price.

Our paper makes several contributions to diversification literature and to the application of the RO approach to strategic decision analysis. Firstly, our study offers fresh

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insights into corporate diversification from RO logic, by accounting for heterogeneous diversification strategies in terms of growth options. Our paper delves into the characterization and understanding of diversification and its value-driver mechanisms of diversification from RO reasoning. We offer a closer look at the mechanisms connected to a firm's growth options value which may play a part in the performance of corporate diversification. Insofar as the generation and evolution of growth options are intrinsically linked to firm-specific capabilities, this RO perspective helps overcome the traditional discount/premium dilemma and examines the nature of diversification *per se* more closely.

Secondly, we add to the literature linking diversification and growth options by considering the multidimensional nature of diversification strategy and explicitly articulating how this strategy builds on the firm's growth options portfolio. We characterize the different diversifiers on the bases of two dimensions (scope and relatedness) and the combination of both. Thirdly, this study responds to recent calls (Reuer and Tong, 2007; Cuervo-Cazurra and Un, 2010) to fill the gap in empirical works which apply the RO approach to strategy in order to advance the RO theory. Our paper joins a growing stream of literature extending the RO approach to strategic analysis (Folta and O'Brien, 2004; Tong *et al.*, 2008; Klingebiel and Adner, 2015; among others) and provides empirical evidence on the relation between RO relevance and corporate diversification. Our results confirm that the degree of diversification and relatedness interact with the growth option value, both individually and jointly. In addition, we offer updated evidence on a post-1997 sample under the new SFAS 131 reporting standard implemented in the U.S., which is seen to report more consistent and disaggregated segment information (Berger and Hann 2003). We also tie in with recent streams of

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research which advocate the endogenous nature of the diversification decision. We control for endogeneity in all regressions by using an instrumental estimation technique (GMM).

This study opens up interesting new perspectives for business management. Through the RO lenses, certain managerial investment decisions which may seem counter-valuable for a firm's assets-in-place can, however, be justified in terms of their options value. Our evidence provides some guidance on the dynamics of corporate diversification when configuring the growth options portfolio. Interestingly, our study sheds light on the need to explore further those contingent factors which may play a crucial role in the success or failure of the diversification strategy. Certain growth options can be embedded in those investments, thus opening up possible future paths in the long run. This may provide managers with the key concerning the timeliness of implementing the diversification strategy in their companies and if so, which type of diversification path they should choose.

Our paper suffers from certain limitations which might point to interesting directions for further research. First, our sample comprises exclusively U.S. firms. It might prove interesting to evaluate the consistency of our empirical findings in an international setting. Secondly, the lack of observability in real options complicates their value estimation. Similarly, the relatedness dimension has proved difficult to measure in prior literature. Further research might seek to complement existing measures and develop alternative ones so as to identify and capture distinguishable components of relatedness such as skill bases and physical bases (Farjoun, 1998). Future research might also go deeper in a contingent approach to diversification and seek additional factors, such as uncertainty, which might shape the value effects of this strategy on a firm's growth options portfolio. Finally, future research avenues could explore further the temporality of the diversification phenomenon

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in an effort to shed more light on how interrelated investments are carried out over time, for example by adopting complementary views such as an acquisition program perspective into diversification analyses (Laamanen and Keil, 2008; Smit and Moraitis, 2010).

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APPENDIX

Table 1
[Summary statistics of variables (1998-2010)]

This table displays descriptive statistics of the variables involved in our models for the full sample (5,592 firm-year observations) and for the diversified firms subsample (3,836 firm-year observations). *MBAR* (the market-to-book assets ratio) proxies for growth options value. *NUM_4d* (number of business segments at the 4-digit SIC code level), *NUM_2d* (number of business segments at the 2-digit SIC code level), *HERF_4d* (the Herfindahl index at the 4-digit SIC code level), *HERF_2d* (the Herfindahl index at the 2-digit SIC code level), and *TENTROPY* (the Entropy index) are alternative measures for the level of diversification. *RELATED* (Related Entropy) captures relatedness between segments. Control variables: *LTA* (size), and *DTA* (financial leverage). Figures are expressed in million US$.

Variable	N	Mean	Median	STD	Min	Max	1st quartile	3rd quartile
Panel A: FULL SAMPLE								
Growth options								
MBAR	5,592	2.3652	1.5139	7.0503	0.1391	468.1636	1.0760	2.4610
Degree of diversification								
NUM_4d	5,592	2.0962	2	0.9738	1	7	1	3
NUM_2d	5,592	1.8044	2	0.7305	1	6	1	2
HERF_4d	5,592	0.2783	0.2853	0.2391	0	0.8309	0	0.4858
HERF_2d	5,592	0.2198	0.1864	0.2133	0	0.8004	0	0.4218
TENTROPY	5,592	0.4583	0.4709	0.4022	0	1.8582	0	0.6902
Control variables								
LTA	5,592	6.8121	6.7894	2.0336	1.7710	12.5269	5.2193	8.3158
DTA	5,592	0.2328	0.2282	0.1711	0	0.8393	0.0865	0.3486
Panel B: DIVERSIFIED FIRMS SUBSAMPLE								
Growth options								
MBAR	3,836	2.2130	1.5025	2.5698	0.2600	78.1077	1.0817	2.4004
Degree of diversification								
NUM_4d	3,836	2.5446	2	0.8147	2	7	2	3
NUM_2d	3,836	2.1340	2	0.6206	1	6	2	2
HERF_4d	3,836	0.3930	0.4263	0.1905	0.0002	0.8309	0.2455	0.5082
HERF_2d	3,836	0.3121	0.3428	0.1903	0	0.8004	0.1460	0.4695
TENTROPY	3,836	0.6475	0.6412	0.3292	0.0011	1.8582	0.4181	0.8503
Relatedness								
RELATED	3,836	0.1518	0	0.2650	0	1.3594	0	0.2579
Control variables								
LTA	3,836	6.7848	6.8200	1.9540	1.7710	12.5269	5.2689	8.1375
DTA	3,836	0.2317	0.2266	0.1656	0	0.8380	0.0951	0.3442

Table 2
[Correlation matrix]

This table lists pair-wise correlations for our study variables. *MBAR* (the market-to-book assets ratio) proxies for growth options value. *NUM_4d* (number of business segments at the 4-digit SIC code level), *NUM_2d* (number of business segments at the 2-digit SIC code level), *HERF_4d* (the Herfindahl index at the 4-digit SIC code level), *NUM_2d* (number of business segments at the 2-digit SIC code level), and *TENTROPY* (the Entropy index) are alternative measures for the level of diversification. *RELATED* (Related Entropy) captures relatedness between segments. Control variables: *LTA* (size), and *DTA* (financial leverage). ****, ** and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Note: Correlations between the variable *RELATED* with each of the remaining variables are computed on the diversified firms subsample (3,836 firm-year observations). The remaining correlations refer to the full sample (5,592 firm-year observations).

	MBAR	NUM_4d	NUM_2d	HERF_4d	HERF_2d	TENTROPY	RELATED	LTA	DTA
MBAR	1.0000								
NUM_4d	-0.0277**	1.0000							
NUM_2d	-0.0310**	0.7890***	1.0000						
HERF_4d	-0.0333***	0.8156***	0.6616***	1.0000					
HERF_2d	-0.0369***	0.6349***	0.8015***	0.8271***	1.0000				
TENTROPY	-0.0318**	0.8919***	0.7076***	0.9842***	0.8000***	1.0000			
RELATED	0.0178	0.5045***	-0.3350***	0.4688***	-0.3157***	0.5216***	1.0000		
LTA	-0.0200	0.1036***	-0.0153	0.0555***	-0.0401***	0.0830***	0.2490***	1.0000	
DTA	-0.1057***	-0.0041	0.0017	-0.0021	0.0000	-0.0019	-0.0060	0.1874***	1.0000

Table 3
[Degree of diversification and growth options (eq. [1])]

This table reports the two-step GMM system estimations of equation [1]. Growth options value (GOV) (proxied by *MBAR* (the market-to-book assets ratio)) is regressed on the degree of diversification. *NUM_4d* (number of business segments at the 4-digit SIC code level), *NUM_2d* (number of business segments at the 2-digit SIC code level), *HERF_4d* (the Herfindahl index at the 4-digit SIC code level), *NUM_2d* (number of business segments at the 2-digit SIC code level), and *TENTROPY* (the Entropy index) are alternative measures for the level of diversification. Firm size (*LTA*), financial leverage (*DTA*), industry effect (*dumINDUSTRY*) and time effect (*dumYEAR*) are controlled in all estimations. The Wald test contrasts the null hypothesis of no joint significance of the explanatory variables. m_1 and m_2 are tests for no first-order and second-order serial correlation, respectively, in the first difference residuals. Hansen J-statistic, distributed as χ^2- (degrees of freedom in parentheses), is the test of over-identifying restrictions. Standard error is shown in parentheses under coefficients. ****, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively. In the bottom part of the table, some additional tests of a U-shaped relationship between GOV and degree of diversification are offered.

	Dependent variable: MBAR									
	LINEAR EFFECTS					NON-LINEAR EFFECTS				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	3.5555*** (0.4281)	3.6825*** (0.4271)	3.4142*** (0.4314)	3.5120*** (0.3868)	3.3785*** (0.4227)	4.1341*** (0.4664)	6.1267*** (0.3887)	4.4640*** (0.3125)	4.0018*** (0.3471)	3.3362*** (0.3966)
Direct effects										
NUM_4d	-0.2950*** (0.0835)					-0.9028*** (0.1877)				
NUM_2d		-0.4336*** (0.1026)					-2.0214*** (0.2233)			
HERF_4d			-1.5544*** (0.3801)					-2.7689*** (0.4968)		
HERF_2d				-1.2615*** (0.3696)					-3.3224*** (0.7642)	
TENTROPY					-0.8327*** (0.2306)					-1.6437*** (0.4233)
Non-linear effects										
$(NUM\_4d)^2$						0.1021*** (0.0251)				
$(NUM\_2d)^2$							0.3250*** (0.0355)			
$(HERF\_4d)^2$								2.7053*** (0.6998)		
$(HERF\_2d)^2$									4.1668*** (1.1684)	
$(TENTROPY)^2$										0.8317*** (0.2850)
Control variables										
LTA	0.1197** (0.0581)	0.1214** (0.0542)	0.1063* (0.0625)	0.0610 (0.0569)	0.1022* (0.0615)	0.1435*** (0.0549)	0.0264 (0.0433)	-0.0093 (0.0429)	0.0201 (0.0496)	0.1307** (0.0569)
DTA	-4.3024*** (0.3534)	-4.2785*** (0.3207)	-4.0810*** (0.3723)	-4.0000*** (0.3460)	-4.0618*** (0.3695)	-4.3244*** (0.3469)	-4.5426*** (0.3333)	-5.0998*** (0.2624)	-4.3654*** (0.3210)	-4.2978*** (0.3610)

dumINDUSTRY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
dumYEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	5,592	5,592	5,592	5,592	5,592	5,592	5,592	5,592	5,592	5,592
Wald test	445.48***	471.44***	395.70***	441.99***	409.00***	550.17***	577.78***	1188.65***	630.85***	475.85***
m_1	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
m_2	0.96	0.96	0.95	0.95	0.95	0.97	0.96	0.95	0.96	0.96
p-value m_2 test	0.335	0.341	0.342	0.34	0.340	0.332	0.338	0.342	0.339	0.337
Hansen test	220.44 (212)	230.58 (212)	201.91 (188)	212.38 (188)	203.504 (188)	239.22 (241)	260.18 (241)	328.29 (333)	245.23 (241)	211.19 (205)
p-value Hansen test	0.331	0.182	0.231	0.107	0.208	0.520	0.189	0.563	0.412	0.369
Sasabuchi-test of U-shape in degree of diversification	--	--	--	--	--	3.02***	8.89***	2.31***	2.74***	2.05**
Estimated extreme point	--	--	--	--	--	4.4171	3.1100	0.5118	0.3987	0.9882
95% confidence interval (CI)- Fieller method	--	--	--	--	--	[3.9628; 5.3469]	[2.9774; 3.2450]	[0.4185; 0.7382]	[0.3206; 0.5660]	[0.7580; 1.7493]

Table 4
[Relatedness and growth options, and the moderating effect of diversification (eq. [2] and [3])]

This table reports the two-step GMM system estimations of eq. [2] and [3]. Growth options value (GOV) (proxied by *MBAR* (the market-to-book assets ratio)) is regressed on relatedness. Relatedness is proxied by *RELATED* (Related Entropy). When estimating the moderating effects, dummy variables are used to capture high and low levels of diversification (*dumNUM*, *dumHERF* and *dumTENTROPY*). *dumNUM* is a dummy variable which equals 1 if the observation displays *NUM_4d* above the sample mean, and null value otherwise. *dumHERF* equals 1 if the observation shows *HERF_4d* above the sample mean, and null value otherwise. Similarly, *dumTENTROPY* equals 1 if the observation exhibits *TENTROPY* above the sample mean, and null value otherwise. ∑linear effect tests the joint significance of the relatedness linear variable plus the interaction effect on the diversification dummy. ∑non-linear effect tests the joint significance of the relatedness squared variable plus the interaction effect on the diversification dummy. Firm size (*LTA*), financial leverage (*DTA*), industry effect (*dumINDUSTRY*) and time effect (*dumYEAR*) are controlled in all estimations. The Wald test contrasts the null hypothesis of no joint significance of the explanatory variables. m_1 and m_2 are tests for no first-order and second-order serial correlation, respectively, in the first difference residuals. The Hansen J-statistic, distributed as χ^2- (degrees of freedom in parentheses), is the test of over-identifying restrictions. Standard error is shown in parentheses under coefficients. ****, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively. In the bottom part of the table, some additional tests of an inversely U-shaped relationship between GOV and relatedness are offered.

	Dependent variable: MBAR				
	Direct effects	Non linear effects	Moderating effects		
	(1)	(2)	(3)	(4)	(5)
Constant	3.9074*** (0.3599)	3.9934*** (0.1217)	3.8220*** (0.1143)	3.9835*** (0.2001)	4.2750*** (0.2303)
Direct effect					
RELATED	0.4671*** (0.1820)	0.8590*** (0.0735)	5.4926*** (0.1979)	5.2838*** (0.5805)	5.9018*** (0.2520)
Non-linear effects					
$RELATED^2$		-1.3699*** (0.0515)	-7.5826*** (0.2618)	-7.2222*** (0.9593)	-8.4930*** (0.2935)
Moderation effects					
RELATEDx dumNUM			-2.5068*** (0.3219)		
$RELATED^2$x dumNUM			4.7275*** (0.3082)		
RELATEDx dumHERF				-4.5492*** (0.5660)	
$RELATED^2$x dumHERF				6.6121*** (0.9733)	
RELATEDx dumTENTROPY					-4.7319*** (0.2908)
$RELATED^2$x dumTENTROPY					7.5915*** (0.3309)
∑ linear effect			2.9858*** (0.2270)	0.7346*** (0.2603)	1.1699*** (0.2371)
∑ non-linear effect			-2.8576*** (0.1406)	-0.6102*** (0.2464)	-0.9015*** (0.2512)
Control variables					
dumNUM			-0.7306*** (0.0764)		
dumHERF				-0.4449*** (0.0814)	
dumTENTROPY					-0.7582*** (0.0896)
LTA	-0.0259 (0.0526)	0.0155 (0.0156)	0.0525*** (0.0121)	-0.0423* (0.0255)	-0.0741** (0.0295)
DTA	-3.8911*** (0.3466)	-4.8580*** (0.0682)	-4.6133*** (0.0953)	-3.6009*** (0.2367)	-3.4968*** (0.2085)
dumINDUSTRY	Yes	Yes	Yes	Yes	Yes
dumYEAR	Yes	Yes	Yes	Yes	Yes
No. obs.	3,836	3,836	3,836	3,836	3,836
Wald test	698.56***	20875.61***	575154.79***	103412.93***	211119.93***
m_1	-2.42**	-2.48**	-2.54**	-2.60***	-2.46**
m_2	0.13	0.19	-0.01	0.25	-0.47
p-value m_2 test	0.895	0.851	0.993	0.805	0.636

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Hansen test	179.40 (188)	362.29 (333)	338.36 (309)	250.93 (225)	235.72 (225)
p-value Hansen test	0.661	0.129	0.121	0.113	0.299
Sasabuchi-test of inverse U-shape in relatedness	--	11.68***	--	--	--
Estimated extreme point	--	0.3135	--	--	--
95% confidence interval (CI)- Fieller method	--	[0.2790; 0.3443]	--	--	--

Figure 1
[Moderation effects of diversification on the relatedness and growth options relation]

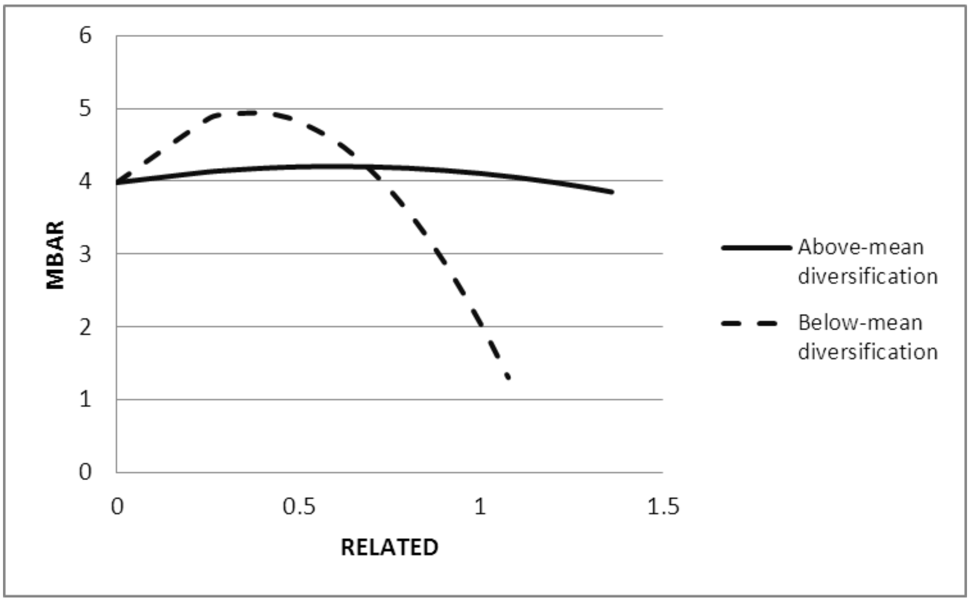

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Table 5
[Full model (eq. [4])]

This table reports the two-step GMM system estimations of eq. [4]. Growth options value (GOV) (proxied by *MBAR* (the market-to-book assets ratio)) is regressed on degree of diversification and relatedness. *NUM_4d* (number of business segments at the 4-digit SIC code level), *HERF_4d* (the Herfindahl index at the 4-digit SIC code level), and *TENTROPY* (the Entropy index) represent alternative measures for the level of diversification. Relatedness is proxied by *RELATED* (Related Entropy). When estimating the moderating effects, dummy variables are used to capture high and low levels of diversification (*dumNUM*, *dumHERF* and *dumTENTROPY*). *dumNUM* is a dummy variable which equals 1 if the observation displays *NUM_4d* above the sample mean, and null value otherwise. *dumHERF* equals 1 if the observation shows *HERF_4d* above the sample mean, and null value otherwise. Similarly, *dumTENTROPY* equals 1 if the observation exhibits *TENTROPY* above the sample mean, and null value otherwise. ∑linear effect tests the joint significance of the relatedness linear variable plus the interaction effect on the diversification dummy. ∑non-linear effect tests the joint significance of the relatedness squared variable plus the interaction effect on the diversification dummy. Firm size (*LTA*), financial leverage (*DTA*), industry effect (*dumINDUSTRY*) and time effect (*dumYEAR*) are controlled in all estimations. The Wald test contrasts the null hypothesis of no joint significance of the explanatory variables. m_1 and m_2 are tests for no first-order and second-order serial correlation, respectively, in the first difference residuals. The Hansen J-statistic, distributed as χ^2- (degrees of freedom in parentheses), is the test of over-identifying restrictions. Standard error is shown in parentheses under coefficients. ****, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively. In the bottom part of the table, some additional tests of an inversely U-shaped relationship between GOV and relatedness are offered.

	Dependent variable: MBAR		
	(1)	(2)	(3)
Constant	4.2338***	4.7110***	4.7775***
	(0.0400)	(0.1204)	(0.1008)
Degree of diversification			
NUM_4d	-0.2490***		
	(0.0139)		
(NUM_4d)^2	0.0262***		
	(0.0013)		
HERF_4d		-3.6396***	
		(0.2626)	
(HERF_4d)^2		2.4367***	
		(0.2999)	
TENTROPY			-2.4108***
			(0.1451)
(TENTROPY)^2			1.3158***
			(0.0884)
Relatedness			
RELATED	9.5432***	5.6536***	5.8937***
	(0.1689)	(0.2620)	(0.1555)
RELATED^2	-13.7707***	-6.6887***	-7.1267***
	(0.2524)	(0.5052)	(0.2699)
Moderation effects			
RELATEDx dumNUM	-8.1533***		
	(0.1591)		
RELATED^{2}x dumNUM	12.3005***		
	(0.2464)		
RELATEDx dumHERF		-5.0019***	
		(0.2414)	
RELATED^{2}x dumHERF		6.2312***	
		(0.4755)	
RELATEDx dumTENTROPY			-4.8806***
			(0.1809)
RELATED^{2}x dumTENTROPY			6.1196***
			(0.3009)
∑ linear effect	1.3899***	0.6517***	1.0131***
	(0.0597)	(0.1434)	(0.0985)
∑ non-linear effect	-1.4703***	-0.4575***	-1.0072***
	(0.0392)	(0.1181)	(0.0869)
Control variables			
dumNUM	-0.3926***		
	(0.0226)		
dumHERF		0.3066***	
		(0.0361)	
dumTENTROPY			-0.1407***

			(0.0403)
LTA	0.0842***	-0.0308**	0.0027
	(0.0057)	(0.0130)	(0.0119)
DTA	-5.0913***	-4.0647***	-4.2823***
	(0.0324)	(0.1136)	(0.0839)
dumINDUSTRY	Yes	Yes	Yes
dumYEAR	Yes	Yes	Yes
No. obs.	3,836	3,836	3,836
Wald test	5.39e+06***	315164.47***	175005.33***
m_1	-2.58***	-2.56***	-2.49**
m_2	-0.13	0.08	-0.37
p-value m_2 test	0.895	0.932	0.713
Hansen test	456.99	351.59	374.72
	(424)	(353)	(353)
p-value Hansen test	0.130	0.511	0.204