Faculty of Economics and Management
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Essays on Real Options and Multinationality

PhD Dissertation

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UNIVERSITY OF CYPRUS
THESIS ACCEPTANCE CERTIFICATE

The undersigned, appointed by the Council of the Department of Public and Business Administration of the University of Cyprus (UCY), certify that:

1. We have examined the dissertation submitted by Sophocles P. Ioulianou, entitled "Essays on Real Options and Multinationality".

2. The candidate successfully delivered a public defence of his dissertation in Nicosia on May 4, 2012 and was subjected to an examination by the committee.

3. In our opinion this thesis is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Π Ε Ρ Ι Λ Η Ψ Η
Δ Ι Δ Α Κ Τ Ο Ρ Ι Κ Η Σ Δ Ι Α Τ Ρ Ι Β Η Σ

Η παρούσα διδακτορική διατριβή ασχολείται με το ερευνητικό θέμα "Real Options και Multinationality". Η θεωρία των "Real Options" αφορά τη χρήση μεθόδων αποτίμησης προαιρετικών δικαιωμάτων για εκτίμηση επενδύσεων και λήψη βέλτιστων επενδυτικών αποφάσεων σε συνθήκες αβεβαιότητας και ευελιξίας. Η συγκεκριμένη διατριβή μελετά πώς μπορεί να χρησιμοποιηθεί η θεωρία των "Real Options" για αποτίμηση εταιρειών που παρουσιάζουν σημαντικές προοπτικές ανάπτυξης, και κατά πόσο η εξειδικευμένη γνώση των διοικητικών στελεχών για τη θεωρία αυτή επηρεάζει την μελλοντική επίδοση και κερδοφορία. Επίσης μελετάται πώς επηρεάζει η γνώση αυτή τις πολυεθνικές εταιρείες, σε αντίθεση με τις εγχώριες (που δραστηριοποιούνται μόνο στην Αμερική), ιδιαίτερα όσον αφορά τις στρατηγικές τους επιλογές και την επικερδότητα τους. Η έρευνα αυτή αποκαλύπτει ότι οι επιλογές, οι γνώσεις και οι ενέργειες των διοικητικών στελεχών επηρεάζουν όχι μόνο την κερδοφορία των εταιρειών τους αλλά προσφέρουν και βαθμό προστασίας των επιχειρήσεων από το ρίσκο μελλοντικών αρνητικών εξελίξεων (downside risk). Η επίδραση αυτή των "Real Options" μελετάται και σε συνάρτηση με το βαθμό πολυεθνικότητας (multinationality) των εταιρειών και διερευνάται πώς αυτός επηρεάζει την μελλοντική επίδοση (performance). Γενικά τα θέματα με τα οποία καταπιάνεται η διδακτορική διατριβή είναι πρωτότυπα και προσθέτουν στην βιβλιογραφία σημαντικά εμπειρικά ευρήματα.

Στην εισαγωγή γίνεται μια γενική παρουσίαση των εννοιών "Real Options" και "Multinationality" και δίνεται μια σύντομη περιγραφή των αποτελεσμάτων που προκύπτουν από την διατριβή. Στο πρώτο κεφάλαιο χρησιμοποιείται η θεωρία των "Real Options" για να αποτιμηθεί η πραγματική αξία μιας εταιρείας υψηλής τεχνολογίας με σημαντικές δυνατότητες ανάπτυξης. Η περίπτωση της αμερικανικής εταιρείας EchoStar Communications Corporation χρησιμοποιείται ως υπόδειγμα αποτίμησης. Οι ευκαιρίες ανάπτυξης της εταιρείας μοντελλοποιούνται και εκτιμώνται ως ένα χαρτοφυλάκιο από "Growth Options". Η ανάλυση που γίνεται δεικνύει ότι αποτιμώντας την εταιρεία με βάση το χαρτοφυλάκιο των αναπτυξιακών της επιλογών παρέχεται μια καλύτερη εκτίμηση των προοπτικών ανάπτυξης της επιχείρησης σε σύγκριση με την παραδοσιακή μέθοδο αποτίμησης (DCF).

Στο δεύτερο κεφάλαιο, εξετάζεται η από κοινού επίδραση της πολυεθνικότητας (multinationality), των αναπτυξιακών επιλογών (growth options) και της γνώσης της διοίκησης επί των "Real Options" (awareness) στις μελλοντικές επιδόσεις σε ένα μεγάλο

δείγμα αμερικανικών εισηγμένων εταιρειών για την περίοδο 1996-2005. Η έρευνα και ανάλυση των δεδομένων δεικνύουν ότι όταν οι αναπτυξιακές επιλογές της επιχείρησης και ο βαθμός γνώσης για "Real Options" από τους διευθυντές λαμβάνονται υπόψη, η πολυεθνικότητα έχει σημαντική θετική επίδραση στην απόδοση της επιχείρησης. Επιβεβαιώνεται επίσης η σημαντική θετική επίδραση τόσο των λειτουργικών όσο και των στρατηγικών επιλογών ανάπτυξης (operating και strategic growth options) στην μελλοντική αξία και ότι ο βαθμός επίδρασης της πολυεθνικής ευελιξίας είναι υψηλότερος για τις επιχειρήσεις με υψηλότερο βαθμό γνώσης των διευθυντών για τα "Real Options". Όσο μεγαλύτερη είναι η γνώση από τους διευθυντές τόσο καλύτερη είναι η μελλοντική επίδοση της επιχείρησης.

Στο τρίτο κεφάλαιο, επεκτείνεται η μελέτη επίδρασης της πολυεθνικότητας (multinationality), των αναπτυξιακών επιλογών (growth options) και της γνώσης των "Real Options" στη διερεύνηση του ρίσκου των αρνητικών μελλοντικών εξελίξεων (downside risk) σε ένα μεγάλο δείγμα αμερικανικών εισηγμένων εταιρειών για την περίοδο 1996-2009. Τα αποτελέσματα δεικνύουν ότι όταν οι αναπτυξιακές επιλογές της επιχείρησης και ο βαθμός γνώσης των "Real Options" από τους διευθυντές λαμβάνονται υπόψη, η πολυεθνικότητα έχει σημαντική επίδραση στην μείωση του ρίσκου των αρνητικών μελλοντικών εξελίξεων (downside risk) της επιχείρησης. Επιβεβαιώνεται ακόμα η σημαντική επίδραση τόσο των λειτουργικών όσο και των στρατηγικών επιλογών ανάπτυξης στην μείωση του ρίσκου. Όσο μεγαλύτερη είναι η γνώση από τους διευθυντές τόσο καλύτερη είναι η αντιμετώπιση του ρίσκου της επιχείρησης.

SUMMARY
OF DOCTORAL THESIS

This doctoral thesis focuses on Real Options and Multinationality. The research is motivated by the role of real options as an uncertainty filtering and risk management tool that helps capitalize on strategic growth options, mitigate downside risk and enhance upside potential in a multinational switching network context. The thesis elaborates on the use of real options theory as a powerful methodology for decision making and risk management under uncertainty, helping management optimize the allocation of scarce resources with timing, scaling, sequencing and switching options, thus improving long-term firm performance and resulting in substantial strategic benefit.

Real options theory suggests that multinationality and real options flexibility (i.e., switching, operating and strategic growth options) can reduce downside risk and increase firm value. A key aspect not adequately considered in the literature concerns managers' explicit recognition of real options and how these options are exercised in MNCs, and more generally the role of knowledgeable management in optimizing the multinationality-performance relationship. A main objective of this dissertation is to focus on these valuation aspects and empirical implications of real options that have so far received insufficient attention in the literature. The dissertation consists of three essays that aim to apply or test real options theory in the corporate finance and strategy field, particularly in a multinational context.

The first essay is entitled "Valuing a High-tech Growth Company: The case of EchoStar Communications Corporation". In this essay a new approach is developed to value a company based on real options theory, modeling a firm's growth opportunities in an uncertain environment as a portfolio of corporate real options actively managed by the firm. The essay shows how real options analysis can help provide a more reliable estimate of the value of a growth company and addresses several strategic issues that are important for corporate success in dynamic and volatile industries. The essay specifically illustrates how real options analysis can be applied in an actual case of a US multinational high-tech growth company, EchoStar Communications Corporation.

This application has value both as an illustrative case study and as an exposition of relevant tools and techniques. The company's growth opportunities are modeled and valued as a portfolio of growth options (PVGO). The analysis indicates that the market did not fully capture the value of the future prospects of this high-growth company and was not valuing its stock price correctly. Industries with higher volatility tend to have more valuable growth opportunities and a higher proportion of PVGO to price on average than more stable, established industries. The former involve more unexpected technological changes and competitive moves. As a firm's or industry's dynamic path unfolds, management must be prepared to exercise, adapt or revise future investment decisions. The new theory posits that the market appropriately rewards with higher market valuations those firms better able to adapt to change, capitalizing on upside potential while mitigating downside risk.

The second essay is entitled "Multinational Real Options and Firm Performance: The Moderating Role of Managerial Real Options Awareness". This essay examines the impact of multinationality and real options awareness on firm performance measured by Tobin's Q. Based on a sample of US listed firms for the ten-year period 1996-2005, it shows that when a firm's degree of Managerial Real Options Awareness (MROA) is taken into consideration, multinationality has a significant positive impact on firm performance. It also confirms a significant positive effect of operating and strategic growth options on firm value and that the impact of multinational flexibility is higher for firms with a higher degree of real options awareness. The more aware managers are about corporate real options, the better the firm performance. This underlines the role of management in generating "super-normal" returns for MNCs through effective management of their portfolio of multinational real options.

The third essay is entitled "Multinationality and Managerial Real Options Awareness: Impact on Downside Risk and Upside Potential". This is an extension of the second essay and revisits the strategy literature concerning the impact of multinationality on downside risk. It also considers analogous implications for firm upside potential. This part of the thesis again examines the mediating role of MROA in the new context analyzing the joint impact of multinationality, growth options and MROA on firm downside risk and upside potential.

Based on a sample of US listed firms for the period 1996-2009, this essay documents that when a firm's growth options and degree of managerial real options awareness are taken into consideration, multinationality significantly reduces downside risk and enhances firm

upside potential. It also confirms a significant beneficial impact of strategic growth and operating options on downside risk. Multinational firms who are aware of their options are able to attain better downside risk management and upside performance. The beneficial impact of multinational flexibility on downside risk (and excess firm performance) is more pronounced for firms with a higher degree of real options awareness. In the absence of MROA and related organizational risk management capability, mere multinational operations do not guarantee reduced downside risk (or improved upside potential).

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Contents

i. Foreword

The use of real options theory (Dixit and Pindyck, 1994; Trigeorgis, 1996) is a powerful methodology for optimal decision making and risk management under uncertainty. It helps optimize the allocation of scarce resources with timing, scaling and sequencing options, improving long-term performance and strategic benefit. The real options approach allows a better management of risk and increases marginal return. This research is motivated by the role of real options as an uncertainty filtering and a risk management tool that helps capitalize on strategic growth options, mitigate downside risk and enhance upside potential in a multinational context.

Existing research on real options in corporate finance and strategy tended to take a prescriptive approach to studying these investments and has provided insufficient empirical evidence on the theory's key propositions. Recent research has examined whether multinational real options can be significant determinants of firm performance. Benefits of multinational operations switching, joint-venture agreements and international market entry have been investigated under the real options lens with interesting implications for the understanding of multinationality and the association between FDI and firm performance (Tong and Reuer, 2007; Lee et al., 2008).

Real options theory suggests that multinationality and real options flexibility (i.e., switching, operating and strategic growth options) can reduce downside risk and increase firm value (Kogut, 1984, 1985; Trigeorgis, 1996; Lee and Makhija, 2009). A key aspect not adequately considered in the literature concerns managers' explicit recognition of real options and how these options are exercised in MNCs, and more generally the role of knowledgeable management in optimizing the multinationality-performance relationship (Hennart, 2007).

A main objective of this dissertation is to focus on valuation aspects and empirical implications of real options that have not received sufficient attention in the literature. The dissertation consists of three essays that aim to apply or test real options theory in the corporate strategy field, and particularly in a multinational context. In the first essay we develop a new approach to value a company based on real options theory, modeling a firm's growth opportunities in an uncertain environment as a portfolio of corporate real options actively managed by the firm. We show how a real options analysis can help provide a more reliable estimate of the value of a growth company and address several strategic issues that are important for corporate success in dynamic and volatile industries. We specifically

illustrate how real options analysis can be applied in an actual case of a US multinational high-tech growth company, EchoStar Communications Corporation.

This application has value both as an illustrative case study and as an exposition of relevant tools and techniques. The company's growth opportunities are modeled and valued as a portfolio of growth options (PVGO), namely options to expand its pay-TV, equipment, and internet services. Our analysis indicates that the market did not fully capture the value of the future prospects of this high-growth company and was not valuing its stock price correctly. Industries with higher volatility tend to have more valuable growth opportunities and a higher proportion of PVGO to price on average than more stable, established industries. The former involve more unexpected technological changes and competitive moves. As a firm's or industry's dynamic path unfolds, management must be prepared to exercise, adapt, or revise future investment decisions. We posit that the market appropriately rewards with higher market valuations those firms better able to adapt to change, capitalizing on upside potential while mitigating downside risk.

Based on real options valuation analysis the market seemed to underprice the company's growth prospects at the time of valuation suggesting that EchoStar's share was significantly undervalued. In the post-valuation period EchoStar in fact adapted a number of strategic expansion moves reaffirming its growth options path underlying our analysis.

In the second essay we examine the impact of multinationality and real options awareness on firm performance. Based on a sample of US listed firms for the ten-year period 1996-2005, we show that when a firm's degree of managerial real options awareness is taken into consideration, multinationality has a significant positive impact on firm performance. We also confirm a significant positive effect of operating and strategic growth options on firm value and that the impact of multinational flexibility is higher for firms with a higher degree of real options awareness. The more aware managers are about corporate real options, the better the firm performance.

There are several rational arguments for firms to become multinational. First, multinational operations may enable reducing taxes or trade tariffs. Second, an MNC may take advantage of a lower-cost location for its production facilities or better skilled or cheaper labor in specific regions. Third, an MNC may reach foreign markets more effectively through its diverse export distribution and operations network. These examples of multinational operations underline the flexibility advantage of MNCs and the real options embedded in multinational networks (Kogut, 1984, 1985). Consistent with the real options logic, multinationality and flexibility are performance driving variables that can increase MNC

value and profitability under uncertainty. In this regard, multinationality plays two key roles: a) it provides a platform or network of switching options to deal with the variability of multinational operations, and b) through its interaction with firm operational and growth options, it offers extra opportunity exploitation and risk management advantages operating in international markets. However, in order for such linkages to result in superior performance, it is essential that MNC managers recognize and exploit the real option features of multinational operations and strategic foreign investments.

Since real options analysis and its managerial logic are viewed as a decision-making tool influencing managerial choices, it is reasonable to consider heterogeneity in managerial practices and awareness across MNCs, as suggested by the resource based view (RBV) and the dynamic capabilities view (DCV) of the firm (Barney, 1986; Teece and Pisano, 1994; Teece, Pisano and Shuen, 1997; Pitelis and Teece, 2009). Heterogeneity in managerial attention or real options awareness may help explain differences in flexibility management among MNCs (Kogut, 1984; Reuer and Leiblein, 2000) and help clarify the conditional impact of multinational switching flexibility on firm performance. Benefits from multinational flexibility might be fully realized only if the MNC has adequate organizational structures and managerial awareness to properly identify, cultivate and exploit real options opportunities. Real options awareness is considered an indicator of managerial real options skills within the organization measuring the aggregate level of real options know-how and its specific real options decision-making potential. As the real options logic is not systematically used in practice, such know-how does not yet constitute part of a firm's set of managerial capabilities but can be viewed as an intangible knowledge resource contributing to decision-making and superior performance. We thus investigate the role of real options awareness as a managerial intangible resource leading to more effective real options decision-making in organizations and examine how real options know-how interacts with flexibility moderating the impact of multinationality on firm value, downside risk and upside performance.

By real options awareness we refer to a firm's managerial aptitude to recognize, access, maintain and effectively manage its real options using an informed option-based view of decision-making. Managerial real options awareness presupposes management's specific ability to pay attention to real options (Barnett, 2005, 2008) and is accompanied by organizational investments in real options learning and decision support. The outcome from such learning can be translated into knowledge resources available to the firm and results in the development of managerial awareness specificity for each firm. This specificity influences the nature of the relationship(s) between multinationality, growth options and firm

value, contributing both directly and indirectly to firm performance. If managerial awareness is high, then real options know-how should positively contribute to performance.

We examine these effects in the context of a large sample of US listed firms differing in their degree of multinationality and managerial real options awareness. These effects are also tested on a separate sample of manufacturing firms and on a group of US listed MNCs. Using various specifications of sample groupings, we unveil the moderating and conditional value-enhancing impact of managerial real options awareness on firm performance. Our findings are an important addition to the literature as they directly address the practice of real options decision-making and option exercise in corporations.

To assess this impact properly, we control for mechanisms and effects predicted by alternative theories of the MNC (e.g., internalization, market power, diversification, transaction economics). This task is performed in order to isolate real options theory predictions from alternative theory effects providing a cleaner estimation of the relationships between multinationality, growth options, awareness and firm performance. We thus consider other theories of the MNC whose roles are complementary to the real options-based view (ROV). We employ for this purpose a two-stage multivariate model of firm performance, taking into account self-selection bias and endogeneity, accounting for the determinants of both multinationality and managerial real options awareness through propensity score matching and Heckman estimation procedures (Villalonga, 2004; Heckman, 1979).

We find that the performance impact of multinational flexibility is more pronounced for firms with higher degree of real options awareness. This confirms that the more effective the firm's organizational structure is in recognizing, managing and exercising corporate real options the better the firm performance. We also confirm that firm operating and growth options significantly interact with the degree of managerial real options awareness within the firm. This underlines the role of management in generating "super-normal" returns for MNCs through effective management of their portfolio of multinational real options. Our results are robust to a wide range of alternative specifications.

Extending the above work, the third essay revisits the strategy literature concerning the impact of multinationality on downside risk. We also consider analogous implications for firm upside potential. We thus examine the mediating role of Managerial Real Options Awareness (MROA) and study the joint impact of multinationality, growth options and MROA on firm downside risk and upside potential. Based on a sample of US listed firms for the period 1996-2009 we find that when a firm's growth options and degree of managerial real options awareness are taken into consideration, multinationality significantly reduces

downside risk and enhances firm upside potential. We also confirm a significant beneficial impact of strategic growth and operating options on downside risk. Multinational firms who are aware of their options are able to attain better downside risk management and upside performance. The beneficial impact of multinational flexibility on downside risk (and excess firm performance) is more pronounced for firms with a higher degree of real options awareness. In the absence of MROA and related organizational risk management capability, mere multinational operations do not guarantee reduced downside risk (or improved upside potential).

We examine these effects in the context of a large sample of US listed firms differing in their degree of managerial real options awareness and consider the full spectrum of real option platforms available to MNCs (i.e., switching, growth and operating options) and assess their joint impact, in combination with MROA, on DR, UP and UP/DR ratio. The basic premise is that rational investors care not only about attaining higher returns (through enhanced firm performance), but also care about containing losses by reducing downside risk below a specified target level (e.g. mean of the industry). Using the analogue concept of upside potential (UP) defined as above-target performance, we test empirically the impact of our set of option-motivated explanatory variables on DR and UP, as well as on excess performance to downside risk ratio (UP/DR).

We employ again a two-stage multivariate model of DR and UP, taking into account self-selection bias and endogeneity issues, accounting for the determinants of both multinationality and managerial real options awareness through propensity score matching and Heckman estimation procedures (e.g., see Villalonga, 2004; Heckman, 1979). Results from our panel dataset of US listed firms for the 1996-2009 period confirm that when a firm's operating and strategic growth options and the degree of managerial real options awareness are taken into consideration, multinationality does reduce DR and enhances UP even after controlling for other MNC drivers. We find that the DR and UP impact of multinational flexibility is more pronounced for firms with a higher degree of managerial real options awareness. This confirms that the more effective the firm's organizational structure is in recognizing, managing and exercising corporate real options the better the ability to reduce DR and increase UP for the firm.

The valuation or empirical results and conclusions from all three essays of this dissertation are consistent with the theoretical predictions of real options theory, reinforcing the notion that effective real options decision-making can be a source of competitive advantage for multinational firms in an uncertain and changing global market environment.

These findings help address some recent questions raised by a number of strategic management scholars regarding the pertinence of real options management in business strategy (e.g., Coff and Laverty, 2001; Carr, 2002; Adner and Levinthal, 2004; Reuer and Leiblein, 2000; Tong and Reuer, 2007), and call for further theoretical and empirical research that goes beyond the basic real options logic to also consider behavioral, structural and infrastructural elements of real options management in corporate decision-making.

ii. Chapter 1.*
Valuing a High-tech Growth Company: The Case of EchoStar Communications Corporation

Abstract

This article uses real options to value a high-tech company with significant growth option potential. The case of EchoStar Communications Corp is used as an illustration. The company's growth opportunities are modeled and valued as a portfolio of growth options (PVGO), namely options to expand its pay-TV, equipment, and internet services. Expansion of the main business can occur geographically (in the U.S., internationally, and through partnerships) or through cross-selling new products and services to its customer base. The internet business can expand via switching to DSL and through partnerships. The underlying asset (business) for the expansion options is the "base" DCF, after removing the constant growth rate in the terminal-value DCF assumption. The options-based estimate of PVGO value substitutes for the terminal growth DCF estimate. We show that our options-based portfolio PVGO provides a better estimate of the firm's growth prospects than the terminal growth DCF assumption.

* This chapter is based on joint work with Lenos Trigeorgis.

1. Introduction

Firms can increase their shareholder value by taking advantage of their strengths and opportunities as well as by recognizing their weaknesses and threats from the environment they operate in. Markets are volatile and technological changes and competitive threats can be disruptive. The strategic positioning of a firm is vulnerable not just to the actions of its direct competitors but also to unanticipated moves by new entrants. Alternative products or entirely new technologies can modify the very competitive landscape the firm operates under. Moreover, the increased power of customers and suppliers is forcing firms to be more proactive.

Traditionally, Discounted Cash Flow (DCF) methods have been used by academics, managers and analysts to determine how much a firm is worth. Net Present Value (NPV), Payback, Profitability Index, and Internal Rate of Return (IRR) are some of the more widely used DCF techniques (Brigham *et al.* 1999). DCF techniques have been popular because the decision rules (if a proposed project should be accepted or rejected) and criteria are theory-based, straight-forward and easy to use. DCF methods, however, are based on rigid assumptions that ignore the management of embedded flexibility in investment opportunities. Brealey *et al.* (2011) argue that real options are valuable sources of flexibility that are inherent in or can be built into corporate assets. The value of such options are generally not captured by the standard DCF approach. An alternative method, Real Options Valuation (ROV), has therefore emerged. This method uses option pricing (Black and Scholes, 1973) and treats firm opportunities as portfolios of corporate real options. Real options theory suggests that a firm has the opportunity (not the obligation) to act and revise future decisions (e.g. to expand, abandon, rescale, shut down and restart) at a later stage when more information is available.

In light of these challenges, we develop a new conceptual approach based on real options theory (Dixit and Pindyck, 1994; Trigeorgis, 1996), which considers a firm's growth opportunities in an uncertain environment as a portfolio of corporate real options that is actively managed by the firm. In our paper we show how a real options analysis can help provide a more reliable estimate of the value of a growth company and address several strategic questions that are important for corporate success in dynamic and volatile industries, like: What is the value of growth opportunities in a business (beyond the value of cash flows from assets in place)? What is the contribution of each expansion option to the overall firm value? When is the right time for investing in or exiting from a business?

We illustrate how real options analysis can be realistically applied in an actual case of a high-tech growth company, EchoStar Communications Corporation. This application has value both as an illustrative case study and as an exposition of relevant tools and techniques. The company's growth opportunities are modeled and valued as a portfolio of growth options (PVGO), namely options to expand its pay-TV, equipment, and internet services. Our analysis indicates that the market did not fully capture the value of the future prospects of this high-growth company and was not valuing its stock price correctly. Based on this analysis, performed as of 9 October 2004, EchoStar was underpriced at the time.[1]

A firm's growth opportunities and its strategic prospects in the industry are invariably reflected in stock market prices. Not all stocks generate the same earnings stream or have the same growth potential. Growth stocks (e.g., in high-tech, bio-tech, pharmaceuticals or information technology) typically yield high price-earnings and market-to-book ratios. It is precisely the intangible and strategic value of their growth opportunities that determines most of the market value of such high-tech firms in a continuously-changing environment. A proper analysis of strategic growth value is more difficult to capture than price/earnings ratios, book-to-market or other multiples might suggest. An underlying theory that can incorporate the strategic option characteristics of a firm's growth opportunities has been available.[2] There is already an appreciation in the market for the firm's bundle of corporate real options (present value of growth opportunities, or PVGO). Industries with higher volatility (such as information technology, pharmaceuticals, and consumer electronics) tend to have more valuable growth opportunities and a higher proportion of PVGO to price on average than more stable, established industries (such as transportation, chemicals and electric power). The former industries involve more unexpected technological changes and competitive moves. As the firm's or the industry's dynamic path unfolds, management must be better prepared to exercise, adapt, or revise future investment decisions. The market appropriately rewards with higher market valuations those firms better able to cope with change, capitalizing on the upside potential while mitigating downside risk.

The new insights and valuation tools from modern corporate finance based on real options theory can help management more fully appreciate the value of corporate capabilities to enhance the firm's adaptability and strategic positioning in a competitive and volatile environment (Trigeorgis, 1996; Smit and Trigeorgis, 2004). A firm's overall value consists of

[1] We value EchoStar Communications Corp as of 9 October 2004. The company was publicly traded on NASDAQ under the symbol "DISH".
[2] See for example *Business Week*, "How Do you Read this Crazy Market?", 29 March 1999, and *International Herald Tribune*, "Valuation Puzzle for Tech Stocks", 22 April 1999.

the value of expected future cash flows from existing businesses and the value of future growth options (PVGO). The impact of volatility on these two value components is different. Traditionally, managers used to perceive risk as a penalty which decreases a firm's current value. Real options theory helps elucidate that uncertainty provides a window of opportunity that enhances the value of a firm's future opportunities. Mr. Ergen, EchoStar's CEO, commented that his company was making "small bets" on broadband technology, such as on its relationship with SBC Communications Inc. EchoStar was launching a satellite with broadband capability and some satellite spectrum was expected to be available in the next few years. "We are treading water because we don't know how it's all going to turn out," he said, as if uncertainty was his company's ally.[3]

Surveys of managerial use of capital budgeting methods indicate predominant use of DCF and lesser use of real options and other practices. Graham and Harvey (2001) conduct a survey of 398 CFO's, 75% of whom report "always or almost always" using net present value (NPV), with 25% of CFOs reporting using real options methods. Firms in the survey report "always or almost always" using many other methods as well, including IRR, payback and P/E multiples. Ryan and Ryan (2002) find that 85% of firms asked use NPV "always or often" and that methods such as real options and simulation are used by less than 15% of firms. Copeland and Howe (2002) report 27% of CFOs using the real options approach. The survey evidence suggests that firms commonly use multiple capital budgeting methods in making decisions, weighing the results using some subjective judgment. There is also evidence that firms may be adjusting their application of DCF methods to account indirectly for the impact of real options through heuristics. McDonald (2000) finds that using a higher hurdle rate in practice has an equivalent effect as attempting to optimally delay an investment. Similarly, using a lower hurdle rate in certain strategic situations is equivalent to accounting for subsequent growth or strategic opportunities.

Recent research confirms that stock valuation is significantly affected by individual analyst forecast or model accuracy. Loh and Mian (2006), and Gleason *et al.* (2009) provide evidence that stock recommendations are more effective and profitable for analysts who are better at forecasting short-term than long-term earnings. Demirakos *et al.* (2004, 2009), examining a database of analysts' stock reports, find that analysts' price to earnings (P/E) based models outperform DCF models in target price accuracy and that this effect is mitigated by the difficulty of the valuation task.

[3] Excerpts from Mr. Ergen's interview with analysts on 9 August 2004 (http://articles.boston.com/2004-08-16/business/29204415_1_offering-local-channels-satellite-tv-digital-cable).

Glaum and Friedrich (2006) document increased use of DCF analysis in European telecom analysts' reports after the late 1990s. Deloof *et al.* (2009) study the valuation choices of French underwriters documenting that they use DCF analysis to support IPO offer prices. All-star unaffiliated underwriters in the US markets tend to be less optimistically biased and less willing to follow a firm in the period following an IPO with significant underpricing (Bradley *et al.*, 2009). Interview research by Imam *et al.* (2008) also suggests a shift among UK analysts towards the use of more analytical valuation models.

Apart from the above academic work, in July 2010 two opinions from the Delaware Court of Chancery offer important guidance for the preparation and use of DCF analysis in appraisal and merger-related proceedings.[4] In the first case, Vice Chancellor Leo E. Strine Jr. arrived at an appraised value of a merger based on determinations of the terminal growth rate, the equity risk premium and beta. In the second case he concluded that the proxy statement for a proposed merger was misleading with respect to its explanation of how a discount rate was determined. The present article, as an illustrative case study backed up by well-developed recent tools and techniques based on real options analysis sheds additional light on the limitations of current DCF methods and offers useful comparative practical prescriptions (e.g., options based PVGO vs. terminal growth DCF estimates).

The remainder of the paper is organized as follows. The next section provides a brief literature review. Section 3 provides a brief background on the company, while Section 4 describes the industry and competitor situation. Section 5 discusses EchoStar's financial condition and basic DCF analysis. In Section 6 we describe the growth prospects of the company, and in Section 7 we present an options analysis of growth opportunities. The final section concludes.

2. Brief Literature Review

A number of academics have conducted several empirical studies to examine the ability of real options analysis to explain observed market prices in a variety of contexts. Paddock *et al.* (1988) examine oil tract leases and find that real options prices are closer to market prices for oil lease tracts than DCF estimates. Quigg (1993) and Cunningham (2006), in their examination of real estate prices, find that flexibility has a significant impact on land prices and that greater price uncertainty slows down development and raises prices, consistent with

[4] Global GT LP v. Golden Telecom, Inc., C.A. No. 3698-VCS (Del. Ch. April 23, 2010); Maric Capital Master Fund, Ltd. v. Plato Learning, Inc., C.A. No. 5402-VCS (Del. Ch. May 13, 2010).

real options prediction. Moel and Tufano (2002) study managerial decisions involved with the closing and openings of gold mines that are consistent with optimal behavior in the exercise of real options. Berger *et al.* (1996) examine whether abandonment value is reflected in market prices. Based on the idea that the value of a firm should be the DCF of existing operations plus the option value of abandoning, they find that manufacturing firms with more abandonment value and more flexible assets have higher prices. Caballero and Pindyck (1996) and Abel and Eberly (2002) find evidence in investing data that irreversibility of investment affects the decision to invest in the first place.

Spencer-Young and Durand (2004) examine the difference between the NPV and ROV evaluations of game lodge concessions in South African national parks. They conclude that the difference between winning bids for concessions and mean concession values is related to the real option value of the concessions. Presumably, winning bidders pay more than the traditional NPV method would justify due to a "feeling" the bidders have about the concessions' actual value. The authors support the use of ROV in practice and recommend that bidders should use it to value concessions as it can lead to more accurate values. More recently, Clark *et al.* (2010) examine divestitures by 144 UK firms and test whether and how accurately investors price the firm's option to abandon assets in exchange for their exit value. They find that investors do price the abandonment option but that they do so imperfectly because the exit price is private information.

Despite the above empirical evidence supporting the incorporation of the impact of real options into market prices, actual company valuations using real options methods have been rather limited due to the complexity involved and the interactions among portfolios of corporate real options. Among the few exceptions, Trigeorgis (1990) describes a real options application in a natural resource investment project at British Petroleum. Kemma (1993) discusses insights gained from three actual cases of real options application with Shell group planning: a timing option in the offshore industry, a growth option in the manufacturing industry, and an abandonment option in the refinery industry. Schwartz and Moon (2000) use real options methodology to value Amazon, while Schwartz and Moon (2001) value e-Bay taking account of the option value to walk away from an unprofitable operation. They find that estimated real option values are closer to the observed prices of these companies. Lint and Pennings (2001) provide a case study of new product development at Philips Electronics. Kenyon and Cheliotis (2002) value a dark fiber investment that generates no revenue at present but may do so at some unknown future time (when prices drop in an uncertain environment).

Merck & Co.'s opportunity to create a venture in the early nineties is another application of ROV. Bowman and Moskowitz (2001) describe how Merck was interested in entering a new line of business and contemplated purchasing a new technology from a small biotech company. Because the biotech firm had patented the technology, Merck had to license the new technology in order to use it in the development of its new product line. However, Merck was facing considerable uncertainty from this new venture: on one hand, it was not certain that a product could in fact be developed from the venture since the technology was in a preliminary stage; on the other hand, even if developed, the product's commercial potential could not be predicted with a fair amount of accuracy. The biotech firm was willing to sell the patent to Merck, because the option would be more valuable in the hands of the latter because of its superior capabilities and better market access. Merck used ROV to plan and evaluate this investment opportunity: the opportunity represented a call option for Merck as it gave it the opportunity --but not obligation-- to roll out the product in exchange for paying a premium. A more institutional-wide use of ROV-based management at Merck is described in Nichols (1994).

According to Venkatesan (2005), real options valuation (ROV) has gained increasing support in the corporate world, with some of the largest companies being noted to have applied ROV.[5] Boyer *et al.* (2003) refer to Airbus, General Electric, Hewlett Packard, Intel and Toshiba as companies that have used ROV. According to Teach (2003), Enron was considered an "innovative user" of ROV and its concepts. Mauboussin (1999) discusses how Enron saw the volatility in electricity prices more as an opportunity than a risk and, accordingly, the firm used ROV to plan its investments in the power industry.[6] Park (2002) further suggests that real options has gained wide acceptance as a tool for making strategic investment decisions, reporting that 27% of Fortune 500 companies have used this approach in their strategic planning.

Trigeorgis (2005) discusses a comprehensive example and other illustrative applications of real options in various industries, reviewing the key lessons and implications of real options thinking for flexible decision making. Benninga and Tolkowsky (2002) illustrate how a real options decision framework can add flexibility into the capital budgeting process, using R&D in the pharmaceutical industry as an illustration. Karsak and Ozogul

[5] ROV has also been used for valuing public projects and investments. For example, Kitabatake (2002) conducted an ex ante evaluation of a large scale road construction project in the Minami Alps forest estimating the market value of the underlying project and its volatility using historical data from similar projects. This involves identifying related market-evaluated goods and services.

[6] Coy (1999) explains how Enron capitalized on electricity price volatility by building less efficient but flexible power plants. The plants were left idle during periods of low or moderate electricity prices and were put into operation only when electricity prices peaked or went sufficiently high. The "peak" power plants were seen as options to be switched on only when prices went up. Enron was not obliged to commit itself to investing at any point in time but did so at peak periods when clearly profitable.

(2002) discuss how the value of expansion flexibility can be captured in the manufacturing process through real option valuation. Davis (2002) cautions that increasing market volatility can destroy growth option value for firms holding "quality" growth options. Miller and Park (2002) survey other research work in the area of real options.

More recently, Copeland (2010) discusses situations where traditional NPV forces false mutual exclusivity among alternatives and illustrates how modularity of project design can be more valuable than large economies of scale. Arnold and Shockley (2010) argue that real options analysis is justified in any situation where investors want managers to maximize NPV. Sick and Gamba (2010) discuss organizational issues that impede adoption of real options strategies and analytic techniques. More articles on ROV and practical applications can be found in several recent special issues on real options.[7] Related work on growth options and strategy from a real options perspective includes Kester (1984), Luehrman (1988), Bowman and Hurry (1993), Smith and Triantis (1994), Trigeorgis (1996), and Teece *et al.* (1997). Related work on technology valuation and strategy includes McGahan (1994), Grenadier and Weiss (1997), and McGrath and MacMillan (2000).

Smit and Trigeorgis (2004, 2010) synthesize real options and game theory to evaluate projects or acquisitions, suggesting that the "Expanded NPV" framework better reconciles flexibility and strategic commitment, viewing strategic planning as managing a portfolio of real options with competitive interaction. Trigeorgis *et al.* (2007), focusing on business strategy issues, argue that real options analysis can also be useful in helping strategic planners address the challenges of competition. Many managers already incorporate game theory into their planning to help predict how competition will play out. But with competition emerging and evolving more rapidly than ever, supplementing game theory with real options analysis can help companies be more flexible in how they react. What this all adds up to is a portfolio of corporate real options, each with a value that will change along with the company's developing markets. Those who manage that portfolio most effectively will be in the best position to realize their company's growth potential. The present case application is an illustration of how one can practically assess the value of such a portfolio of corporate growth options.

[7] See, for example: *Financial Management* special issue on Real Options (Autumn, 1993); *The Engineering Economist* special issues on Real Options (2002, 2005); *Review of Financial Economics* special issue on Real Options (Vol. 13, nos 3-4, 2005); *Multinational Finance Journal* special issues on Real Options (Vol 14, nos 1-2 and nos 3-4, 2010); *European Journal of Finance* special issue on Real Options (forthcoming, 2011).

3. Company Description

EchoStar Communications Corporation (EchoStar), founded in 1980, has been a leading provider of satellite-delivered digital television services to customers across the United States through its digital information sky highway DISH Network.[8] In 2004, the company conducted substantially all of its operations through its subsidiaries and operated through two principal business units: The DISH Network and EchoStar Technologies Corporation (ETC). The DISH Network provided various services, including video, audio and data channels, interactive television channels, digital video recording, high-definition television, international programming, professional installation and 24-hour customer service.

EchoStar started offering subscription television services on the DISH Network in March 1996. As of the time of the analysis (October 2004), the company had approximately 10 million subscribers. EchoStar launched its first satellite in 1995 and it had nine in-orbit satellites that enabled it to offer over 1,000 video and audio channels to consumers across the United States. Through its wholly owned subsidiary, EchoStar Technologies Corporation (ETC), the Company designed and developed direct broadcast satellite (DBS) set-top boxes, antennae and other digital equipment for the DISH Network. ETC also designed, developed and distributed similar equipment for international satellite service providers.

In 1987, foreseeing changing technology in the satellite TV industry, EchoStar filed for a direct broadcast satellite (DBS) license with the FCC. Its platform of nine orbits enabled the company to effectively access virtually every household in the U.S. Throughout its 24-year history (and just 8 years after launching the DISH Network), EchoStar had demonstrated its innovative capability by achieving significant industry innovations: it was the first company to develop a UHF remote control, offer an Integrated Receiver Descrambler (IRD) for C-band satellite TV, a nationwide installation network dedicated solely to satellite TV systems, a satellite receiver with built-in digital video recording, and local channels to local markets in all states of America.

EchoStar had deployed substantial resources over the previous decade to develop the EchoStar DBS System. The DBS System consisted of the company's FCC-allocated DBS spectrum, its nine in-orbit satellites, EchoStar receiver systems, digital broadcast operations centers, customer service facilities and other assets utilized in its operations. Its several programming packages to consumers included a number of popular digital video channels.

[8] Information about EchoStar was collected by the authors as of the time of valuation in October 2004 (and is valid as of that date) through various sources: Bloomberg, CnnMoney, EchoStar.com, Financial Times, GoogleFinance, Reuters, SEC, ThomsonOneAnalytics, Yahoo!Finance and several analyst reports on the company.

Satellite-delivered local channels were also available separately in 110 of the largest markets in the United States. EchoStar also offered an expanded basic cable package plus a digital music service, movie packages and foreign-language programming packages. It offered approximately 60 foreign-language channels. The company continued to expand its offerings to include interactive services. DISH Network customers could purchase or lease receivers with built-in hard disk drives that permitted viewers to pause and record live programs without the need for videotape. EchoStar offered receivers capable of storing up to 180 hours of programming and expected to increase storage capacity on future receiver models. The company also offered receivers that provided a variety of interactive television services and applications.

Independent distributors, retailers and consumer electronics stores were selling EchoStar receiver systems and were soliciting orders for DISH Network programming services. While the company was also selling receiver systems and programming directly, independent retailers were responsible for most of its sales. These independent retailers were primarily local retailers who specialized in television and home entertainment systems. EchoStar's distribution channels included a national network of retailers including Costco, Sears, Wal-Mart and certain regional consumer electronic chains. In addition, RadioShack was selling EchoStar receiver systems and DISH Network programming services through its 5,200 corporate stores and in approximately 1,000 dealer franchise stores throughout the U.S. EchoStar had a strong market presence with ethnic programming to various select groups, giving it a loyal customer base.

The main source of the company's revenues was pay-TV subscriber-related revenue (TV). In October 2004 this accounted for approximately 94.5% of total revenues. Equipment sales (EQ) accounted for about 5%, while 0.5% came from internet subscriptions (INT). Figure 1 provides a summary of conditional parameter estimates specific to each division, namely each division's weight (%), its long-term growth rate in terminal value (g), beta (adjusted), the divisional risk premia, and the WACC for each division. The last row provides the (market-weighted) average estimates (e.g., g of 4.5%, adjusted beta of 1.55, Risk premium of 8.5% and WACC of 10.6%) which are being used in the DCF analysis.[9]

[9] The long-term growth estimates were obtained based on averages of analyst reports on the TV, Equipment and Internet sectors. Beta estimates were obtained as industry weighted averages for these sectors based on most recent 30 monthly returns of each company in the sector using the CAPM. Betas were "adjusted" by taking 2/3 of the actual beta estimate + 1/3 x 1 as betas tend toward 1 over time (see Brealey *et al*. 2011). Divisional risk-premia (RP) were derived from these beta estimates assuming a market risk premium of 5.5%. WACC data were based on analyst reports. Debt/Firm Value ratio was estimated at 29.7% and the 10-year risk-free (U.S. Treasury bond) interest rate at 4.2%.

[INSERT FIGURE 1 HERE]

EchoStar's success was based on a number of strengths. EchoStar had benefited from its robust business model and the reputation of its management. The company's business model focused on growing EchoStar's loyal subscriber base while management's reputation helped create greater shareholder confidence in the company. EchoStar's subscriber base had been experiencing substantial growth (15.3% in the previous year) while further increases were anticipated over the coming years. EchoStar was expected to have 11.3 million subscribers by 2007. This growing subscriber base enabled the company to sustain profitability.

EchoStar enjoyed a capital cost advantage over many of its competitors. Its cost leadership enabled it to provide low-cost services, so potential customers might buy EchoStar services ahead of competitors enabling the company to expand its market share. EchoStar had a number of distribution agreements that benefited its subscriber acquisition efforts. The company had distribution agreements with Radio Shack, Wal-Mart and CompUSA, among others. These distribution agreements helped EchoStar sign up more subscribers at a lower cost compared with other traditional methods of subscriber acquisition.

EchoStar Technologies (ETC) was selling digital satellite receivers internationally, either directly to television service operators or to independent distributors worldwide. This created a source of additional business for EchoStar as well as synergies that directly benefited the DISH Network. For example, the company's satellite receivers were designed around the Digital Video Broadcasting standard, widely used in Europe and Asia. The same employees who designed EchoStar receiver systems for the DISH Network were also involved in designing set-top boxes sold to international TV customers. EchoStar benefited when ETC's international projects resulted in improvements in design and economies of scale in the production of EchoStar receiver systems for the DISH Network.

EchoStar had a lot of opportunities, which embedded expansion options for the company. The development of broadband technologies represented a significant opportunity for EchoStar to generate increased revenues in the future. The company's strategy in the broadband sector was to offer satellite-based platforms in rural areas and wireless technologies (such as Wi-Fi) in urban areas. The emergence of these technologies enabled the company to offer a consistent level of service to both rural and urban areas. EchoStar faced the challenge to develop its offerings in this area and make sure they were superior to those of rivals. The media industry's consolidation trend might potentially benefit EchoStar if it

could continue to operate on a stand-alone basis. Media industry consolidation might provide opportunities for EchoStar to acquire some of its own industry rivals in order to expand both its reach and subscriber base.

In October 2004, there were over 20 million subscribers to direct broadcast satellite and other direct-to-home satellite services in the U.S. It was estimated that there were more than 90 million TV subscribers in the U.S., and there continued to be significant unsatisfied demand for high quality, reasonably-priced television programming services. EchoStar could target some of this untapped market potential in order to capture a greater share of the market and increase its subscriber base. Internationally, direct-to-home satellite services were particularly attractive for countries without an extensive cable infrastructure. EchoStar might actively solicit new business for its pay TV services and ETC division to diversify its revenue stream away from the U.S. market.

EchoStar had several weaknesses. It had a customer churn rate of 1-2% so it should increase subscriber acquisition efforts in order to capture new subscribers to replace those lost. This would result in increased costs that would restrain company profits. EchoStar spent a lot of money in its efforts to acquire new subscribers. The company needed to maintain an aggressive promotional effort in order to sign up more subscribers. EchoStar's subscriber acquisition costs usually arose from promotional activities, such as free installation promotions. These costs had to be incurred in order for EchoStar to generate increased revenues in the medium and long-term.

The company was also facing a number of threats. It faced competition from a number of industry rivals, including DirecTV, Comcast and Time Warner Cable. The acquisition of DirecTV's parent company (Hughes Electronics) by The News Corporation was expected to intensify competition in the DBS TV market. News Corp had significant interests in satellite and cable TV operations all over the globe. Piracy also represented a significant threat to EchoStar's business. EchoStar's international revenue depended largely on the success of international operators, which depended on the level of consumer acceptance of direct-to-home satellite TV products and the intensity of competition for international subscription TV subscribers. EchoStar`s business was also susceptible to weakness in the U.S. and global economy.

4. Industry and Competitor Analysis

Many were skeptical in the early days of the cable industry as to who would pay for TV services. By 2004 demand in pay TV services had stimulated investments in network infrastructure and product offerings worldwide. In the U.S., the Telecommunications Act of 1996 removed barriers to entry into cable operations by phone companies. For a time telecom companies welcomed the opportunity to enter new markets. However, despite some initial cross-industry movement, most companies stayed with what they knew best.

In spite of controlling large networks, one of the challenges that incumbent phone companies had to face in providing cable services was a lack of control of TV programming, which proved costly to acquire. Cable service providers, which also operated their own networks, though in smaller scope, enjoyed closer relationships with TV, movie and other media entertainment producers. Cable operators realized that network expansion would be necessary to confront phone companies. Investments in upgrading infrastructure and cable systems facilities in the U.S. rose to more than $75 billion since 1996. The new two-way capable cable networks allowed operators to offer advanced services, such as broadband Internet access, digital video, video on demand (VOD), and competitive telephone services. Cable systems provided greater bandwidth than the traditional copper lines of phone companies. That advantage allowed cable system operators to gain the lead in the deployment of high-speed broadband internet access. Outside North America, where cable infrastructure was generally less developed, few cable operators, such as NTL and UGC, were able to offer advanced services. Even in the more developed regions of Europe, cable operators were slower than their U.S. counterparts to upgrade to the two-way broadband networks.

Most regions of the world relied more on satellite delivery, a more effective means for providing services to rural and remote areas. Satellite delivery lost its cost-effectiveness in more populated areas. Some satellite delivery services were being improved to offer two-way access. Both cable and satellite operators worldwide were counting on the increasing demand for broadband internet access to be a major growth driver. Cable companies were running ahead of competition from the digital subscriber line (DSL) services offered by incumbent local phone companies and a host of telecom upstarts. Satellite broadband delivery, though advantageous for rural areas inaccessible by other means, had not yet provided serious competition for cable or DSL providers. Cable companies, phone companies and satellite providers competed head-to-head to provide broadband internet access and pay-TV programming.

This trend suggested that people worldwide were shifting to satellite TV. Satellite providers were reporting hefty gains while the cable industry profitability had declined. Consumers were expected to see aggressive marketing promotions in the years ahead as companies fought for customers. Competition came down to service and price: Cable companies offered video-on-demand features, high-speed internet access and, in some cases, telephone service. Satellite providers offered all-digital service and channel packages that were often cheaper and broader than digital cable. Advantages included digital picture, high-definition TV, more choices, and a user-friendly channel guide.

Satellite TV had grown substantially since 1999 when Congress allowed providers to offer local channels. By mid-2004, it accounted for one-fourth of all households in the U.S. that subscribed to pay-TV services. DirecTV, U.S.'s largest satellite TV provider, was in over 150 markets while EchoStar was in over 140 markets. By mid-2004, satellite providers had a combined net gain of about 1.6 million subscribers, increasing the total to 23 million subscribers. EchoStar alone surpassed 10 million customers. Part of its growth was due to expansion into new markets, primarily rural areas, as well as competitive pricing. While cable customers had to pay extra for digital service, satellite providers had been quicker with more innovative technology, such as interactive services and digital video recorders.

About 80% of television households in the U.S. subscribed to some sort of pay-TV service at the time. While cable was expected to face flat to modest growth, satellite was expected to grow steadily until it completed local market launches. A key advantage of cable over satellite had been broadband internet service. Although both satellite providers had marketing relationships with telephone companies that offered DSL lines, they were not truly bundled services.

Porter's "five forces" (Porter, 1979, 1980, 2008) help characterize the dynamic state of this industry at the time.[10] The power of potential entrants was high in the broadcasting and cable TV industry. Barriers to entry were low, technological innovation was rapid, time to market was short, and intellectual property and patents were difficult to protect. Success of first movers could attract large software and content providers. Following the economic downturn surrounding the internet bubble of 2002, it became easier for competitors from other industries to enter into broadcasting and cable TV by purchasing smaller or struggling

[10] Porter's "five forces" is a framework for industry analysis and business strategy developed by Michael E. Porter (1979, 1980). These forces are: new market entrants, substitute products (including technology change), suppliers, the power of buyers/customers, and existing competitive rivalry. Porter (2008) discusses common misunderstandings, providing practical guidance for users of the framework, and its implications for strategy today.

companies.[11] Microsoft and AOL, for example, had complementary businesses and sufficient resources to enter the industry rapidly. Telecom and utility companies could leverage their large installed infrastructures by changing their business models through their core competencies in distribution and economies of scale to enter the industry.

The power of alternative products was medium to high. Standard TV, home video, pay per view and internet via PC addressed most viewers' needs and wants. The development of a widely-recognized new product or service was crucial for EchoStar to demonstrate the value of interactive TV (iTV). There were various types of suppliers in this industry with high power. E-commerce and interactive advertising suppliers were the most powerful since they owned the infrastructure and had strong relationships with potential buyers. Content and application providers were important players since they provided the programs and applications that viewers demanded. Advertisers that sponsored most of the content on TV also had power since advertising might lead to follow-on investments and sponsorships. Finally, there were other suppliers, such as middleware providers, real-time developers and manufacturers who provided the needed hardware and software.

The power of customers, viewers and subscribers was medium to low. Customers had some flexibility to switch among established mediums like broadcast TV, cable TV and satellite TV. They had some bargaining power via the ability to choose the service provider. But aggressive pricing by service providers and the inability of consumers to act as a single buying entity left end customers with little power.

Industry rivalry was an important force in the industry. As most parties in the industry's value chain possessed medium to high power, industry rivalry was rather high. The relative power varied in the different segments, with suppliers generally holding substantial power, while individual viewers had little power. The strong interdependencies in the value chain, the absence of an accepted technological standard for software and hardware integration, and the uncertainty about revenue distribution between the different satellite TV features allowed for different market visions. Companies that shared a given vision created partnerships to develop an end-to-end product, producing a value chain where products were differentiated.

[11] In 2002 (March to September) there was a sharp drop in stock prices on stock exchanges across the United States, Canada, Asia and Europe. This downturn was characterized as the "Internet Bubble" bursting as a number of internet companies (e.g., Webvan, Exodus Communications, Pets.com) went bankrupt while others (Amazon.com, eBay, Yahoo!) lost substantial value. An outbreak of accounting scandals (Enron, Arthur Andersen, Adelphia, and WorldCom) expedited the fall as numerous firms were forced to restate earnings and investor confidence suffered.

The growth of pay TV services depended on these developments. Cable companies had to complete system upgrades, DBS operators had to deploy iTV services, and TV programmers had to embed interactivity into their content. Their power on the development of the whole industry was substantial. Pressure from customers, aggressive competition, and new added value could provide incentives to transition to iTV. Demonstrating added value to the end customer was a key issue that companies involved in the launch of iTV needed to address.

EchoStar's capital costs were about one-third those of the cable providers, giving it an advantage in offering discount pricing. Its base subscription services provided a relatively stable cash flow stream, while its fully digital products offered a competitive advantage in non-two-way cable markets and rural areas where it was expensive for cable providers to build cable infrastructure.

[INSERT FIGURE 2 HERE]

Figure 2 summarizes the specific industries in which EchoStar's main competitors operated, with the big conglomerates operating in many different industries in the broader sector. EchoStar's main direct competitors in Cable and Satellite TV services were DirecTV (DTV) and Comcast Corp. (CSCSA). Other indirect competitors included News Corp. (NWS), Time Warner Inc. (TWX) and Viacom Inc. (VIA), as well as Yahoo! Inc. in internet.

[INSERT FIGURE 3 HERE]

5. Financial Condition and DCF Analysis

Figure 3 summarizes comparable key statistics and financial performance for EchoStar (over the previous 4 years), some of its main competitors, and the industry/sector and market averages. By end of 2004, EchoStar's 10 million subscribers helped generate revenues of about $7b, up 22% from 2003 ($5.7b). This primarily reflected DISH Network's subscriber growth. This 22% annual revenue growth compared favorably to the sector and market. Subscriber-acquisition costs and subscriber-related expenses, such as programming and marketing campaigns, however, rose by more than 30%. In net, gross profit margin dropped to 32% from 39% in previous years, below that of competitors and the industry. Operating

profit (EBIT), estimated at $558m, was 20% lower than the previous year. Operating margin also dropped slightly to 8%, below that of the industry.

EchoStar's net income remained at approximately the same level as the previous year ($203m compared to $224.5m in 2003) showing significant cash-flow improvement (especially given the losses in previous years). This compared favorably with DTV and Comcast, taking account of its lower size and revenue base. Profit margin dropped slightly to about 3% (from 3.9% the previous year), still fine compared to its direct competitors (DTV and CMCSA) but lower than the industry, sector and overall market. In terms of accounting profitability, EchoStar's ROA dropped to 1.22, still better than its direct competitors, but lower than the industry and sector averages. In terms of market valuation, however, the company enjoyed Price/Earnings (P/E) and Price/Cash flow ratios well above its main competitors and industry, an indication that the market was already recognizing its significant growth potential.

The firm's financial condition was moderate compared to industry standards. Its cash balance position ($1.72b) seemed sufficient and compared favorably to that of DTV and CMSA relative to its size. EchoStar's current ratio (CA/CL) continued to decline (to 13%), but remained within industry norms. Its interest coverage ratio was low compared to the norms in the industry, alerting that the company should control its interest expense and borrowings.

[INSERT FIGURE 4 HERE]

The company's operating and financial performance based on these ratios was mixed compared to its main competitors and the sector. Although EchoStar outperformed the sector over a longer (5-yr) horizon, its price performance in 2004 over the previous year showed signs of potential undervaluation relative to the sector (see Figure 4). Nevertheless, the company's prospects and growth options needed to be examined more carefully in order to reach rational conclusions about its proper market valuation at the time.

[INSERT FIGURE 5 HERE]

The following analysis depends on a basic DCF analysis as a starting basis. Figure 5 provides a summary of our DCF analysis for EchoStar. It is based on analysts' 22% growth

projections of total revenues over the next 5 years along with an estimate of residual-year revenue, assumed to grow subsequently at an average long-term growth rate (g) of 4.5% (the average estimate by analysts). The derived free cash flow projections are shown in the last row (including the residual year). These are discounted at an average company WACC of 10.6% (based on the company's adjusted beta estimate of 1.55, its 29,7% debt/firm value ratio, and a 4.2% risk-free rate). This results in a total DCF value of $19.7b and total firm value of $20.4b. After adjusting for total debt ($6b), this results in an equity value of $14.4b, or $31.71 per share. This is close to the prevailing price of $31.30 as of October 9, 2004. Interestingly, it is as if the market priced the company using DCF with an implied average long-term (l-t) growth rate of 4.5%.

It is noteworthy that almost 90% of the DCF valuation derived from the terminal (residual) value, primarily driven by the implicit DCF long-term growth assumption of g=4.5%. Hence one's confidence in the standard DCF valuation hinges on whether this long-term growth rate assumption appropriately reflected and captured the value of the portfolio of EchoStar's growth options. Conceptually, we will remove the impact of the long-term growth rate estimate through the terminal value DCF assumption (obtaining the "base DCF" value) and then replace it with an explicit accounting of the firm's portfolio of growth options embedded in each of its business areas over the long term.

Figure 6 summarizes the results of our DCF analysis, separating the "base-DCF" part from the growth component. At an average growth rate of 4.5%, DCF analysis results in a total firm value of $20.41b. By subtracting the outstanding debt of $6b we get the equity value of $14.41b, or $31.71 per share. The second column gives the base DCF, i.e., the value of sustaining operations without any further growth (setting g=0% and Capex at the depreciation rate). The difference between these two values is the growth value (PVGO) implied by the market ($7.79b or $17.16 per share). That is, the implied Growth Potential is about 38%.

[INSERT FIGURE 6 HERE]

Figure 7 breaks down EchoStar's DCF (g=4.5%) and base-DCF (g=0%) values by division. As of October 9, 2004 the TV division had a DCF value of about $19.3b or $30 per share ($12b or $14 per share base-DCF without growth), Equipment was valued at $1b or $1.6 per share ($0.6b or $0.7 per share base-DCF without growth), and Internet was estimated at $0.1b or $0.16 per share ($0.01b or $0.07 per share assuming no growth). The

total company DCF of $20.41b (resulting in a $31.71 per share DCF estimate) provides a lower bound to the true worth of EchoStar's equity as it does not adequately reflect the option value of its growth (expansion) opportunities embedded in each of its three business divisions, especially the substantial growth potential of its new internet division. We describe these growth opportunities next. To determine the correct worth of these growth opportunities a proper bottom-up real options analysis is carried out in the following section.

[INSERT FIGURE 7 HERE]

6. EchoStar's Growth Prospects

EchoStar had been systematically developing its growth options through a series of investments in the previous years. A number of key events are noteworthy in terms of understanding the company's development and future prospects. In December 1995, EchoStar took the first step for its worldwide expansion by launching its first satellite, EchoStar I, from Xichang, China. In November 1998, EchoStar acquired the 110° West Longitude orbital slot from News Corporation and MCI World Communications, another significant step positioning itself for future growth. In August 2002, EchoStar's DISH Network Satellite TV systems were made available at Wal-Mart stores nationwide. In July 2003, EchoStar reached agreement with Qwest to offer satellite services as part of a communications bundle. EchoStar and SBC Communications forged a strategic partnership to offer SBC DISH Network television service.

In February 2004, EchoStar announced plans with RadioShack to partner with Sirius satellite radio service and a bundling agreement with Sprint services. In March 2004, DISH Network reached a long-term agreement with Viacom on rights to carry CBS, MTV and other channels. It also launched partnership with SBC, selling a four-way bundle that included video. In July 2004 DISH Network and a RadioShack franchise retailer teamed with the town of Center, Colorado to convert approximately 600 municipally-owned cable customers to the DISH Network satellite TV.

In August 2004, EchoStar and SBC Communications Inc. teamed up to launch an online movie-on-demand service. Channeling video content through the internet might avoid the spectrum constraints of broadcast television. In addition, EchoStar and CenturyTel signed a Strategic Partnership Agreement to offer CenturyTel and DISH TV Services to households in 22 states served by CenturyTel. This would allow CenturyTel to offer its customers multi-

channel digital TV as part of its full suite of bundled product and service offerings. Also, the TV Guide Channel had been launched on the DISH Network, bringing its customers a guide to "what's on" and providing EchoStar with a valuable medium through which to communicate with customers.

By September 2004, the DISH Network had expanded its offerings of local TV channels by satellite TV to regions of Virginia and Florida, expanding local channel availability to 150 markets, including all 50 states, Puerto Rico and DC. At that time, EchoStar announced it would seek to expand relationships with current and future telecom partners that focus on meeting customer demand for single-bill, bundled services.

[INSERT FIGURE 8 HERE]

By all indications, as of October 2004 EchoStar would continue its expanding course by taking advantage of similar growth opportunities embedded in each of its three divisions. The option map of Figure 8 serves to summarize what were then EchoStar's future growth opportunities by division. The value of growth or expansion options shown in the option map is *incremental*, going beyond the value of cash flows from sustaining existing (steady-state) operations captured in base-DCF. The company's base-DCF incorporates the cash-flow value from its existing businesses and from its strategic plan commitments over the short-term (next 5-years). Beyond the 5-year horizon management can exploit a range of future growth opportunities, embedded in each of its divisions. The future growth or expansion opportunities are examined separately below for each of the three business areas (divisions), as each has different characteristics and prospects.

Expand TV services (TV). EchoStar's opportunities to expand its TV business were expected mainly to come from geographic expansion of its content and from cross-selling new services to its existing TV customer base. This option to expand EchoStar's businesses is depicted in the top branch in the option map of Figure 8. At the time, its primary operation, pay-TV services, accounted for 94.5% of its total business revenues. This area focused on providing on-demand TV programs, games and related services (iTV). The DISH Network offered the lowest all-digital TV price in America and continually looked for ways to offer new services, such as high definition TV, and bring more programming choices to its existing TV customer base in the U.S. The company also offered receivers that provided a variety of new interactive television services and applications to its existing customers.

EchoStar planned to use Broadcom's phase shift keying (8PSK) technology across its newest line of DISH Network satellite TV receivers and Dish Player-DVR products. Broadcom's 8PSK was an advanced modulation and coding technology that was able to increase information throughput by 35% in a given radio frequency link with no additional power requirements. This capability would allow EchoStar's DISH Network to provide more programming services to existing subscribers using current dish antennas. With the help of Broadcom code technology in its new line of satellite set-top boxes, the DISH Network could also expand its available video and audio programming services to include local stations. Bandwidth high-definition TV programming could be utilized to expand to additional geographic areas in the U.S. (both on its own and via partnerships) as well as internationally. Besides its four movie packages (which included up to 10 movie channels per package), EchoStar offered approximately 60 foreign-language channels, including Spanish, Arabic, South Asian, Hindu, Russian, Chinese, Greek and other languages generating valuable options to expand internationally.

In the U.S. EchoStar sought to develop and expand relationships with current and future telecom partners to meet customer demand for single-bill, bundled services as a means of attracting more subscribers. Customers across the U.S. had embraced the convenience and cost savings provided through such partnerships generating a valuable option to expand TV services through partnerships. For example, the partnership with SBC Communications Inc., announced in 2003, promised to deliver significant strategic and marketing benefits for both EchoStar and SBC. EchoStar would acquire a powerful sales and marketing channel for its DISH Network satellite TV service. EchoStar and SBC also planned to develop set-top boxes that were able to combine the features of satellite TV, digital video recording, broadband, home networking and telecom services, moving to truly integrated telecom and entertainment services providing greater interactivity, features and functionality for their consumers.

Expand Equipment (EQ). EchoStar's opportunity to expand the equipment business was also expected to mainly come from geographical expansion and from introduction of new equipment products. The equipment division at the time accounted for about 5% of company operations and consisted of selling high-definition TVs, receivers, antennas, set-top boxes and accessories. Growth prospects in equipment were driven by TV expansion opportunities so effectively the two divisions gained their expansion value from the same source. The option to expand EchoStar's Equipment business is depicted in the second branch of the option map of Figure 8. Again, growth opportunities could come from geographic expansion and from sales of new products to existing and new customers. Geographic

expansion could be achieved either through partnerships or by expanding the business on their own. At a first stage geographic expansion was focused primarily in the U.S., particularly coverage of rural areas and ethnic groups. Within the following five years (and up to year 10) the company had an option to expand its equipment business internationally, covering more countries overseas driven by the international expansion of TV services.

Expand Internet (INT). This new business area, broadband internet connectivity (both dial-up and DSL), was at its infancy stage, accounting for only 0.5% of company revenues. However, it represented a valuable early-stage growth option. It was providing the promise of tremendous growth potential for the company. EchoStar's opportunity to expand would come mainly from two sources: (a) partnerships using broadband connectivity and (b) switching existing customers from dial-up to DSL. The option to expand EchoStar's Internet segment is depicted in the third branch of the option map of Figure 8. Specifically, the internet broadband business opportunity represented the most significant growth option. In the next five years (year 0-5, i.e., 2004-2009) EchoStar had the opportunity to expand its broadband internet services through partnerships and switch its small dial-up connection customer base to DSL. Within the subsequent five years (year 5-10, i.e., 2009-2014) the company at the time had a follow-on option to further expand its broadband internet (DSL) services by adding broadband satellite capacity, both locally and internationally.

7. Options Analysis of Growth Opportunities

Based on the DCF analysis conducted earlier, we arrived at a total firm value for EchoStar of $20.4b (resulting, after appropriate balance-sheet adjustments, in an equity value of $14.4b or $31.71 per share), as of October 9, 2004. This DCF value includes the company's existing committed plans at the time to expand over the next 5 years and a terminal value (assuming a residual average long-term growth rate of 4.5%) subsequently. Our approach here is to obtain a better estimate of the firm's long-term growth option value by first removing the impact of the long-term growth rate through the terminal value DCF assumption (obtaining the "base DCF" value) and then replacing it with an explicit accounting of the firm's portfolio of growth options embedded in each of its three business areas after year 5 (as shown in the option map of Figure 8).

To obtain the "base DCF" value of the company based on its existing plans at the time (assuming a no-future-growth policy), we back out (set to zero) this residual growth and set capital expenditures equal to the level of depreciation expenses under a sustainable no-growth

policy. The "base" (no-growth) DCF enterprise value of the company as a whole [V_0 - I_0] is estimated to be about \$12.57b. The base underlying asset value for the company [V_0] used to obtain a better estimate of the value of the various divisions and their business expansion options is \$16.42b.[12] Figure 9 summarizes the parameter estimates for the main option value drivers for implementing the option map of Figure 8 and obtaining valuation results.

[INSERT FIGURE 9 HERE]

Our bottom-up options analysis takes into account management's plans to develop its main strategic expansion options around its most important business areas discussed above (along with an option to abandon/sell this relatively young firm for a salvage value of \$4b in five years if things do not go well). As reported in Figure 9, the option to further develop and expand EchoStar's existing business within a 5-year period was modeled using an estimated FCF value growth rate (g) of 10% and business volatility (σ) of 30%. The risk premium (RP) was estimated to be 8.5% and the 10-year risk free rate (r) 4.2% during the relevant period. Overall company expansion was expected to be achieved through discretionary investment outlays of about \$4.73b over the next five years. An estimated \$8.8b investment was needed subsequently based on current investment projections. An additional \$4.5b would be needed within the next 10 years if the company pursued international expansion of its TV and equipment operations as well as expansion of its broadband internet (DSL) business. The above would result in a total investment cost (I) of \$13.3b. The expected timing or option maturity (T_i), investment costs (I_i) and resulting expansion factors (e_i) by division *i* are summarized in Figure 10.

[INSERT FIGURE 10 HERE]

A number of consistency checks were applied throughout the valuation process. For example, the expansion (growth) factors used were subject to several tests of consistency. First, the expansion factors shown in Figure 10 were set proportional to the conditional growth rates for each division (based on projections of growth by other analyst sources). When these conditional growth rates are averaged across divisions they result in the average long-term company growth rate of 4.5%. The expansion factors are also such that when the

[12] Base-DCF or $NPV_0 = V_0 - I_0$, therefore V_0 = Base-DCF + I_0 = 12.57 + 3.85 = \$16.42b, where $I_0 = I_5/(1+r)^5 = 4.73/1.042^5$ = \$3.85b.

growth (expansion) options are "committed", our expanded-NPV (options) analysis reduces to our DCF valuation of $14.4b for the whole company. Finally, when each division's options are committed, the individual DCF estimate for that division is obtained. In this latter procedure the option to abandon is "disabled" in order to achieve consistency with the traditional NPV estimate.

The option valuation results are shown at the top of each option node in Figure 8. The initial value of the business, estimated as the PV of free cash flows from the existing TV, equipment and internet business, is about $16.42b. The value to expand the TV division is estimated at about $4.72b or $10.4 per share, to expand the Equipment division $0.98b or $0.22 per share, and to expand the Internet business is $3.92b or $8.6 per share. The total value of growth opportunities (PVGO) in all three areas is $9.63b or $21.2 per share and the total firm value is estimated at $23.73b as of October 9, 2004. After subtracting net debt, the real option valuation method estimates the share price at the time to be $40.13.

In terms of value breakdown, the value of the option to expand the TV business comes from two sources: the option to expand geographically is estimated at $4.05b while the option to sell more TV services to existing customers (cross-selling) is estimated at $0.67b. The option to expand geographically can be broken down into the sum of the option to expand on its own in the U.S. market ($3.02b) and the value to expand through partnerships ($1.03b). The option to expand in the U.S. is much higher as it also takes into account the fact that after five years there is an embedded follow-on option of expanding internationally ($2.8b).

EchoStar's option to expand the Equipment division similarly comes from two sources: the option to expand geographically ($0.84b) and the option to extend its product mix by selling new products ($0.13b). Geographic expansion involves the sum of the option to expand through partnerships ($0.09b) and the option to expand its equipment business to the U.S. on its own ($0.75b). This last option has greater value as it embeds the follow-on option to expand the equipment business internationally ($0.76b). The company's option to expand its broadband internet business is worth $3.92b. This value is the sum of the option to offer more broadband services through partnerships ($3.91b) and to switch its current dial-up customers to DSL ($0.01b). The option to provide broadband internet services through partnerships includes a follow-on option to expand the provision of DSL connectivity between years 5-10 ($3b).

[INSERT FIGURE 11 HERE]

Total company value using Real Options Valuation (ROV) is estimated at $23.73b or $40.13 per share, compared to the DCF estimate of $20.41b or $31.71 per share (assuming 4.5% long-term growth rate) as of October 9, 2004. Figure 11 summarizes our valuation results by division. Our value estimate for the TV division is $18.1b or $28.33 per share, close to the DCF estimate of $19.3b or $30 per share. Our option valuation of Equipment is around $1.7b or $3.11 per share, while our DCF estimate is $1b or $1.60 per share. The Internet valuation, around $4b or $8.72 per share, shows the greatest disparity from the DCF estimates ($0.1b or $0.16 per share). This confirms that the young Internet division is heavily undervalued by DCF as most of its value comes from future growth opportunities rather than current subscription levels. Although the proportions each division contributes to company's revenues are 94.5% for TV, 5% for Equipment and only 0.5% for Internet, in value terms they represent 70% for TV, 8% for Equipment and 22% for Internet. The latter represents the beneficial upside potential of the uncertain internet business, contrary to traditional DCF thinking.

8. Conclusions

We develop a new approach to value a company based on real options theory, modeling a firm's growth opportunities in an uncertain environment as a portfolio of corporate real options actively managed by the firm. We show how a real options analysis can help provide a more reliable estimate of the value of a growth company and address several strategic issues that are important for corporate success in dynamic and volatile industries. We specifically illustrate how real options analysis can be applied in an actual case of a US multinational high-tech growth company, EchoStar Communications Corporation.

Real company valuations using real options methods have been rather limited due to the complexity involved and the interactions within portfolios of corporate real options. This application therefore has value both as an illustrative case study and as an exposition of relevant tools and techniques. It also contributes by providing a step-by-step methodology of how to model a company's future growth opportunities valuing them as a portfolio of growth options.

This article discussed the use of real options methodology in valuing a high-tech company with significant growth option potential. The company's growth potential was viewed and valued as a portfolio of growth (expansion) options. The starting point was to

perform a standard DCF analysis. The growth part improperly handled in the terminal value assumption was removed and replaced by an explicit modeling of the firm's portfolio of growth options embedded in its various divisions. Our DCF analysis (based on FCF, using a 4.5% average long-term growth rate) resulted in a value for the company of about $20.4b or $31.71 per share, around the prevailing price of $31.30 on October 9, 2004. The in-depth real options analysis was based on modeling EchoStar's growth (expansion) opportunities as shown in the option map of Figure 8. The option valuation resulted in total company value of $23.7b, or $40.13 per share. In terms of value breakdown, most uncertainty concerned the value of the internet division where the option and DCF estimates diverged the most. DCF analysis has been shown to have serious weakness in that it significantly undervalues such out-of-the-money options.

EchoStar, operating in a more established though competitive line of business (TV and Equipment), started a new business (Internet) in an uncertain environment. This actually represented investment in an asset that it could develop and expand now or later, depending on market conditions. This was an option that the firm could develop or expand if demand developed sufficiently. EchoStar similarly had other expansion options in the other businesses. Ignoring the available options and valuing the entire firm based on today´s expectation of prices and demand conditions using DCF can lead to significant undervaluation of both the options and the firm. If management understands how to value a new start-up line of business as an option, it can take better advantage of the upside potential behind uncertain conditions, exploit possible strategic partnerships or evaluate more effectively potential M&A bids on its future path.

If EchoStar's management valued its new internet start-up business using the standard DCF approach, misleading conclusions would be reached. Depending on current prices, the existing level of demand, expected growth and the costs of expanding the business line, management would make explicit assumptions and form expectations concerning the timing and scale of expansion and the resulting expected future cash inflows. The value of the start-up business would be obtained by discounting these expected cash flows and adding them up (net of the expected costs). Given that the new start-up business is more volatile a higher discount rate will likely be used following naively the DCF methodology. A higher discount rate would lead to a lower estimated value for the internet start-up asset. This is a gross mistake.

This undervaluation occurs because DCF ignores the flexibility that EchoStar's management has regarding weather and when to exercise its option to expand the internet

division, which was in its infancy. As such out-of-the-money options are more valuable when there is more future uncertainty about market demand conditions or technology, the internet start-up is actually more valuable when demand is unknown and more volatile. DCF erroneously suggests that the greater the uncertainty over future demand, the lower the investment in new start-ups should be. ROV, by contrast, prescribes the opposite: higher volatility means higher upside potential value for the start-up business and thus more investment in the start-up. By treating a start-up business as an out-of-the money option, we can value it correctly using ROV; moreover, we can also determine when is the best time to invest in the development or expansion of the new business. Developing or expanding a new business is like exercising a call option, where the exercise price is the cost of development or expansion. The greater the uncertainty over demand, prices, competitive conditions or technology, the longer the firm should wait keeping alive its option to develop it and the more valuable the option to develop the business is.

The ROV view of investment can also help EchoStar's management account for flexibility in its expansion plans for the existing TV and Equipment divisions. Should the firm commit itself to large amounts of investment right upfront or should it retain flexibility by investing in stages, keeping its options whether or not to grow open? Although many industries struggle with this dilemma, it is particularly important for technology firms, such as EchoStar, whose expansion plans must balance the advantages of expanding mature divisions at once to exploit cost savings from economies of scale versus the advantages of investing gradually to maintain adjustment flexibility. If EchoStar makes a large irreversible investment in a mature division and then demand grows slowly or shrinks, it will suffer losses from a capital investment it doesn't need. When the growth of demand is uncertain, there is a trade-off between investing big due to economies of scale versus the flexibility that is gained by proceeding in stages as needed. DCF favours the big investment, but this does not mean that it is the better or even the more economical alternative. ROV can do a better job to assess the importance of the flexibility that smaller, staged additions to existing business would provide.[13]

High-tech firms increasingly find that the value of flexibility can be large and that standard DCF methods that ignore this flexibility can be very misleading. Managers also understand that successful investing in uncertain technological businesses often creates strategic benefits as the initial investment may lead to follow-on opportunities or other

[13] For further discussion on these tradeoffs and the advantages of ROV vs. DCF see Dixit and Pindyck (1995).

extensions or applications. In fact, some investments are pursued primarily because they provide the possibility to open up future growth prospects that might otherwise be unavailable to the firm. DCF misses the value of such multi-stage or compound-like options as well. In general, ROV is a better tool for firm valuation than DCF methods as it recognizes and explicitly values the flexibility in investment opportunities and the importance of future growth options and other strategic considerations. Effective real options valuation and management favorably alters the probability distribution of the returns of the firm´s portfolio of investment opportunities by skewing it to the right. The firm´s upside potential is consequently improved while downside risk is limited.

In our valuation of EchoStar, our real option valuation of the firm's growth potential was about $9.6b, compared to $7.8b factored in by the market (based on the DCF approach) at the time. That is, the market seemed to underprice the company's growth prospects at the time of valuation. Based on the above analysis, we estimate that the company's total option-based value was about $23.7b or $40 per share. This was about $9 per share above the then prevailing price of $31.30 (or the DCF estimate of $31.70). Hence our ROV analysis indicates that EchoStar's share was significantly undervalued as of October 9, 2004. Perhaps the comparative analysis of ROV vs. DCF is better understood today than in 2004.

History has proven us right as the following "reprise" of how things have actually panned out for EchoStar suggests.[14] By January 2007, EchoStar's share price rose to our target estimate of $40 per share and remained above this level subsequently. The events that followed confirm the growth option potential revealed in our analysis. Two months later, in January 2005, EchoStar bought the broadcasting assets of the troubled High-definition television (HDTV) satellite provider Voom. On April 29 EchoStar announced it would expand its HDTV programming by adding the first 10 of 21 original Voom channels and mirror the channels on a CONUS slot. DISH Network proceeded to add CNN HD in Spanish along with other packages in its Latino HD lineup. On 25 September 2007, EchoStar agreed to acquire Sling Media Inc., a leading firm in the digital lifestyle space which had achieved an international distribution of its software in over 5,000 retail stores in 11 countries. EchoStar's acquisition of Sling Media enabled it to offer and develop new innovative products and services for its existing subscribers, as well as new digital media consumers and

[14] These results were presented at the 10th Annual International Conference on Real Options at Columbia University, New York, in June 2006. The confirmation of the validity of our valuation was revealed in the marketplace subsequently.

strategic partners. Through these strategic expansion moves EchoStar reaffirmed its growth options path underlying our analysis.[15]

[15] January 2008 marked the most important event in EchoStar's life. DISH Network business was demerged from the equipment, technology and infrastructure side of the business creating two separate companies: DISH Network Corporation, consisting mainly of the DISH Network business, and EchoStar Broadcasting Corporation, which retained ownership of the technology side including the satellites, Sling Media and the set-top box development arm. Dish Network Corporation, the larger of the two companies, focuses on programming, service and marketing of satellite television, while EchoStar Corporation runs a majority of the satellites and other signal infrastructure. DISH Network Corporation´s and EchoStar Broadcasting Corporation´s common stock are now publicly traded on NASDAQ under the symbols "DISH" and "SATS", respectively.

FIGURES

FIGURE 1. Parameter Estimates by Division/Business

Division	Weight (w%)	L-t g (TV)	β (adj)	RP(=β*5.5%)	WACC
TV	94.5%	4.5%	1.56	8.6%	10.6%
Equipment	5.0%	3.5%	1.32	7.3%	9.7%
Internet	0.5%	6.5%	1.90	10.5%	11.9%
Avg/Total	100%	4.5%	1.55	8.5%	10.6%

Note: Long-term growth (L-t g) estimates were obtained based on averages of analyst reports on the TV, Equipment and Internet sectors. Beta (β) estimates obtained as industry weighted averages of these sectors based on recent 30 monthly returns of each company in the sector using the CAPM. Betas were "adjusted" by taking 2/3 of the actual beta estimate + 1/3 x 1. Divisional risk-premia (RP) were derived from these beta estimates assuming a market risk premium of 5.5%. WACC data were based on analyst reports. Debt/Firm value ratio was estimated at 29.7% and the 10-year risk-free (U.S. Treasury bond) interest rate at 4.2%.

FIGURE 2. Main Competitors in Related Industries

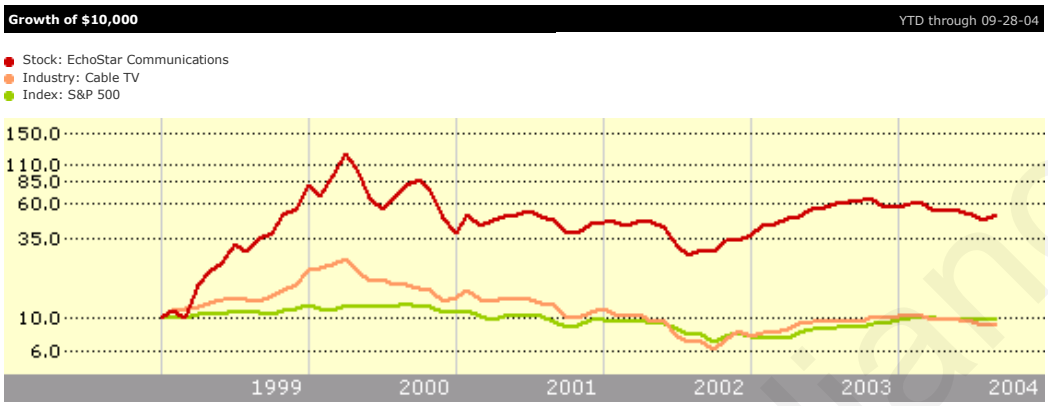
Competitor	TV	Cable	Satellite TV	Internet	Films	Publishing
EchoStar		√	√	√		
DirecTV	√	√	√	√		
Comcast		√	√			
News Corp	√	√	√	√	√	√
Time Warner	√	√	√	√	√	√
Viacom	√	√		√	√	√
Yahoo				√		

FIGURE 3. Echostar's Financial Performance: Comparable Key Statistics and Indicators

Indicator	DISH				DTV	CMCSA	TWX	Industry	Sector	Market
	2001	2002	2003	2004*						
Revenues ($b)	4.00	4.82	5.74	7.00	10.66	19.26	41.42	0.31		
Growth (%)	20.5%	19.0%	20.0%	22.0%	29.0%	15.0%	13.8%	26.6%/16.6%	23.8%/13.4%	19.1%/10.8%
Gross Margin (%)	35.90%	39.10%	39.20%	31.60%	42.12%	58.72%	39.30%	41.93%	43.47%	47.88%
SG&A/Sales (%)	23.60%	21.90%	19.90%	17.09%	35.35%	25.88%	23.21%			
EBITDA (=EBIT + D&A) ($b)	0.21	-0.33	0.79	1.02	594	7.03	11,497			
Operating Profit (EBIT) ($m)	212.30	452.00	707.60	557.94	-160.60	2,381.00	5,840.00			
Operating Margin (%)	5.31%	5.20%	9.30%	8.00%	-1.51%	14.00%	14.10%	12.33%	13.54%	21.56%
Net Income (Avl to Common) ($m)	-215.50	-850.00	224.50	203.00	-113.30	557.00	4,220.00			
Profit margin (%)	-5.39%	-17.63%	3.91%	2.90%	-1.06%	2.89%	10.19%	4.37%	8.38%	13.93%
Capital Ex/Sales (%)	15.93%	9.04%	5.61%	6.95%	4.40%	20.00%	0.31%			
CF from Operations ($m)	62.0	-477.0	622.0	895.0	NA	3,490.0	6,110.0			
Free Cash Flow ($b)	-679.0	-732.0	-1,309.0	224.0	NA	-0.4	3.2			
Financial Condition										
Interest Expense ($m)	274.0	370.0	487.0	360.0						
CL ($b)	1.13	1.20	2.46	2.01	4.84	8.63	12.72			
Debt ($b)	5.70	5.36	5.50	6.00	2.43	25.78	24.31			
Debt/Equity (Book) (%)	NA	NA	NA	NA	28.00%	62.00%	41.80%	51.00%	83.00%	81.00%
Cash ($b)	0.74	1.48	1.29	1.72	1.83	3.08	6.23			
WC (=CA-CL) ($b)	2.4	2.1	2.1	0.6	3.8	-4.2	0.0			
Current Ratio (= CA/CL)	3.11	2.76	1.86	1.32	1.78	0.51	1.00	1.13	1.45	1.80
Interest Coverage Ratio (=EBIT/Interest)	0.53	0.89	1.26	1.04	-1.66	1.38	8.63	3.94	8.01	11.94
Market Data & Profitability										
Market Cap ($b)	12.79	10.40	16.10	14.2	23.0	63.5	77.2			
Enterprise Value ($b)	NA	NA	NA	20.2	23.8	86.1	95.3			
/Market Cap	NA	NA	NA	1.4	1.0	1.4	1.2			
/EBITDA	NA	NA	NA	19.80	40.1	12.2	13.48			
EPS	-0.45	-1.76	0.46	0.45	-0.08	0.25	0.91			
P/E	-59.36	-12.25	71.69	70.05	NA	115.29	18.62	24.07	27.42	22.52
P/CF	11.90	9.69	14.92	29.91	NA	13.14	7.80	15.54	16.21	15.81
Market/Book	NA	NA	NA	NA	2.60	1.53	1.33	1.80	3.60	4.14
ROA	-3.86	-6.95	3.24	1.22	-0.96	0.55	3.52	1.55	6.21	7.12
ROE	-8.09	-39.35	6.81	6.49	-2.99	1.36	7.52	2.94	12.99	19.68
Beta (adj)				1.55	1.44	0.90	1.70	1.48	0.98	1.00

FIGURE 4. Performance of EchoStar vs. Industry, Sector and Market

Panel A. Performance of EchoStar vs. Cable TV and S&P Over 5-year Period



Total Returns %	1999	2000	2001	2002	2003	YTD
Stock	706.2	-53.3	20.7	-19.0	52.7	-7.6
+/- Industry	524.3	-23.4	32.3	9.4	12.0	3.9
+/- S&P 500	685.1	-44.2	32.6	3.1	24.0	-8.6

Panel B. Performance of EchoStar vs. Media Over Previous Year

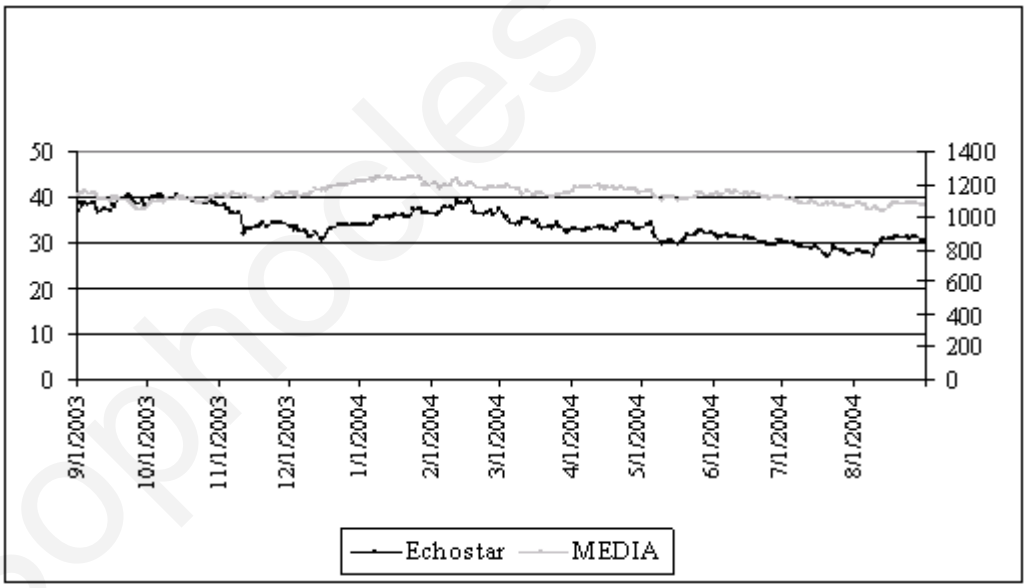


FIGURE 5. Summary of DCF Analysis

	0	1	2	3	4	5	Residual
	2004	2005	2006	2007	2008	2009	Year
Total revenue	7,002	8,542	10,422	12,714	15,512	18,924	19,776
% growth		*22.0%*	*22.0%*	*22.0%*	*22.0%*	*22.0%*	*4.5%*
Operating expenses	-1,196	-1,708	-2,084	-2,543	-3,102	-3,785	-3,955
% of sales	*17.1%*	*20.0%*	*20.0%*	*20.0%*	*20.0%*	*20.0%*	*20.0%*
Operating profit (EBIT)	586	834	1,018	1,241	1,515	1,848	1,931
EBIT margin	*8.4%*	*9.8%*	*9.8%*	*9.8%*	*9.8%*	*9.8%*	*9.8%*
Income before tax	226	452	613	813	1,060	1,366	1,420
Tax (@10%)	-23	-45	-61	-81	-106	-137	-142
Net income (PAT)	203	407	552	731	954	1,229	1,278
Earnings after tax (EAT)	527	751	916	1,117	1,363	1,663	1,738
Adjustments to net income	180	181	182	183	184	185	186
Operating income (NOPAT)	708	932	1,098	1,300	1,547	1,848	1,924
Depreciation & amortization	458	598	730	890	1,086	1,325	1,384
Increase in operating working capital	-722	-67	-194	-237	-289	-353	-88
Cash flow from operations (CFO)	895	1,463	1,633	1,953	2,344	2,820	3,220
Investment costs	-671	-1,049	-918	-981	-1,053	-1,265	-1,595
Net Free Cash Flows (NCF)	224	414	715	973	1,291	1,555	1,625

Valuation

PV of free cash flows (5 years)	3,484
PV of terminal value	16,223
as % of total value	*79.5%*
Total DCF	19,707
Excess cash	700
Total firm value	**20,407**
Net debt adjustment	-6,000
Equity value	14,407
Number of shares	454
Value per share	**$31.71**

Risk-free rate	4.2%
Cost of debt	6.0%
Beta (adj)	1.55
Market risk premium	5.5%
Cost of equity (ke)	12.7%
Debt/Firm value	29.7%
WACC	10.6%
Residual growth	4.5%

Note: e.g. for Year 2 (2006):

EAT = EBIT x (1-tax) = PAT + Interest after tax = NOPAT - Adjustments to NI
= 1,018 x (1-0.10) = 552 + 364 = 1,098 - 182 = 916

CFO = EAT + Depreciation - Increase in WC + Adjustments to NI
= 916 + 730 - 194 + 182 = 1,633

NCF = CFO - Investment costs = 1,633 - 918 = 715

FIGURE 6. DCF Valuation: Separating Base-DCF from Growth (PVGO)

	Std DCF (g=4.5%)	Base DCF (g=0%)	PVGO (std-base)
Firm value (V)	20.41	12.61	7.79
Equity (E)	14.41	6.61	7.79
Price/share (P)	$31.71	$14.56	$17.16

FIGURE 7. DCF Value Broken Down by Division:

DCF(g=4.5%) and Base DCF (g=0%) ($b and $ per share)

Division	Weight	DCF (g=4.5%)	Per share	Base DCF (g=0)	Per share
TV	94.5%	19.29	$29.97	11.92	$13.76
Equipment	5.0%	1.02	$1.59	0.63	$0.73
Internet	0.5%	0.10	$0.16	0.01	$0.07
Avg/Total	100%	20.41	$31.71	12.61	$14.56

FIGURE 8. Option Map for EchoStar's Growth (Expansion) Opportunities

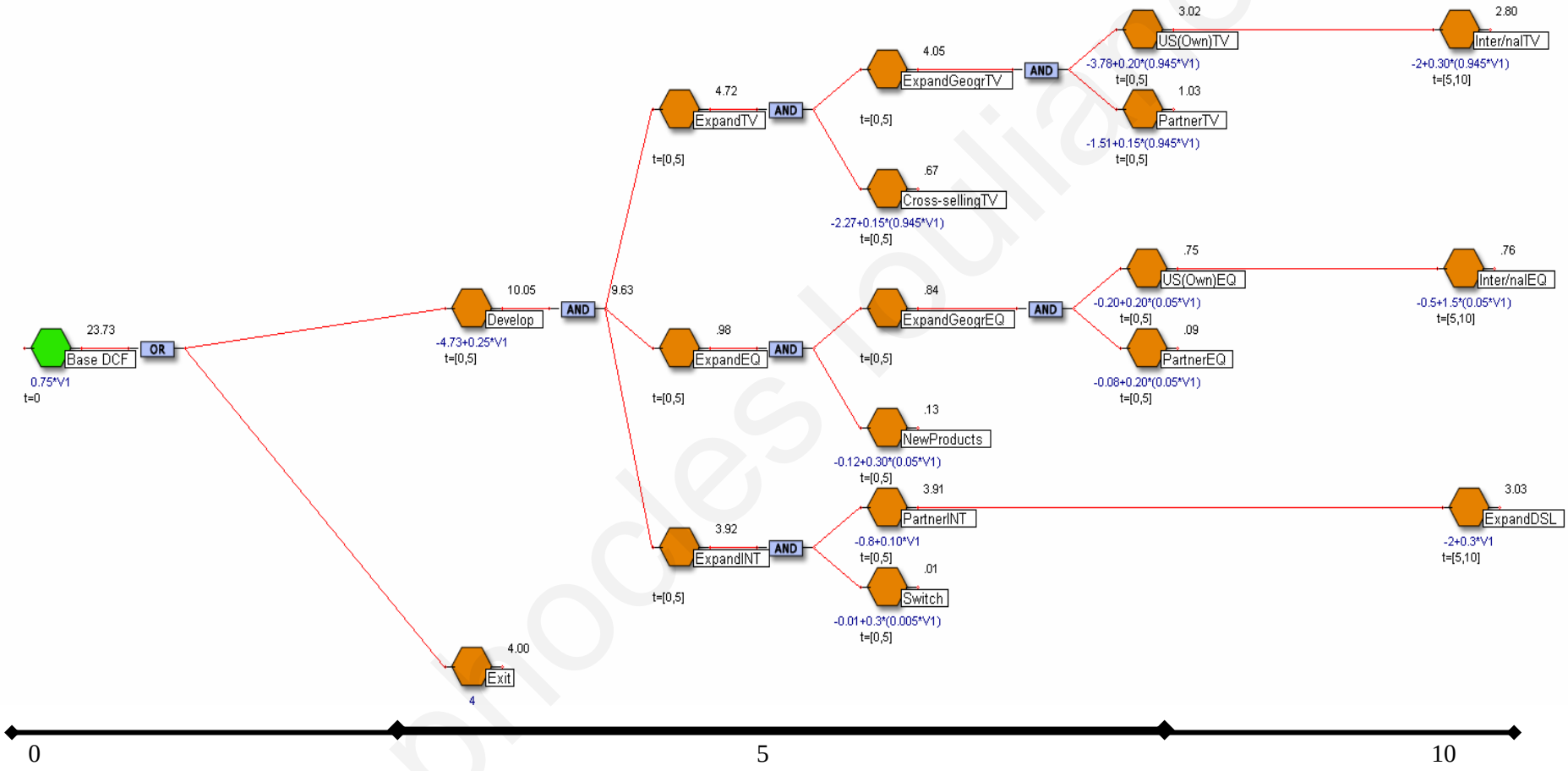


FIGURE 9. Option Value Variables and Parameter Estimates

Variable	Estimate
Initial value (V)	$16.42b
Growth in PV (g)	10.0%
Risk premium (RP)	8.5%
Payout (δ)	2.7%
Volatility (σ)	30%
Investment cost (I)	-$13.3b

Note: Option maturity (*T*) 5–10 years; risk-free rate (*r*) 4.2%.

FIGURE 10. Expected Timing or Option Maturity (T_i), Investment Costs (I_i) and Expansion Factors (e_i) by Division (i)

Division	T_i (yrs)	I_i ($b)	e_i
TV (g=4.5%)			
Cross-selling TV	5	-2.27	0.15
US (own) TV	5	-3.78	0.20
Partner TV	5	-1.51	0.15
International TV	10	-2.00	0.30
Equipment (g=3.5%)			
New Products	5	-0.12	0.30
US (own) EQ	5	-0.20	0.20
Partner EQ	5	-0.08	0.20
International EQ	10	-0.50	1.50
Internet (g=6.5%)			
Partner INT	5	-0.80	0.10
Switch INT	5	-0.01	0.30
Expand DSL	10	-2.00	0.30
Total/AVG (g=4.5%)		-13.30	

FIGURE 11. Summary of DCF and Real Options Valuation Results by Division ($b and $ per share)

Division	DCF	Per share	ROV	Per share
TV	19.29	$29.97	18.07	$28.33
Equipment	1.02	$1.59	1.69	$3.11
Internet	0.10	$0.16	3.99	$8.72
Total	20.41	$31.71	23.73	$40.13

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iii. Chapter 2.[**]
Multinational Real Options and Firm Performance: The Moderating Role of Managerial Real Options Awareness

Abstract

We examine the joint impact of multinationality, growth options and real options awareness on firm performance. Based on a sample of US listed firms for the ten-year period 1996-2005, we show that when a firm's growth options and degree of managerial real options awareness are taken into consideration, multinationality has a significant positive impact on firm performance. We also confirm a significant positive effect of both operating and strategic growth options on firm value and that the impact of multinational flexibility is higher for firms with a higher degree of real options awareness. The more aware managers are about corporate real options, the better the firm performance.

[**] This chapter is based on joint work with Tarik Driouchi and Lenos Trigeorgis.

1. Introduction

Besides exerting significant influence on international relations and politics, multinational corporations (MNCs) provide the necessary infrastructure to support globalization and the integration of national economies into the international system through exports, foreign direct investments (FDI), capital flows, labor migration and the transfer of technology. MNCs locate their businesses in multiple countries. There are several rational arguments for doing so. First, multinational operations may enable reducing taxes or trade tariffs. An Asian or American firm, for example, by moving operations to a plant in a European country, can gain access to the European market without having to pay import or export tariffs. Second, an MNC may take advantage of a lower-cost location for its production facilities or better skilled or cheaper labor in specific regions. Third, an MNC may reach foreign markets more effectively through its diverse export distribution and operations network. These examples of multinational operations underline the flexibility advantage of MNCs and the shadow real options embedded in multinational networks (Kogut, 1984, 1985). Consistent with the real options logic, multinationality and flexibility are performance driving variables that can increase MNC value and profitability under uncertainty. In this regard, multinationality plays two key roles: 1) it provides a platform or network of switching options to deal with the variability of multinational operations, and 2) through its interaction with firm operational and growth options, it offers extra opportunity exploitation and risk management advantages operating in international markets. However, in order for such linkages to result in superior performance, it is essential that MNC managers recognise and exploit the real option features of multinational operations and strategic foreign investments.

Recent empirical research has examined whether multinational real options can be significant determinants of firm performance. Benefits of multinational operations switching, joint-venture agreements and international market entry have been investigated under the real options lens with interesting implications for the understanding of multinationality and the association between FDI and firm performance (Tong and Reuer, 2007; Lee *et al.*, 2008). Real options theory suggests that multinationality and real options flexibility (i.e., switching, operating and strategic growth options) can reduce downside risk and increase firm value (Kogut, 1984, 1985; Trigeorgis, 1996; Lee and Makhija, 2009). One aspect not adequately

considered in the literature concerns managers' explicit recognition of real options and how these options are exercised in MNCs, and more generally the role of knowledgeable management in optimising the multinationality-performance relationship (Hennart, 2007).

Given ample evidence of real options practice particularly in MNCs (e.g., Billington *et al.*, 2002; Hartmann and Hassan, 2006), it is interesting to assess the flexibility and performance implications of multinational real options in firms with explicit managerial real options attention (Barnett, 2008) and across firms with heterogeneous aptitudes to real options decision-making. Since real options analysis and its managerial logic are viewed as a decision-making tool influencing managerial choices, it is reasonable to consider heterogeneity in managerial practices and awareness across MNCs, as suggested by the resource based view (RBV) and the dynamic capabilities view (DCV) of the firm (Barney, 1986; Teece and Pisano, 1994; Teece, Pisano and Shuen, 1997; Pitelis and Teece, 2009). Heterogeneity in managerial attention or real options awareness may help explain differences in flexibility management among MNCs (Kogut, 1984; Reuer and Leiblein, 2000) and help clarify the conditional impact of multinational switching flexibility on firm performance. Benefits from multinational flexibility might be fully realized only if the MNC has adequate organizational structures and managerial awareness to properly identify, cultivate and exploit real options opportunities. Real options awareness is considered in this work as an indicator of managerial real options skills within the organization measuring the aggregate level of real options know-how and its specific real options decision-making potential. As the real options logic is not systematically used in practice, such know-how does not yet constitute part of a firm's set of managerial capabilities but can be viewed as an intangible knowledge resource contributing to decision-making and superior performance. We thus investigate the role of real options awareness as a managerial intangible resource leading to more effective real options decision-making in organizations and examine how real options know-how interacts with flexibility moderating the impact of multinationality on firm value and performance. Specifically, we examine the joint impact of multinational switching, operating and growth options in interaction with managerial real options awareness on firm performance.

Our notion of real options awareness is backed up by observation of real options practice in MNCs (e.g., Triantis, 2005; Barnett, 2008) and by knowledge-

based view (KBV) literature concerning the role of managerial learning and flexibility in firm evolution and long-term performance (e.g., Kogut, 1984, 2008; Miller, 2002).[1] [2] By real options awareness, we refer specifically to a firm's managerial aptitude to recognize, access, maintain and effectively manage its real options using an informed option-based view of decision-making. Managerial real options awareness presupposes management's specific ability to pay attention to real options (Barnett, 2005, 2008) and is accompanied by organizational investments in real options learning and decision support.[3] The outcome from such learning can be translated into knowledge resources available to the firm and results in the development of managerial awareness specificity for each firm. This specificity influences the nature of the relationship(s) between multinationality, growth options and firm value, contributing both directly and indirectly to firm performance. If managerial awareness is high, then real options know-how should positively contribute to performance.

We examine these effects in the context of a large sample of US listed firms differing in their degree of multinationality and managerial real options awareness. These effects are also tested on a separate sample of manufacturing firms and on a group of US listed MNCs. Using various specifications of sample groupings, we unveil the moderating and conditional value enhancing impact of managerial real options awareness on firm performance. Our findings are an important addition to the literature as they directly address the practice of real options decision-making and option exercise in corporations. Going beyond previous research in the area, we additionally contribute by examining the full spectrum of real options platforms available to MNCs (i.e., multinational switching, growth and operating options and their interactions) and assess their joint impact, moderated by managerial real options awareness, on firm value and performance.

To assess this impact properly and in a robust manner, we control for mechanisms and effects predicted by alternative theories of the MNC (e.g., internalization, market power, diversification, transaction economics). This particular task is performed in order to isolate real options theory predictions from alternative

[1] From a strategy perspective, this definition is in line with the RBV (Barney, 1986, 1991) and the DCV (Teece and Pisano, 1994).
[2] A subset of firms in the study are users or adopters of the real options "technology" (Mun, 2003; Trigeorgis, 2005).
[3] This is in line with the notion that effective real options management is heterogeneous across firms, so managers do not make uniform real options decisions in international business environments (Tong and Reuer, 2007; Certo *et al*., 2008).

theory effects providing a cleaner estimation of the relationships between multinationality, growth options, awareness and firm performance. In this sense, we consider other theories of the MNC whose roles are complementary to the real options-based view (ROV). We employ for this purpose a two-stage multivariate model of firm performance, taking into account self-selection bias and endogeneity, accounting for the determinants of both multinationality and managerial real options awareness through propensity score matching and Heckman estimation procedures (Villalonga, 2004; Heckman, 1979). Results from a panel dataset of active US listed firms for the 1996-2005 period confirm that, when a firm's operating and strategic growth options and degree of managerial real options awareness are taken into consideration, multinationality does affect firm performance positively after controlling for other effects supported by alternative theories of the MNC; this holds also when firms' FDI determinants and real options know-how drivers are included in our structural performance models. We also confirm the significant positive impact of operating and strategic growth options, including non-additive interactions and real options portfolio effects.[4] We find that the performance impact of multinational switching flexibility is more pronounced for firms with higher degree of real options awareness. This confirms that the more effective the firm's organizational structure is in recognizing, managing and exercising corporate real options the better the firm performance. We also reveal that firm operating and growth options significantly interact with the degree of managerial real options awareness within the firm. This underlines the role of management in generating "super-normal" returns for MNCs through effective management of their portfolio of multinational real options. Our results are robust to a wide range of alternative specifications.

The remainder of the paper is organized as follows: the next section provides an overview of the related literature on multinationality and real options and develops our testable hypotheses. A description of our data, sampling procedures, models and methodology is given in Section 3. Section 4 provides a discussion and interpretation of our results, including robustness/sensitivity checks, endogeneity controls and selection bias correction. Section 5 concludes and discusses implications.

[4] These portfolio effects relate specifically to the interactions among firm multinationality, operating and growth options platforms in international markets.

2. Background, literature and testable hypotheses

In spite of a large body of research examining the relationship between multinationality and performance in MNCs (e.g., Doukas and Travlos, 1988; Ramaswamy, 1995), there is general agreement that the overall findings remain incomplete. A number of authors for example find that the association between multinationality and performance is negative (e.g., Chang and Thomas, 1989; Michel and Shaked, 1986; Denis *et al.*, 2002). Others reveal a positive and linear relationship (Vernon, 1971; Grant, 1987; Kim *et al.*, 1993; Seth *et al.*, 2002). Other studies show that the relationship is curvilinear due to coordination problems, transaction and internalization issues (e.g., Sullivan, 1994; Gomes and Ramaswamy, 1999). A few papers report a non-significant relationship or no association at all (Kumar, 1984; Kim and Lyn, 1986; Tallman and Li, 1996).

Such seemingly mixed but in fact incomplete results may find their origins in the number of alternative theoretical predictions put forward to study the economic and managerial motives of FDI and in the difficulty in reconciling competing arguments methodologically, resulting in empirical situations where economic effects from one or more theories may often obstruct or be obstructed by those of other theories.[5] Various authors found diverse support for these apparently competing theories: internalization theory (Mishra and Gobeli, 1998), transaction costs (Leiblein, 2003), resources and dynamic capabilities (Leiblein, 2003; Teece, 2009), diversification (Chang and Thomas, 1989), and organisational learning (Kogut and Zander, 1993). However, very few have investigated their complementary features or tested them together in one explanatory model of firm performance (e.g., see Villalonga and McGahan, 2005, and Tong and Reuer, 2007). For these reasons, a few transaction costs proponents have recently argued that the multinationality-performance relationship might be insignificant after all and could only be positive due to luck or superior management skills (Hennart, 2007).

Regarding real options research dealing with strategic foreign investments and multinational operations, a similar pattern of findings emerges. Findings vary across

[5] For example, internalization or market power theories suggest that intangibles or firm size can confound the relationship between multinationality and performance. The RBV argues that unobserved resources and firm specific attributes might moderate this association. Diversification theory and the DCV suggest that variance reducing or value creation rationales might be behind the decision to invest abroad. Agency theory argues that firms may diversify because they are underperforming in their current operating environment or business segments.

studies and are again incomplete. For example, Allen and Pantzalis (1996) report a positive linear relationship between multinational switching flexibility and firm value after accounting for the effects of intangibles and certain firm-specific attributes. Reuer and Leiblein (2000), on the other hand, find no link between multinationality, international joint-ventures and firm performance in US manufacturing MNCs, challenging predictions related to the flexibility/diversification benefits of multinationality. Examining multinational growth options, Pantzalis (2001) provides evidence that investment in emerging markets can increase firm value as suggested by real options theory. However, some of this evidence seems conditional. Reuer and Tong (2005) and Tong *et al.* (2008) show that the growth options effects of emerging economies may in fact depend on, besides usual transaction costs matters, the specific emerging market and industrial segment the firm is operating in if entry is accomplished through sequential modes or joint venture investments. Again economic and managerial effects predicted by real options theory may interact with effects predicted by alternative theories of the MNC. Recent research by Villalonga and McGahan (2005) and Tong and Reuer (2007) suggests that various theories of the MNC (including ROV) might be complementary rather than competing in the context of multinational decision-making, and that the mechanisms underneath them should be controlled for when investigating firm performance determinants. This is an important step in the performance-multinationality research agenda. Examining the impact of multinational switching flexibility, Tong and Reuer (2007) report a curvilinear association between risk and firm international presence after incorporating firm characteristics, self-selection correction and FDI determinants. By controlling for alternative MNC theory predictions while focusing on firm managerial real options attention, we extend these recent findings by 1) studying the full spectrum of real options platforms available to MNCs, 2) examining the joint impact of multinationality and real options flexibility on firm performance and 3) assessing the effect(s) of managerial real options awareness, as a specific firm attribute and measure of real options know-how, on real options flexibility and MNC performance.

It is clear from the above literature that to more accurately determine the flexibility impact and real options characteristics of multinationality on firm performance, a number of factors, including past performance, need to be controlled for (Villalonga, 2004). These factors relate to self-selection and endogeneity issues, the role of intangibles, firm heterogeneous characteristics and managerial

specificities, as well as industry factors in multinational operations (e.g., Tong and Reuer, 2007).[6] For example, it may be that poorly performing firms go multinational to diversify, leading to seemingly a negative association between multinationality and performance. At the same time, good past performers may go multinational to leverage their flexibility and growth options advantage, leading to a positive association. The net result may be mixed. Controlling for past performance and self-selection, as well as alternative theory determinants of multinationality (e.g., intangibles, R&D intensity, market power etc) and firm specific attributes (such as managerial real options awareness), may help reveal the true conditional relation between multinationality and performance, which real options theory predicts should be positive.

This paper consequently examines the joint impact of multinationality, growth options and managerial real options awareness on firm performance while taking into account mechanisms predicted by alternative theories of the MNC (market power, diversification, internalization, innovation/organisational learning). These mechanisms are captured in a two-stage structural performance model of the MNC that considers the performance implications of multinationality and real options awareness while controlling for self-selection, firm FDI determinants and real options know-how drivers. In accordance with real options theory (Trigeorgis, 1996), the RBV (Barney, 1986) and DCV (Teece and Pisano, 1994), we posit that the degree of managerial real options awareness and know-how present in MNCs plays a significant role in the effective management of multinational real options flexibility and in extracting its full benefits. This key managerial driver has not been taken into proper consideration in a detailed structural performance model in prior empirical studies.[7] We focus on firm value measured by Tobin's Q as an indicator of performance and examine the full set of flexibility platforms (multinational switching as well as growth and operating options) available to multinational firms to shed new light on the relation between multinationality and firm performance. We suggest that firms that are managerially aware of their multinational flexibility options or have put in place an appropriate organizational infrastructure to devote managerial attention to

[6] Brouthers *et al*. (2008) suggest that diversification and real options effects might be dominated by transaction costs motives in some situations (e.g., during specific time periods or for firms operating in specific economic regions) and vice-versa.

[7] The closest works addressing this issue are Tong and Reuer (2007) and Driouchi and Bennett (2011). Focusing exclusively on multinational switching options, these authors suggest that firm's heterogeneous factors and managerial aspects can be important determinants of downside risk in MNCs.

cultivating and exercising their real options will likely exhibit a comparatively better (positive) performance. The next section discusses the theory behind these predictions. The definitions of flexibility we use here are in line with those found in the real options literature (e.g., Trigeorgis, 1996; Triantis, 2005). The words flexibility and real options are hence used interchangeably in the remainder of the paper.

The multinational nature of MNC operations and related infrastructure investments enable the MNC to take advantage of its network of operations in multiple countries and exercise a broad menu of real options: delay or time entry in a new market, expand or contract production via outsourcing, switch inputs or outputs through multi-country operations, switch operations or grow into new expanding or emerging markets. Trigeorgis (1996) categorises the menu of such managerial options into growth options conferring strategic flexibility, operating options providing operational flexibility (resulting from previously exercised growth options), and multinational switching options emanating from multinational flexibility. The following sections discuss the characteristics of these options categories and hypothesise their impact(s) on firm performance.

2.1. Multinationality as a switching flexibility platform

The diversity and geographic dispersion of global operations provides multinational firms with better hedging and exploitation opportunities than domestic rivals in a changing global business environment. Multinationality provides a more potent platform for the "markets" in which the MNCs' operating and strategic options get exercised. It provides valuable switching flexibility to deal with the variability in multinational operations. Switching may be justified as physical hedging in case of unfavourable events (e.g., in the foreign exchange or international labour markets) or as a result of profit making opportunities arising from positive developments in local or global environmental factors (e.g., corporate tax reductions or FDI boosting policies from local governments).

In line with real options theory predictions, the value of multinational network flexibility and hence the value and performance of a multinational firm will be higher the broader the range of alternative choices (i.e., countries of operation) the MNC has. The more the alternative choices within the multinational network, the greater the

switching flexibility value conferred to the MNC. Specifically, the greater the number of countries with foreign operating subsidiaries (M), the larger the MNC switching flexibility value when local or global environmental factors vary. The relation between multinational flexibility and value is likely to be positive and declines non linearly (e.g., logarithmically). As the number of countries with foreign subsidiaries rises, the correlation structure among alternative country operations within the firm's portfolio mix increases, thus lowering switching option value. At the same time coordination costs rise and the marginal benefits likely decline. Alternative theories also predict nonlinear relationships, so we rely on the now standard use of ln(1+M) in the literature (e.g., Caves and Mehra, 1986; Reuer and Leiblein, 2000) as a reasonable multinationality proxy under the real options lens.

When examining the relationship between multinationality and performance, it is important to also consider alternative motives or theories behind FDI because of firm tendencies to self-select in going multinational. In accord with MNCs market power advantage hypothesis (Bain, 1956; Hymer, 1976), past size and market concentration increase the likelihood or degree of multinationality. Internalization and transaction costs theories advocate that a key motive for going multinational is cost efficiency. This can be captured by the association between firm intangibles and multinationality. Diversification theory predicts that going multinational is motivated by risk diversification and the reduction of total firm-specific risk. Higher business volatility should therefore increase FDI. Knowledge-based and organizational learning views argue that firms may go multinational to leverage knowledge, innovation and organizational flexibility (Kogut and Zander, 1992, 1993). These predictions can be captured by the association between firm R&D intensity and its level of multinationality. Finally, real options theory predicts that the greater the number of countries with foreign operating subsidiaries, the larger the MNC switching flexibility value under uncertainty. A corporation's multinationality should therefore positively contribute to MNC performance. However, in order to isolate the real options effects of multinationality on firm performance, the alternative MNC mechanisms described above need to be controlled for. This leads to the following:

Hypothesis 1. Multinationality, as a switching flexibility platform, enhances firm performance (after controlling for alternative determinants of FDI).

The above hypothesis concerns mainly the impact of multinational switching options on firm performance. To avoid reverse causality issues (as past performance might be a determinant of multinationality), the tested relationship should measure the effect of past, rather than present, levels of multinational switching flexibility on performance. Multinationality may also interact with managerial awareness and growth options. Interaction effects are examined in the empirical results/robustness section.

2.2. Real operating and growth options

As discussed previously, the multinational firm holds a portfolio of operating and strategic growth options that benefit from market uncertainty. Operating options consist of the operational choices in the realm of firms' real activities embedded in assets in place. On the other hand, strategic growth options concern the long-term prospects of companies and their future value-creation potential. Operating and strategic growth options are hence located in existing operating assets and in strategic resources, respectively. The value and performance of an MNC will be higher the more uncertain the business environment facing the MNC's operating segments. In a more uncertain environment the greater will be the firm's operating flexibility and the greater the association of the real options specificity, reflecting exercise of past investment, expansion or switch options. Generated from past growth opportunities that have been exercised and integrated in firm operations, operating options serve as levers or hedges the firm can exercise within its internal operations to enhance profits or reduce corporate risk exposure.[8] They effectively provide insurance and leveraging tools contained within a corporation's network of global operations. Because of the operational nature of these decisions (embedded in investment, expansion or switching decisions from previous periods), it is appropriate to account for them in enhanced plants, property and equipment (Ramaswamy, 1995; Allen and Pantzalis, 1996; Ramezani *et al.*, 2002). Therefore, short-term or immediate changes in capital expenditures are more representative of firm operating options fluctuations. The firm's performance should thus be a function of changes in these operating assets in place or capital expenditures (ΔCapex), effectively representing exercise of past

[8] Operating options can take many forms in the context of international operations. The options to delay production or shut down operations after a sudden decline in market demand are typical examples (Trigeorgis, 1996). The option to outsource operations to a low-cost location is another example of operating flexibility (Leiblein and Miller, 2003; Mol *et al.*, 2005).

growth options converted into operating assets in place. By operating flexibility options in this context we refer to the change in operating assets in place or Capex.[9]

This argument is in accord with recent finance and accounting literature on capital investment and the determinants of stock returns which use Capex and related variables such as total asset growth or accruals as operating firm characteristics. For example, Titman *et al.* (2004) use the change in Capex (growth in capital investment) and find that firms which substantially increase Capex experience lower subsequent stock returns. Anderson and Garcia-Feijoo (2006) find that growth in capital expenditures explains returns to portfolios sorted based on size and book-to-market and the cross section of stock returns. They argue that these findings are consistent with theoretical predictions (e.g., Berk, Green, and Naik, 1999) in which the exercise of investment-growth options results in changes in both systematic risk and expected stock returns. Cooper *et al.* (2008) examine the relation between total asset growth and subsequent stock returns and confirm empirically that the change in capital expenditures (ΔCapex) is the most important component of total asset growth, particularly so for large firms.[10] Cao *et al.* (2008) use both PVGO and Capex as two complementary proxies of growth options and find that growth options explain the trend in idiosyncratic volatility. Garleanu, Panageas and Yu (2011) also consider the distinct roles of both exercised as well as unexercised growth options. In parallel to this literature, we use the specific term operating options to refer to real options operational flexibility, proxying for exercising past growth options and turning them into assets in place. The term strategic growth options or strategic real options flexibility refers to creation of new or future option value. We posit that short-term changes in Capex are likely to be indicative of potential operating options exercise. For robustness purposes, we additionally use an alternative measure also plausible for the generation of operational flexibility: non-controlling investment (NCI). NCI represents investment and advances to unconsolidated subsidiaries, affiliates and joint ventures in which the parent company has less than 50% equity control, scaled by total assets.[11] This alternative variable amounts to an equity option to expand/divest operations or upgrade existing or already established firm investments. This operating

[9] Capex refers to Capital Expenditures (CAPX in the Compustat data platform).
[10] Liu, Whited and Zhang (2009), Li and Zhang (2010) and Lam and Wei (2011) also use Capex to investigate the investment-return relationship based on Q theory of investment.
[11] A variant in the context of international joint ventures, but focused on more than 50% control (hence involving less of an option value) has been used by Reuer and Tong (2005) and Tong *et al.* (2008).

proxy leads to subsequent growth and flexibility for the firm. The above leads to the following:

Hypothesis 2a. Operational flexibility enhances multinational firm performance.

Based on real options theory (e.g., Trigeorgis, 1996), we also conjecture that the value and performance of an MNC will be higher the higher the firm's (pre)existing level of infrastructure or strategic growth options and the greater the recent increase in such strategic flexibility (i.e., the change in strategic growth options). Strategic growth options provide the platforms for exploiting company future growth opportunities. Unlike operating flexibility that concerns exercise of past growth options enhancing commitment in current plant and equipment, strategic growth options refer to future value creation and future expansion of business operations through newly considered strategic commitments (Smit and Trigeorgis, 2004). These are reflected in strategic or infrastructure investments, such as FDI and R&D (Kester, 1984; Trigeorgis, 1996). In the context of multinationality, strategic growth options include all market entry decisions and resources related to foreign direct investments (Li and Rugman, 2007; Fisch, 2008; Gulamhussen, 2009). They can take the form of acquisitions, greenfield projects, new partnerships, or new joint-venture agreements. These types of investments are targeted to the creation of future growth opportunities and future strategic value. Recent enhancement in these investment platforms is indicative of improvement in firm growth options stock. Strategic growth options and growth options improvements should thus positively contribute to MNC performance. This leads to the following:

Hypothesis 2b. The level of and change in strategic growth options are positively related with multinational firm performance.

This hypothesis concerns the effect of (changes in) strategic real options flexibility on firm performance. It deals specifically with the creation of options for the future and takes account of changes in growth options value; it assesses to which extent growth potential and growth options stock are reflected in firm value and performance. To avoid issues of reverse causality we focus on the relationship between strategic growth options and next-period performance. We also consider the interactions

dimensions of this category of real options with firm multinationality and managerial awareness in our empirical analysis, accounting for non-additive effects.

2.3. Managerial real options awareness

Despite real option theory predictions, the value of MNC flexibility can be fully realized only if MNCs can manage and exercise their switching, strategic growth and operating options effectively and at the right time. A key premise of this paper is that the flexibility benefits of multinational operations are more pronounced for firms with greater managerial awareness to real options. We posit that familiarity with the real options logic (i.e., high or low managerial awareness) and having in place adaptive organizational capabilities for decision-making under changing conditions is key to the proper and effective exercise of real options. This managerial real options attention specificity leads to real options recognition and more effective management of multinational operations thus being a source of improved performance for organisations (Barnett, 2008). The ability to recognize and more effectively exploit strategic and operating flexibility platforms is essential for real options design and implementation. Managerial real options awareness also enhances learning opportunities (Mascarenhas, 1982; Kogut, 1983). Once recognized and developed, real options become part of MNC value-creating resources. Strategic growth options capabilities contribute to asset renewal and the creation of new core competences and learning opportunities. Operating flexibility in turn helps reconfigure resources and develop new operating procedures. The integration of strategic growth options and operating flexibility enables the firm to adapt and take advantage of dynamic managerial capabilities in the face of uncertainty. Managerial real options awareness as a knowledge/learning factor thereby contributes to value creation and the facilitating of real options decision-making in organizations. As a result, the MNC is more effective via its switch, growth and operating options in enhancing profitability. A managerially aware firm is able to better detect and more effectively exploit multinational switch, growth and operating options.

The how, when and why of real options exploitation fall within the domain of managerial capabilities specific to firm processes and practices. This dual specificity makes effective real options management itself a valuable capability. Real options awareness helps activate this capability, integrating options knowledge into the firm's

systems and processes. Heterogeneity in managerial awareness levels leads to firm specificity of real options skills. A high level of awareness is associated with superior real options know-how and management skills relative to firms with lower degrees of awareness. The ability to detect real option prospects is a prerequisite for effective options exploitation and indicative of a firm's capability to manage its real options. Real options awareness is thus a source of value for MNCs. However, because of the specificity of this construct we control for mechanisms leading to its development to mitigate endogeneity bias or reverse causality. Firm specific attributes such as past performance, prior size and level of multinationality can play a key role in determining the likelihood of managerial real options awareness in MNCs. This leads to the following hypotheses:

Hypothesis 3a. A higher degree of managerial real options awareness is positively related to firm performance.

Hypothesis 3b. Managerial real options awareness enhances the beneficial impact of multinationality (after controlling for firm specific attributes).

These hypotheses jointly examine the direct and indirect role of managerial real options awareness in explaining firm performance. H3a predicts that superior managerial skills in the form of managerial real options awareness (*MROA*) will increase firm performance. This is more likely to occur for higher levels of awareness as real options know-how can enhance organizational adaptive capabilities. H3b predicts that *MROA* will moderate positively the relationship between multinationality (*MULTI*) and performance, as awareness will enhance the effectiveness of managing the MNC switching network operations. This justifies the inclusion of an interaction term, *MULTI*MROA*, in our explanatory performance models (see Section 3.2). Managerial real options awareness, as a moderating mechanism, might also interact with other categories of real options. We discuss these interactions in our empirical results/robustness sections.

3. Methodology

3.1. Sample

To construct our panel dataset, we used accounting, financial, market and fundamental data on all 5879 US firms (excluding financial institutions) with publicly available data in the Compustat disc platform over the ten-year period 1996-2005.[12] Data on multinationality (*MULTI*) were collected by the authors from the *International Directory of Corporate Affiliations* of LexisNexis, Compact Disclosure data platform and the submitted financial statements of firms obtained from the U.S. Securities and Exchange Commission (SEC).[13] This sampling approach is consistent with existing literature (e.g., Ramaswamy, 1995; Gomes and Ramaswamy, 1999; Denis *et al.*, 2002; Creal *et al.*, 2011).

Information on the managerial real options awareness (*MROA*) proxy was hand collected by the authors based on documentation available in the public domain, such as the popular press (e.g., the *Economist*, *Financial Times*, *CFO Europe*, *CFO Magazine* etc.),[14] related practice literature (e.g., Bowman and Moscowitz, 2001; Triantis and Borison, 2001; Billington *et al.*, 2002; De Neufville, 2003; Keefer, 2004; Smit and Trigeorgis, 2004), data from related consulting services firms (e.g., the Real Options Group, Decisioneering, Deloitte), and the International Real Options Conference database.[15] Data on *MROA* was very rare or non-existent prior to 1996, the starting year of our research period.[16] In recent years, between 10 to 26 percent of Fortune 1000 firms state they used real options techniques for their real asset allocation providing factual evidence of managerial real options awareness in

[12] We started with all firms listed in the Compustat disc during the 1996-2005 period. This included 9732 active (i.e., listed and operating) firms. Inactive firms delisted due to bankruptcy, mergers or liquidations are not included. Of these, all financial institutions (2503 firms) with SIC codes between 6000 to 6999 were excluded due to the regulatory specificity of the sector. From the remaining, 1350 firms were excluded due to missing accounting, market and fundamental data related to our explanatory and control variables. Since we are using panel data for a ten-year period, if a firm had missing figures in at least one year it was eliminated from our sample. The final sample consists of 5879 firms. Of these, 165 are categorized as being managerially aware of their real options; 158 firms were MNCs and the rest (5721) non-MNCs.

[13] Exhibit 21 of each firm's financial statements (available at www.sec.gov) includes information about subsidiaries. The authors collected data on subsidiaries and counted the number of foreign countries each multinational firm has subsidiaries in from LexisNexis, Compact Disclosure and SEC data sources.

[14] See also, among others, Borissiouk and Peli (2001) and Gupta (2002). This adoption activity dates from the mid-1990s (see *Business Week*, 1999; *CFO Europe*, 1999; Trigeorgis, 1999; *CFO Magazine*, 2001; De Neufville, 2003).

[15] It is not uncommon in the finance and accounting literatures to use multiple data sources for the categorisation of non systematic characteristics or for the gathering of latent variables data.

[16] The annual international real options conference and serious consulting activity (e.g., by PriceWaterhouseCoopers, Ernst & Young, Andersen Consulting/Accenture, Decisioneering, Deloitte Consulting and others) promoting real options awareness on a broad basis among MNCs and large US corporations started about this time.

corporations (Ryan and Ryan, 2002; Graham and Harvey, 2001). Busby and Pitts (1997) report that out of the FTSE100 UK firms they surveyed, about 25% were interested in applying real options reasoning to monitor their investments. Ryan and Ryan (2002) find that 88.6% of companies they consulted only rarely or never used real options as a capital budgeting tool. Although the option-based approach to managing investments might not have been a common practice in industry during this period, there is a cluster of firms that have been managerially aware of their real options. Using the aforementioned information sources and documentation, we obtained a representative sample of this population of aware firms and produced a procedure for categorisation. The final sample included 165 real options aware firms. Such dataset is reflective of the current state of real options practice in industry and is a good step towards more complete and rigorous tests related to the explicit exercise of real options in firms. Due to heterogeneity of real options practice, firms were categorised into high or low awareness groups subject to the nature of the awareness specificity reported in our information sources (e.g., actual organizational adoption cases or evidence of workshop attendance were indicative of high vs. low awareness, respectively). This distinction also stems from resources based arguments. To ensure (inter-rater) reliability of the awareness construct, the categorization was done first independently and second in coordination by the authors with comparable outcomes. This approach to categorisation is in line with behavioural studies in marketing and other disciplines concerned with the subjective assessment of specific data characteristics and attributes (see e.g., Schneider *et al.*, 1992).

3.2. Model and variables specification

To investigate the validity of our main hypotheses, we develop proxies for operating flexibility (*OFLEX*), strategic growth options (*SGO*) and change in strategic growth options (*ΔSGO*), multinationality (*MULTI*), managerial real options awareness (*MROA*), and examine their joint impact (and their interaction) on firm performance proxied by Tobin's Q. We control for the firm's systematic risk (beta), size, distress level (*DISTR*), leverage (*LEV*), industry effects and endogeneity (past performance). We also include structural fixed year effects in our longitudinal sample. We specify and test the following two-stage (2SLS) multivariate model using panel data:

$$Q_{i,t} = a + bOFLEX_{i,t} + cSGO_{i,t-1} + d\Delta SGO_{i,t} + sMULTI_{i,t-1} + gMROA_{i,t-1} + hMULTI_{i,t-1} * MROA_{i,t-1} + k\beta_{i,t-1} + mSIZE_{i,t-1} + nDISTR_{i,t-1} + pLEV_{i,t-1} + qSIZE_{i,t-1} * LEV_{i,t-1} + uIND_{i,t} + e_i$$

(1)

where:

$Q_{i,t}$: firm *i*'s performance measured by its Tobin's Q at time *t*,

$OFLEX_{i,t}$: firm *i*'s operating flexibility (increase in capital expenditures or NCI) in year *t*,

$SGO_{i,t-1}$: firm *i*'s preexisting level of strategic growth options at time *t-1*,

$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,

$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,[17]

$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,[18]

$MULTI_{i,t-1}*MROA_{i,t-1}$: firm *i*'s interaction term between multinationality and managerial real options awareness at time *t-1*,

$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,

$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,

$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,

$LEV_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,

$SIZE_{i,t-1}*LEV_{i,t-1}$: firm *i*'s interaction term between size and leverage at time *t-1*,

$IND_{i,t}$: firm *i*'s median industry performance level at time *t*.

Multinationality (*MULTI*), a key explanatory variable in our study, reflects the diversity of a firm's global activities across multiple countries. As standard in the literature (Caves and Mehra, 1986; Allen and Pantzalis, 1996; Reuer and Leiblein, 2000), multinationality is defined as the natural logarithm of 1 plus the number (M) of foreign countries in which a firm has operating subsidiaries (*MULTI* = ln(1 + M)). For purely domestic or non-multinational firms (M = 0), the *MULTI* variable gets a value of zero.

The second key explanatory variable, the degree of managerial real options awareness (*MROA*), represents a new contribution to the literature. We posit that it is

[17] In the first-stage regression this is instrumented by market concentration, intangibles, firm-specific volatility, R&D intensity and controlled for prior performance, prior size and prior level of multinationality, with the predicted value of *MULTI* then used in the second stage regression.

[18] In the first-stage regression this is instrumented by prior performance, prior size and prior level of multinationality, with the predicted value of *MROA* then used in the second stage regression.

a crucial missing link between real options implementation and firm performance as it can have significant moderating effects. We categorize all firms in the sample into three main groups: (a) firms that are not aware of the real options logic, (b) firms with basic or low awareness of the real options logic, as evidenced from having attended managerial workshops training or conferences on the subject, and (c) firms with high awareness, namely firms that have used real options in forming their strategy and running their operations, as evidenced by utilizing consulting services by experts on the matter or by documented corporate adoption and practice (e.g. Nichols, 1994; Triantis and Borison, 2001; *CFO Magazine*, 2003; Keefer, 2004). Variable *MROA* is estimated as the natural logarithm of 1 plus the value weight of its awareness group: group (a) "no awareness" has a weight of 0, group (b) "low awareness" has a weight of 1, and group (c) "high awareness" a weight of 2. The higher the degree of managerial real options awareness of a firm, the higher the value of its *MROA* variable. Firms with no real options awareness get a *MROA* value of zero. As robustness checks, alternative specifications of *MROA* with dummy designs, without the logarithm and using subsample analysis were also examined.

All independent variables are lagged by one period (*t-1*) to mitigate potential problems of endogeneity and reverse causality (Bromiley, 1991; Reuer and Leiblein, 2000). *OFLEX* and *ΔSGO* represent changes (increase or decrease between preceding periods) and thus are not lagged. *IND* is used to capture industry effects within the same period as Tobin's Q and is not lagged. Fixed effects are also used to capture time variation, accounting for unobserved heterogeneity and variation at the firm level and capturing the effects of economy-wide variations or other unobserved factors.

3.2.1. First-stage regressions

In order to control for firm heterogeneous factors, endogeneity issues and account for alternative explanations of multinationality, the determinants of multinationality and managerial real options awareness are assessed in the first stage regressions. In line with prior research regarding the determinants of multinationality (e.g., Tong and Reuer, 2007; Grubaugh, 1987; Horst, 1972), based on market power, internalization/transaction costs, diversification, RBV and knowledge-based arguments, we test the impact on *MULTI* likelihood based on the following variable specification:

$$MULTI_{i,t-1} = a + bMCON_{i,t-2} + cINTANG_{i,t-2} + dVOLAT_{i,t-2} + sRD_{i,t-2} + gQ_{i,t-2} + hMULTI_{i,t-2} + jSIZE_{i,t-2} + e_i \quad (2)$$

where:

$MCON_{i,t-2}$: firm *i*'s market concentration at time *t-2*,

$INTANG_{i,t-2}$: firm *i*'s intangible assets at time *t-2*,

$VOLAT_{i,t-2}$: firm-specific volatility or business uncertainty for firm *i* in year *t-2*,

$RD_{i,t-2}$: firm *i*'s research and development (R&D) intensity at time *t-2*,

$Q_{i,t-2}$: firm *i*'s Tobin's Q at time *t-2* (proxying for prior performance),

$MULTI_{i,t-2}$: firm *i*'s multinationality index at time *t-2*,

$SIZE_{i,t-2}$: firm *i*'s size (natural logarithm of total assets) at time *t-2*.

In the above first-stage regression, four instruments (market concentration, intangibles, firm-specific volatility, R&D intensity) and three control variables (prior performance, prior multinationality and prior size) are utilized to tackle endogeneity.

In accord with MNCs market power advantage hypothesis (Bain, 1956; Hymer, 1976), past size and market concentration increase the likelihood of going multinational. The firm's market power and ability to exploit shared growth options relative to competition for the given industrial structure is proxied by market concentration (*MCON*), measured as the square root of the firm's Herfindahl-Hirschman Index (HHI) if the firm has above-average Tobin's Q, and zero if the firm has below-average Q.

According to the internalization theory, a key motive for going multinational is cost efficiency. This aspect is captured by variable *INTANG*, which is the natural logarithm of the firm's ratio of intangible assets to total assets (Vernon, 1971; Buckley and Casson, 1976; Morck and Yeung, 1991). The theory of diversification argues that a key motive for going multinational is risk diversification, reducing total firm-specific risk (Kim *et al*., 1993). Real options theory argues that volatility is beneficial for multinational flexibility, suggesting a reverse volatility effect. Firm-specific volatility (*VOLAT*) or business uncertainty is estimated from the standard deviation (σ) of firm equity returns based on the past 36 monthly stock returns. R&D intensity (*RD*) is included based on arguments that a firm may go multinational to leverage knowledge, innovation and flexibility (Kogut and Zander, 1992, 1993). It is

calculated using the natural logarithm of the ratio of R&D expenses to sales for each firm.

Managerial real options awareness (*MROA)* may also suffer from endogeneity, so in the first-stage regression it is instrumented using prior performance proxied by Tobin's Q ($Q_{i,t-1}$), prior level of multinationality ($MULTI_{i,t-1}$) and prior level of firm size ($SIZE_{i,t-1}$) in line with RBV and DCV. Its predicted value is used in the second stage procedure.[19] [20]

3.2.2. Second-stage regressions

We measure firm performance ($Q_{i,t}$) using the annual Tobin's Q ratio for each firm in our sample. This accords with recent research on corporate strategy and performance (e.g., Cuervo-Cazurra and Un, 2010). Tobin's Q is calculated by dividing the market value of a firm's assets (measured by the market value of its outstanding equity and the book value of its debt) by its replacement cost, as proxied by the firm's book value of assets (Tobin, 1969). If a firm is worth more than its replacement cost (or the cost to rebuild it), excess profits are being earned above and beyond what is necessary for the firm to operate in the industry.[21]

Besides *MULTI* and *MROA*, specified above, we include three real options related independent variables to test our second hypothesis. Operating flexibility ($OFLEX_{i,t}$) embedded in assets in place is measured by the increase in capital investment (ΔCapex), proxying for the degree of exercising past growth options and turning them into current assets in place. It is estimated as the (three-year period) average capital expenditure (CAPX, Compustat item #128) at year end minus the beginning-of-period average Capex, deflated by beginning-of-year total assets (AT,

[19] The explanatory variables are lagged because they do not contemporaneously affect the endogenous variables (MULTI and MROA). In first stage regressions the explanatory variables in the basic model (OFLEX, β, DISTR etc.) are excluded as they do not affect the instrumented/endogenous variables in a statistically significant way. Econometrically this is valid since in the first stage regressions at least one explanatory variable of the basic model is included.

[20] Kleibergen-Paap (2006) weak identification test and Stock-Yogo (2005) weak ID test were conducted. The results reveal that the underidentification and weak identification hypotheses are rejected reassuring that our first stage models are well identified. We also tested for issues of overidentification and instrumental variable relevance in our models using the Sargan, Anderson likelihood and Hansen-J econometric procedures; outcomes from these tests confirm that we used quality instruments.

[21] By using Tobin's Q, the problem of estimating rates of return or marginal costs is avoided. For Tobin's Q estimates to be meaningful, accurate measures of the market value and replacement cost of a firm's assets are needed. These are proxied by the total market value of the firm on the numerator and total book assets on the denominator.

Compustat item #6). For robustness purposes, non-controlling investment (NCI) was also used as an alternative.

Strategic growth options ($SGO_{i,t-1}$) represents the prior infrastructural capabilities the firm has put in place (at *t-1*) to create future strategic growth opportunities. It is measured in two alternative ways. The first (empirical or market-implied model) involves inferring the value of strategic growth opportunities implied in the firm's current market value from:

$$V_{i,t} = \frac{CF_{i,t}}{k} + SGO_{i,t} \quad [\text{or} \quad SGO_{i,t} = V_{i,t} - \frac{CF_{i,t}}{k}] \quad (\textit{Implied SGO approach}) \qquad (3)$$

where $V_{i,t}$ is the market value for firm *i* at time *t*, $CF_{i,t}$ is the (perpetual) Operating Cash Flow at time *t* and *k* is the firm's weighted average cost of capital (WACC). This model is mainly discussed and presented for comparison as it is fundamental in business finance and valuation. The second approach, more in line with real options reasoning, involves regressing a number of theoretical option-driven independent variables on above *SGO*, estimating the model parameters on recent 3-year industry data and using the estimated coefficients and current firm data to derive a predicted *SGO* score for each firm *i* at time *t* (*Instrumental Model SGO approach*).[22] In addition to this level of strategic growth options (predicted *SGO* score), $\Delta SGO_{i,t}$ is also included to capture recent enhancement (*change*) in firm strategic growth options value. *SGO* aims to capture the creation of new strategic growth options and their impact on firm performance. Change in *SGO* accounts for creation of growth opportunities during the previous year and measures recent strategic growth improvement and its current impact on firm performance.

The control variables used as independent constructs are seen in the second line of eq. (1). Most of these variables are standard in the finance literature in explaining returns. Each firm's market or systematic risk, beta ($\beta_{i,t-1}$), is estimated over the previous 36 monthly returns using the Sharpe-Lintner model (CAPM) as in Fama and French (1992). Firm size ($SIZE_{i,t-1}$) is measured as the natural logarithm of the book value of firm *i*'s total assets in the previous period. $DISTR_{i,t-1}$ is a distress dummy that takes the value zero if book value of firm *i* is positive and one if the

[22] *SGO* = *f* (firm-specific volatility, managerial flexibility/asymmetry, financial flexibility (leverage), organizational slack, cash flow position, R&D intensity, cumulative sales growth, market power; fixed effects, industry effects, interactions). See Trigeorgis and Lambertides (2012) for further details. This model SGO is the one we mainly refer to for the rest of our analysis.

prior-period book value of firm *i* is 0 or negative (indicating the firm is likely to be distressed).[23] Leverage ($LEV_{i,t-1}$) is measured in market value terms as the natural logarithm of total liabilities (LT, Compustat item #81) divided by the fiscal year-end firm value (V = ME + LT) at time *t-1*.[24] $IND_{i,t}$ equals the median Tobin's Q of the industry firm *i* operates in, used to capture industry effects.

We run our second stage multivariate panel data regressions based on (all or parts of) eq. (1). Standard statistical tests (z-statistics and model Wald Chi-Square) are reported in Table 4 and analyzed in the next section. We anticipate the impact of all option-related variables (*OFLEX, SGO* and *ΔSGO*), as well as of multinationality (*MULTI*) and managerial real options awareness (*MROA*), to be positive on firm performance. As a market–based performance measure, Tobin's Q should immediately reflect the positive impact on firm values of the operating and strategic options and of our main explanatory variables, multinationality and managerial real options awareness.[25] These predictions are consistent with our hypotheses based on real options theory.

4. Results and discussion

Table 1 provides descriptive statistics for our main variables. The median firm in our sample has a size of $175 million (=exp(5.169)) and a Tobin's Q of 1.37. Based on the way *MULTI* is calculated (=ln(1+M)), the median firm in the sample has foreign subsidiaries in 15 (and the mean firm in 12) countries.

[INSERT TABLE 1 HERE]

Table 2 shows the distribution of our sample firms with a low vs. high degree of managerial real options awareness (*MROA*) among various sectors of the economy. The manufacturing sector (34%) and Chemicals and Pharmaceuticals (18%) exhibit the greatest awareness, followed by Natural Resources/Energy (22%) and Telecom (9%).

[23] Book value of the firm is measured as the book value of common equity (Compustat item #60).
[24] ME: fiscal year-end market value of equity is measured by log[fiscal year-end price per share (Compustat item #199) multiplied by the number of shares outstanding (Compustat item #25)].
[25] The results broadly also hold when using stock returns as an alternative proxy for firm performance.

[INSERT TABLE 2 HERE]

Table 3 presents the correlation matrix among our explanatory and control variables. There is no clear evidence of serial correlation or multicollinearity. Besides size (which exhibits some correlation with several variables), the only strong (positive) correlation is observed between multinationality (*MULTI*) and managerial real options awareness (*MROA*). Multinationals tend to be more aware of latest or more sophisticated approaches and are more likely to have put in place an organizational real options infrastructure (as confirmed by the first-stage regression results). This also motivates the inclusion of an interaction term among these two variables in our model (*MULTI*MROA*).

[INSERT TABLE 3 HERE]

4.1. Regression findings

Before discussing the main second-stage results relating to our hypotheses, we briefly report our findings from the first stage regressions regarding the determinants of multinationality and managerial real options awareness, respectively. In accord with MNCs market power advantage arguments, past firm size and market concentration increase the likelihood of going multinational significantly. In line with real options predictions, high volatility (σ) increases the likelihood of expanding or coordinating businesses abroad. As suggested by transaction costs and internalization arguments, intangibles (*INTANG*) are significantly related to the level of multinationality. In line with knowledge/innovation and dynamic capabilities considerations, R&D intensity (*RD*) is positively (though loosely) associated with multinationality. These results are consistent with prior studies in the area (Hennart, 1982; Caves, 1996; Tong and Reuer, 2007). We also confirm that past performance and prior degree of multinationality are positively related to next period's FDI, as suggested by the RBV.

Regarding the determinants of managerial real options awareness (*MROA)*, we confirm that various firm-specific real-option related characteristics increase the probability of managerial real options attention in MNCs. Specifically, prior size, prior multinationality and lagged performance show significant positive associations with *MROA*, in line with RBV. Large MNCs with good past performance are more

likely to invest in building real options awareness. Similar consistency in findings is observed for the determinants of strategic growth option (*SGO*) value.[26] These first-stage results for *MULTI*, *MROA* and *SGO* serve as a basis for our second-stage regression models which take into account endogeneity and self-selection considerations.

The results of the second stage multivariate panel data regressions explaining firm performance based on Tobin's Q are shown in Table 4. The upper part of the table presents the impact of our real options driven independent variables on firm performance and the lower panel the impact of the control variables. The impact of the control variables is broadly consistent with the literature (particularly in the last, complete Model 3'). Significance levels for all models were determined based on standard z-tests, with the corresponding z-statistics shown in parenthesis below each coefficient along with an indication of significance level. Adjusted overall R^2 and model Wald Chi-Square statistics, along with Model rho, are shown at the bottom of each column indicating the significance of model estimations.

Model 0 in Table 4 shows the impact of the control variables, together with firm-specific business volatility (σ). All the control variables (except β) are significant. Business uncertainty, measured by a firm's standard deviation of stock returns over the past 36 months, has a positive and significant impact on firm value, consistent with real options theory. This motivates the inclusion of the real-option driven variables appearing at the top panel in models 1 to 3', namely: operating flexibility (*OFLEX*) and strategic growth options (*SGO*), as well as *MULTI* and *MROA* (volatility is subsequently omitted from the table to avoid double-counting errors).[27]

Models 1, 1' and 1'' in Table 4 highlight the incremental impact of the two main explanatory variables, multinationality (*MULTI*) and managerial real options awareness (*MROA*), given the control variables. These two main variables, individually and jointly, seem to have a significant positive impact on firm performance (beyond the above control variables), consistent with our main hypotheses H_1 and H_3. The control variables retain their signs when adding explanatory variables to the model, confirming their significant role in helping explain

[26] Specifically, firm-specific volatility, managerial flexibility/asymmetry, organizational slack, R&D intensity, cumulative sales growth and market power show positive and significant association with SGO, in line with the real options logic. Financial flexibility (leverage) and cash flow position are negatively associated with SGO.
[27] Firm-specific uncertainty (σ) is included in the first stage regressions (in *MULTI* and *Model SGO*).

the impact of the main explanatory variables. Firm size appears at first to have a negative impact on firm performance. However, the interaction between leverage and size has a significant positive impact with a higher coefficient than *SIZE* itself, suggesting that the net effect of *SIZE* on firm performance is positive. This is seen more clearly in full Models 3 and 3' (based on model *SGO* estimation).[28] The association between financial leverage and Tobin's Q is negative. This may be because well-performing firms enjoy a higher market value of equity, which lowers the leverage ratio measured in market value. Alternatively, it may be that profitable firms can raise more funds from internal sources, needing less external funds to borrow.

Models 2 and 3 in Table 4 show the results incorporating the incremental impact of the other option-driven explanatory variables, *OFLEX*, *SGO* and *ΔSGO*. For comparison, models 2 and 2' in Table 4 use the *"Implied SGO"* from current market firm values based on eq. (3), while models 3 and 3' are based on the option-theory instrumented *"Model SGO*" approach described in footnote 21. This last model is more reliable. Models 3 and 3' confirm that operating flexibility (*OFLEX*), reflecting an increase in capital expenditures indicating exercise of past growth options, has a significant positive impact on firm performance.[29] Moreover, based on the *"option model-predicted SGO*" of models 3 and 3', both prior strategic growth options (*SGO)* as well as an increase in strategic flexibility (*ΔSGO*) result in a higher (positive) firm market value and firm performance (Tobin's Q), in line with Hypothesis 2b. Some differences are noted depending on the way growth options are estimated. *SGO* appears positive and insignificant based on *"Implied SGO"* but positive and significant, as predicted, based on the option-model *SGO*. *ΔSGO*, capturing the incremental impact of a change in strategic growth options, appears to have a negative sign based on the *"Implied SGO"* estimation method. This, however, is likely due to an estimation error resulting from reverse causality and underlines one of the information content limitations of the *"Implied SGO"* model. A drop in earnings (and to a lesser extent in current market value) may result in a higher estimated *"Implied SGO"* from eq. (3), giving the appearance of a negative association between *ΔSGO*

[28] This might suggest that the relationship between size and performance might be curvilinear due to coordination issues and other cost considerations, and that the structuring features of multinational optionality lead to more effective coordination inducing a positive association between size and performance (i.e., it might be more effective to coordinate and manage optionality in larger firms).

[29] The results based on *"Implied SGO"* seem to be contradictory (Models 2 and 2') but this is mainly due to the specification of the *"implied SGO"* model.

(or even *OFLEX*) and market-based firm performance. This, however, is an artifact of the specific estimation method (i.e., implied rather than options-based model). The instrumented *"model SGO"* approach underlying models 3 and 3' is not subject to such bias and has a higher explanatory power (overall R^2 about 50%). It therefore provides a better and more reliable *SGO* proxy. We rely on this model in subsequent results and robustness tests.

The results in all models (1 – 3') validate Hypothesis 3 concerning the significant positive role of managerial real options awareness (*MROA*) in enhancing firm performance. *MROA* is categorically positive and significant (at 1%) in all models. The role of multinationality is not as straightforward. Multinationality (*MULTI*) by itself (without its interaction term with *MROA*) appears to have a positive and significant net impact on firm performance (Models 1, 1'', 2 and 3). However, when its interaction term with managerial real options awareness (*MULTI*MROA*) is included, the impact of multinationality (*MULTI*) appears negative and insignificant (Models 2' and 3'). This finding may help explain why results on the impact of multinationality on firm performance in prior literature appear incomplete or conflicting. The negative (but insignificant) sign on *MULTI* in the presence of its interaction with *MROA* should not be misinterpreted, however, and may help interpret better the incomplete evidence in the extant literature. Multinationality in interaction with managerial real options awareness (*MULTI*MROA*) has a clear positive and significant impact on firm performance, regardless of the estimation method. This hints at the existence of a multinationality value premium to be exploited by firms (see also Creal et *al.*, 2011).[30]

[30] Based on Model 3 taking partial derivative with respect to MULTI, the effect of MULTI on Tobin's Q is -0.158 + 0.614*MROA, where MROA takes three possible values (0, 1, 2; i.e., ln(1+0), ln(1+1), ln(1+2)). If a multinational firm is non-aware of real options (i.e. MROA=ln(1)=0) the effect on Q is -0.158+0.614*0= -0.158, i.e. multinationality (in absence of real options awareness) decreases Q by 0.158 (this effect is statistically non-significant). If a multinational firm has low real options awareness (i.e. MROA=ln(2)=0.693) the effect on Q is -0.158+0.614*0.693=0.267, i.e. multinationality in conjunction with low awareness increases Q by 0.267 (this effect is statistically significant). If a multinational firm has high real options awareness (i.e. MROA=ln(3)=1.098) the effect on Q is -0.158+0.614*1.098=0.516, i.e. multinationality in conjunction with high awareness increases Q by 0.516 (the effect is statistically significant). This effect is economically significant and large in comparison to the median Tobin's Q of 1.37. To give a specific illustration, when a multinational highly-aware firm has subsidiaries in 4 foreign countries and expands operations to another (fifth) country its Q will increase on average by 0.094 [-0.158*ln(1+5)+0.614*1.098*ln(1+5) – (-0.158*ln(1+4)+0.614* 1.098*ln(1+4)]. This represents a 6.8% increase in Tobin´s Q, a significant and large increase. Likewise, to assess the economic significance and reasonableness of the managerial real options awareness (MROA) effect, we take partial derivative of equation (1) with respect to MROA, setting MULTI (in the interaction variable MULTI*MROA) equal to 1 or 0, depending on whether the firm is multinational or not, respectively. Then we determine the effect on Tobin's Q given that in the final Model 3' the coefficient of MROA is 0.54 and the coefficient of MULTI*MROA is 0.614. If a firm is domestic (MULTI=0) and has low awareness (MROA=0.693), the effect on Q then is 0.54*0.693=0.374 i.e., low awareness increases Q by 0.374 (this effect is statistically significant). If a domestic firm has high awareness

Moreover, the joint (net) impact of multinationality and its interaction term (*MULTI*MROA*) remains positive and significant. It should be evident, however, that although the net impact of multinationality on firm performance is positive, this is not an intrinsic characteristic shared by all firms with multinational operations. Rather, a positive impact of multinationality on firm performance is achieved for those MNCs that also have the managerial awareness (and potentially the organizational capability) to effectively exploit their corporate real options.[31] Absent this firm-specific *MROA* characteristic, the rising coordination costs of multinational operations might lower MNC performance. Our overall conclusion is that multinational firms that are managerially aware of their options are better able to attain positive performance. This is consistent with Hennart's (2007) conjecture regarding how superior managerial characteristics of the MNC might contribute to superior performance.[32]

[INSERT TABLE 4 HERE]

4.2. Robustness checks, selection bias correction and other findings

In order to ensure the reliability and validity of our findings, two sets of robustness tests were implemented. The first set consisted of controlling endogeneity issues and self-selection bias. The second set examined the extent to which our overall results could hold under alternative samples or measure specifications. Findings from these procedures are reported in Tables 5 and 6 below. Table 5 reports robustness test comparisons after controlling for self-selection and endogeneity issues using Heckman (1979)[33] and propensity score matching techniques.[34] The Heckman correction, a two-step statistical approach, offers a means of correcting for non-randomly selected samples when firms have tendencies to self-select. Heckman's correction uses a normality assumption and provides a test and correction for sample

(MROA=1.098) the effect on Q is 0.54*1.098=0.593 i.e. high awareness increases Q by 0.593 (the effect is large and statistically significant).

[31] This suggests that these firms might be more opportunity driven or hedging active (see Carter *et al*., 2003).

[32] Joint tests were conducted to test if our explanatory variables are altogether jointly statistically significant (apart from the individual t-tests shown in tables). Results (all $Chi^2(6) > 147.98$) confirm that our explanatory variables are jointly statistically significant at a significance level of 1% (p-value = 0 for all models tested) supporting the validity and strength of our models.

[33] The two-stage Heckman method was originally employed on cross-sectional data. It was subsequently extended by Heckman to be applied on panel data (see Manski and McFadden 1981, ch. 3). See also Wooldridge (1995), Tong and Reuer (2007) and Chung *et al.* (2010).

[34] See Villalonga (2004) for a detailed description of the propensity matching procedure in the context of explaining the firm diversification discount.

selection bias. In the first stage, using a probit regression we obtain the predicted values of multinationality or managerial real options awareness for each individual firm.[35] In the second stage, we correct for self-selection by incorporating a transformation of these predicted probabilities as an additional explanatory variable, the Inverse Mills Ratio (*IMR*).[36] In Table 5, *IMR* is significant confirming that there is some selectivity bias in our sample. The third and fourth columns of Table 5 show the coefficients of the basic panel 2SLS Models 3 and 3' "corrected" for self-selection bias under the Heckman Method. The results are qualitatively consistent with our previous basic panel 2SLS findings (shown for comparison in the first two columns) indicating that self-selection is not a major issue. Multinationality in itself appears insignificant (with negative sign), exerting a positive influence on performance in interaction with the positive moderating role of managerial real options awareness.

Propensity score matching involves reorganisation of the dataset into a quasi-random sample based on the likelihood or propensity of a firm belonging to a certain category (being multinational or aware of its real options), given a set of known characteristics or covariates (e.g., past performance). Propensity score matching is used here to address endogeneity issues (controlling for past performance) and to reduce selection bias (from studying a small sample of firms that went multinational or were aware of their real options) by using a broader sample (including non-multinationals and non-aware firms) that allows matching groups based on these covariates or propensities.

A two-stage propensity matching procedure was employed. In the first stage, we matched multinational and non-multinational firms based on their propensity scores using the predicted values from an explanatory logit model (that includes covariates controlling for past performance and other theory-based drivers as in eq. 2) of the likelihood or propensity to go multinational. We implemented similar propensity matching for aware and non-aware firms and combined the matched random samples to perform the second stage regressions based on eq. (1). The last two columns of Table 5 show our propensity score findings for the Models 3 and 3'. The overall conclusions regarding our main explanatory variables reached under both

[35] *MULTI* and *MROA* are here treated as dummy variables taking the value of 1 if a firm is multinational and 0 otherwise, and 1 if the firm is managerially aware of real options and 0 otherwise, respectively.

[36] A double-selection model (correcting for self-selection bias for both MULTI and MROA) is constructed as follows: we estimate a probit model for MULTI first. Upon generating the IMR term, this is included in a second probit equation explaining MROA. The appropriate IMR term from this equation is then included in the second stage equation (see Amemiya, 1985). This procedure is also done in reverse order, with similar results.

basic panel data 2SLS and the Heckman method also hold under the propensity score tests. The (two-stage) propensity score models have a more limited sample and less predictive power. A few differences emerge, notably the impact of multinationality here appears positive and significant (at 10%). This relates to differences in design (matching) and sample composition.[37] The interaction between multinationality and managerial real options awareness is the same (i.e. positive). The overall outcomes are consistent with our theory predictions, validating hypotheses 1-3.

[INSERT TABLE 5 HERE]

Other robustness tests on the basic panel (2SLS) regressions confirm similar results. For example, we have used dummy variables to capture low and high managerial real option awareness instead of the scale variable *MROA* and run subsample analysis with comparable results.[38] The findings are also unchanged to inclusion or exclusion of the control variable that uses market data (β) or the variable that controls for industry effects (*IND*).[39] A number of interaction effects were also examined. Concerning the moderating effect of managerial awareness (*MROA),* we find that the interaction between *MROA* and *OFLEX* is significant and positive (at 1%), implying that managerially aware firms may be more effective in operational hedging or opportunities exploitation, managing their operating options and exercising their past growth options turning them into assets in place.[40] We also find a significant negative association between the interaction of *MULTI and SGO* and firm performance, confirming the non-additive interaction effects of multiple options. The interaction is negative as expected from real options theory due to the partly duplicative nature of the multinational switching network platform and the generation of future strategic growth opportunities (*SGO*) (Trigeorgis, 1993).

[37] The quasi-random sample obtained in the propensity score method is defined according to both *MULTI* and *MROA* likelihood characteristics. Therefore, the impact of multinationality is more pronounced in this group of firms as a result of this combined interaction.

[38] The impact of low real options awareness was positive but insignificant in the second-stage regressions, however, suggesting that superficial knowledge without broader organizational capabilities may not be sufficient to ensure superior performance.

[39] The analysis was also done using cross-sectional data and the results broadly resemble those in Table 4. However, preliminary tests (Durbin-Watson, Fama-McBeth procedure and subsample analysis) indicate that the analysis using panel data regressions accounting for fixed-year effects is more suitable. We thank an anonymous referee for this point.

[40] A negative relationship is observed between *MROA* and *SGO*, potentially suggesting that managerially aware firms may have already exploited much of their growth potential. This accords with findings from Bernardo *et al.* (2007) and Bernardo and Chowdry (2002).

Our results are also robust to a wide range of alternative dataset or measure specifications, all summarized in Table 6. Model (1) shows our basic panel (2SLS) results as a benchmark. Model (2) uses a large subset of manufacturing firms, including domestic and multinational entities. This is justified by the general view that manufacturing MNCs tend to shift or switch operations more often than other firms (Kogut and Kulatilaka, 1994; Kouvalis *et al.*, 2001) and is useful to confirm the validity of our findings for comparable samples or groups with similar characteristics. We again find that multinational switching can be positively related to performance and that such positive effect comes mainly from the interaction between multinationality and managerial awareness, in line with the findings reported in Tables 4 and 5. This result is valid for the sample combining both domestic and MNC entities, as well as for a second group of firms composed exclusively of manufacturing MNCs.[41] Model (3) shows that such finding also holds for the sample composed of MNCs only. Models (4) and (5) use alternative definitions of managerial real options awareness (*MROA*), based on subsample analysis (dummy variables) first without the logarithmic transformation (A = 0, 1, 2) and then defined as a single dummy variable (0 non aware, 1 aware). Specifically, we have used dummy variables to capture low and high managerial real option awareness instead of the scale variable *MROA* and run subsample analysis. Results are broadly comparable to those of the benchmark model. Model (6) presents results based on an alternative proxy for operating flexibility (*OFLEX*), specifically using investment with non-controlling-NCI (<50%) equity interest instead of ΔCapex. The effect of the substitute operating options proxy is again positive and significant (dropping ΔCapex). In all cases the results are essentially the same, confirming the robustness of our basic findings.

[INSERT TABLE 6 HERE]

[41] It is anticipated that some industries may present lesser effects of multinational flexibility than others due to industry restrictions or special characteristics. For example, a firm in the mining, oil and gas sector may not be able to switch operations internationally due to specific location or concentration of the resources or other industry related reasons (e.g. high switching costs). By contrast, innovative or high tech manufacturing firms may have more multinational flexibility e.g., involving sourcing flexibility or exchange rate switching. We account for these industry effects by including in our model the industry median of the Y variable and also use industry fixed effects in STATA. For robustness purposes, we also tested separate dummy variables for different industries. The manufacturing industry shows the most significant results on multinational flexibility, and this is one of the motivations for redoing the analysis on the sample of manufacturing firms only. As anticipated, mining, oil and gas exhibit less significant effect. However, due to data restrictions (small sample size of firms at industry level) we cannot test conclusively disaggregate effects for specific industries.

The overall conclusion based on all robustness procedures and the additional set of robustness tests is that after accounting for all sorts of issues (endogeneity, selection-bias, alternative sample specifications, fixed year and industry effects), multinationality, as a flexibility platform, enhances firm performance specifically through its interaction with managerial real options awareness. A higher degree of real options awareness is found positively related to firm performance and moderates positively the impact of multinationality. Operational flexibility and strategic growth options also enhance firm performance in a multinational context. [42] [43]

5. Conclusions and managerial implications

This study offers important insights into the joint performance dynamics of real options flexibility in MNCs, highlighting the impact of managerial real options awareness as a flexibility implementation trigger in multinational operations. Existing research in this area has not explicitly considered this managerial linkage in the structural performance of the MNC. In this paper we focus on firm value as an indicator of performance and examine the full set of flexibility platforms available to MNCs and their determinants, incorporating strategic growth, operational and multinational network switching options under one explanatory performance framework. In addition to these structural real options characteristics, we consider the moderating effect of the managerial real options awareness variable on the multinationality-flexibility-performance relationship, highlighting the logic and process of real options management in MNCs.

[42] To examine the robustness of our modeling specification, we repeated the analysis including Q^L as a variable in the second stage of the 2SLS regression in explaining performance (Tobin's Q). The AR(1) term (lagged Tobin's Q) is positive and significant (as anticipated), but several other variables (MULTI, OFLEX, DISTR,) turn non-significant. However, MROA and SGO remain significant, suggesting that their effect on performance is stronger. This is confirmed by final results where the coefficients of MROA and SGO are bigger than the coefficient of MULTI.

[43] We have also considered an alternative measure of multinationality, the percentage of foreign to total sales (from Compustat). This variable was not significant in explaining firm performance. However, this measure has some limitations. It cannot distinguish between exporters who are long US dollars and multinationals with foreign operations who may be short dollars (Frenkel, Hommel and Rudolf, 2005). This variable, though important, has not been used extensively in the literature. There are some exceptions. Denis, Denis and Yost (2002) base their analysis on % of foreign sales and find that higher global diversification reduces (excess) value. However, they note that "Compustat limits the number of global segments to four, including the domestic segment, that is, no more than three foreign segments are reported for any firm, regardless of the number of countries in which it operates. Compustat aggregates regions as necessary to fit the arbitrary limit of four global segments and thus an individual segment reported on Compustat might represent a single country, or it might represent a very broad geographic region. Given these limitations and because the database does not specify the individual countries that are included in each segment, we are unable to use the number of countries as a measure of global diversification".

The overall findings confirm our main thesis that multinationality, when supplemented with managerial real options awareness, can be a significant source of competitive advantage for MNCs. Multinational firms that are managerially aware of their options are able to attain better (positive) performance. Based on accounting, market and fundamental data on US listed firms for the ten-year period 1996-2005, we show that when both growth options features and the degree of real options awareness are taken into consideration, multinationality affects firm performance positively. We also confirm a significant positive impact of operating flexibility and strategic growth options on firm performance. Our main conclusion is that the beneficial impact of multinational flexibility on firm performance is brought out and is more pronounced for firms with a higher degree of managerial real options awareness. Absent real options awareness and related organizational capability, mere multinational operations do not guarantee improved firm performance as suggested by transaction costs economics.

The above results should be interpreted with some caveats. The dataset includes those companies which have invested in developing a managerial real options awareness and companies which have not, based on public and secondary information during the period 1996-2005. Extending the study period post-2006 or including other periods of significant uncertainty might provide more confidence or additional insights into the real options characteristics of multinational investment activities. Such an extension can rely on a survey design where awareness levels are measured and scaled using responses obtained from a large sample of managers and executives that span multiple organizations, sectors and countries, and over a number of episodes of economic uncertainty. However, going back prior to 1996 may result in a different structural period with lower or little managerial real options awareness (*MROA*).

Despite the limited time period of our study, the resulting implications for multinational finance and management are rather evident. Firms should make investments in learning, knowledge acquisition and awareness building, developing an organizational real options capability to effectively exploit the benefits of flexibility in their operating and strategic decision processes. This should enable more effective planning, structuring and managing of their global network of operations to take better advantage of changes in input prices, demand and other environmental factors. Multinational organizations and firms in general need to develop adequate

organizational systems and practices to proactively deal and cope with uncertainty and effectively manage and exercise their corporate real options. Managerial awareness and an effective real options capability may equip MNCs with the necessary decision apparatus to benefit from fluctuations or differentials in global markets.

Our overall results confirm that effective option-based management of multinational operations can result in enhanced firm performance. The ability of management to recognise and effectively manage real options can determine the success of MNC international strategy. When real options are developed and exploited appropriately through increased managerial awareness, improved performance is likely to follow. However, this depends on firm specific characteristics, the drivers of FDI and the determinants of real options learning. Acquiring the necessary knowledge and putting in place necessary infrastructure investments to enhance real options awareness within organizations should be a priority on managers' agendas in times of uncertainty.

Our results are consistent with the theoretical predictions of real options theory, suggesting that effective real options decision-making can be a source of competitive advantage for multinational firms in an uncertain and changing global market environment. These findings also help address some recent questions raised by a number of strategic management scholars regarding the pertinence of real options management in business strategy (e.g., Coff and Laverty, 2001; Carr, 2002; Adner and Levinthal, 2004), and call for theoretical and empirical research that goes beyond the concept of real options reasoning to also consider behavioural, structural and infrastructural elements of real options management in corporate decision-making.

TABLES

Table 1. Descriptive statistics

Variable	Mean	Median	S.D.
Tobin's Q	2.790	1.370	5.970
β	0.950	0.890	0.500
SIZE	5.045	5.169	2.831
DISTR	0.120	0.001	0.321
LEV	-1.315	-0.988	1.169
OFLEX	0.330	0.030	0.200
SGO	0.630	0.490	1.290
MULTI	2.590	2.810	1.350
MROA	0.870	0.693	0.202

The overall sample consists of 5879 firms listed in Compustat database during 1996-2005. Of these, 165 firms were classified as managerially aware; 158 were MNCs and the rest (5721) were domestic (non-MNC) firms.
β: beta calculated based on 36 monthly returns, *SIZE*: size measured as the natural logarithm of total assets, *DISTR*: distress proxy (dummy with value of 1 if book value is negative or zero and 0 otherwise), *LEV*: leverage measured by (the natural logarithm of) total liabilities divided by firm market value, *OFLEX*: operational flexibility measured as the change in capital expenditures (Capex), *SGO*: strategic growth options, measured in two ways: (1) as market-implied (residual) PVGO, calculated by dividing the Operating Cash Flow perpetuity by WACC and subtracting from MV of the firm; (2) from regressing option-related variables on *SGO* (instrumental model approach) based on recent 3-year industry data {*SGO* = f (business uncertainty, asymmetry, organizational slack, firm growth, cash flow coverage, market power, R&D intensity)}. The above descriptive statistics are based on the instrumental model *SGO* approach. *MULTI*: degree of multinationality, *MROA*: degree of managerial real options awareness.

Table 2. Distribution of firms with Managerial Real Options Awareness (MROA)

	MROA			
Sector	Low	High	Total	
Manufacturing	34	22	56	34%
Telecommunications	7	8	15	9%
Food & Drinks	4	1	5	3%
Chemicals & Pharma	13	16	29	18%
Electricity & Energy	13	5	18	11%
Petroleum Refining	4	6	10	6%
Mining Oil & Gas	3	6	9	5%
Other	17	8	25	15%
Total	93	72	165	

Table 3. Correlation matrix

Variable	β	SIZE	DISTR	LEV	OFLEX	SGO	MULTI	MROA
β	1.000							
SIZE	0.092	1.000						
DISTR	-0.002	-0.370	1.000					
LEV	-0.114	0.351	0.080	1.000				
OFLEX	-0.033	-0.063	-0.001	-0.162	1.000			
SGO	0.061	-0.341	0.202	-0.162	0.005	1.000		
MULTI	0.034	0.200	-0.036	0.019	-0.010	-0.048	1.000	
MROA	0.031	0.244	-0.048	0.024	-0.012	-0.063	0.699	1.000

The overall sample consists of 5879 firms listed in Compustat database during 1996-2005.

β: beta calculated based on 36 monthly returns, *SIZE*: size measured as the natural logarithm of total assets, *DISTR*: distress proxy (dummy with value of 1 if book value is negative or zero and 0 otherwise), *LEV*: leverage measured by (the natural logarithm of) total liabilities divided by firm market value, *OFLEX*: operational flexibility measured as the change in capital expenditures (Capex), *SGO*: strategic growth options, measured in two ways: (1) as market-implied (residual) PVGO, calculated by dividing the Operating Cash Flow perpetuity by WACC and subtracting from MV of the firm; (2) from regressing option-related variables on *SGO* (instrumental model approach) based on recent 3-year industry data {*SGO* = f (business uncertainty, asymmetry, organizational slack, firm growth, cash flow coverage, market power, R&D intensity)}. The above descriptive statistics are based on the instrumental model *SGO* approach. *MULTI*: degree of multinationality, *MROA*: degree of managerial real options awareness.

Table 4. Panel data regressions (2SLS) explaining firm performance (Tobin's Q)

					Implied SGO		Model SGO	
Independent Variables	Model 0	Model 1	Model 1'	Model 1"	Model 2	Model 2'	Model 3	Model 3'
Operating Flexibility (OFLEX)					-0.646 (-2.69)***	-0.645 (2.68)***	0.618 (2.00)**	0.624 (2.02)**
StrategicGrowth Options (SGO)^{L}					0.018 (0.99)	0.017 (0.97)	0.912 (15.21)***	0.910 (15.17)***
Change in Strategic Growth Options (ΔSGO)					-0.130 (-8.98)***	-0.131 (-8.98)***	0.428 (6.18)***	0.427 (6.17)***
Multinationality (MULTI)^{L}		0.458 (9.21)***		0.206 (2.43)**	0.214 (2.46)**	-0.349 (-1.45)	0.074 (1.97)**	-0.158 (-0.86)
Managerial Real Options Awareness (MROA)^{L}			2.424 (14.06)***	0.127 (3.69)***	0.123 (3.49)***	0.124 (3.50)***	0.596 (3.27)***	0.540 (2.84)***
Interaction (MULTI*MROA)^{L}						0.641 (2.52)**		0.614 (2.94)***
Systematic Risk (β)^{L}	-0.012 (-0.71)	0.078 (4.24)***	0.047 (2.76)***	0.078 (4.22)***	0.073 (3.66)***	0.073 (3.68)***	-0.049 (-2.85)***	-0.048 (-2.81)***
Firm Size (SIZE)^{L}	-0.355 (-23.06)***	-0.154 (-12.57)***	-0.191 (-16.28)***	-0.274 (-7.87)***	-0.289 (-7.80)***	-0.289 (-7.80)***	0.223 (12.84)***	0.224 (12.90)***
Distress (DISTR)^{L}	0.241 (65.52)***	0.408 (100.91)***	0.363 (99.70)***	0.402 (94.20)***	0.370 (81.32)***	0.370 (81.30)***	0.204 (26.67)***	0.204 (26.64)***
Leverage (LEV)^{L}	-2.376 (-65.90)***	-2.051 (-57.40)***	-2.088 (-62.37)***	-2.052 (-57.43)***	-2.088 (-52.62)***	-2.090 (-52.67)***	-2.344 (-49.99)***	-2.350 (-50.07)***
Interaction (SIZE*LEV)^{L}	0.289 (36.35)***	0.289 (38.47)***	0.279 (39.57)***	0.290 (38.54)***	0.272 (32.43)***	0.273 (32.50)***	0.177 (19.65)***	0.179 (19.79)***
Industry (IND)	-0.039 (-8.26)***	-0.033 (-6.36)***	-0.045 (-9.21)***	-0.032 (-6.28)***	-0.035 (-6.32)***	-0.035 (-6.31)***	0.015 (1.92)*	0.016 (1.99)**
Business Uncertainty (σ)^{L}	0.201 (7.13)***							
Overall R^2	0.326	0.421	0.395	0.421	0.403	0.403	0.499	0.499
Wald chi^2	18013.97	25489.77	26789.77	25502.07	20285.52	20294.05	9096.68	9109.92
Model rho	0.504	0.166	0.170	0.166	0.200	0.201	0.378	0.378
N	58790	58790	58790	58790	58790	58790	58790	58790

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting level of strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,[44]
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,[45]
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$LEV_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry performance level at time *t*.

[44] In the first-stage regression this is instrumented by market concentration, intangibles, firm-specific volatility, R&D intensity and controlled for prior performance, prior size and prior level of multinationality, with the predicted value of *MULTI* then used in the second stage regression.
[45] In the first-stage regression this is instrumented by prior performance, prior size and prior level of multinationality, with the predicted value of *MROA* then used in the second stage regression.

Table 5. Robustness test comparisons: Accounting for self-selection and endogeneity using Heckman method and propensity score matching

	Basic Panel (2SLS)		Heckman Method		Propensity Score	
Independent Variables	Model 3	Model 3'	Model 3	Model 3'	Model 3	Model 3'
Operating Flexibility (OFLEX)	0.618 (2.00)**	0.624 (2.02)**	0.618 (2.00)**	0.661 (2.14)**	0.653 (8.72)***	0.652 (8.71)***
Strategic Growth Options (SGO)^{L}	0.912 (15.21)***	0.910 (15.17)***	0.913 (15.23)***	0.894 (14.87)***	0.120 (7.82)***	0.120 (7.80)***
Change in Strategic Growth Options (ΔSGO)	0.428 (6.18)***	0.427 (6.17)***	0.428 (6.18)***	0.428 (6.19)***	0.002 (0.09)	0.002 (0.09)
Multinationality (MULTI)^{L}	0.074 (1.97)**	-0.158 (-0.86)	-0.030 (-0.54)	-0.279 (-1.44)	0.051 (1.69)*	0.053 (1.73)*
Managerial Real Options Awareness (MROA)^{L}	0.596 (3.27)***	0.540 (2.84)***	0.538 (2.93)***	0.467 (2.44)**	0.010 (2.82)***	0.058 (1.42)
Interaction (MULTI*MROA)^{L}		0.614 (2.94)***		0.012 (4.05)***		0.014 (3.11)***
Selection Bias correction - Inverse Mill's Ratio (IMR)			-0.194 (-2.49)**	-0.332 (-4.02)***		
Systematic Risk (β)^{L}	-0.049 (-2.85)***	-0.048 (-2.81)***	-0.048 (-2.79)***	-0.044 (-2.57)***	-0.003 (-0.81)	-0.003 (-0.81)
Firm Size (SIZE)^{L}	0.223 (12.84)***	0.224 (12.90)***	0.183 (7.72)***	0.313 (7.75)***	-0.040 (-7.88)***	-0.031 (-7.90)***
Distress (DISTR)^{L}	0.204 (26.67)***	0.204 (26.64)***	0.201 (25.72)***	0.208 (25.99)***	0.011 (4.24)***	0.011 (4.40)***
Leverage (LEV)^{L}	-2.344 (-49.99)***	-2.350 (-50.07)***	-2.342 (-49.95)***	-2.350 (-50.11)***	-0.014 (-0.88)	-0.014 (-0.88)
Interaction (SIZE*LEV)^{L}	0.177 (19.65)***	0.179 (19.79)***	0.178 (19.75)***	0.176 (19.56)***	-0.056 (-18.75)***	-0.056 (-18.69)***
Industry (IND)	0.015 (1.92)*	0.016 (1.99)**	0.014 (1.81)*	0.017 (2.09)**	0.006 (4.38)***	0.006 (4.39)***
Overall R^2	0.499	0.499	0.499	0.498	0.300	0.300
Wald chi^2	9096.68	9109.92	9107.42	9136.69	2866.56	2868.64
N	58790		58790		4480	

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting level of strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$LEV_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry performance level at time *t*.

Table 6. Robustness tests based on alternative samples or measure specifications

	1		2		3		4		5		6	
	Basic Panel (2SLS)		Using only manufacturing firms (MNCs & domestic)		Using only MNCs (no domestic)		Using MROA=0,1,2		Using MROA=0,1		Using NCI instead of ΔCAPEX	
Independent Variables	Model 3	Model 3'	Model 3	Model 3'	Model 3	Model 3'	Model 3	Model 3'	Model 3	Model 3'	Model 3	Model 3'
Operating Flexibility (OFLEX)	0.618	0.624	1.014	1.026	1.150	1.190	0.980	0.624	0.978	0.623	0.136	0.134
	(2.00)**	(2.02)**	(1.94)*	(1.96)**	(2.29)**	(2.41)**	(3.47)***	(2.02)**	(3.46)***	(2.02)**	(1.61)*	(1.61)*
StrategicGrowth Options (SGO)^{L}	0.912	0.910	0.751	0.748	0.722	0.687	0.893	0.910	0.893	0.911	1.130	1.129
	(15.21)***	(15.17)***	(8.83)***	(8.79)***	(8.50)***	(8.20)***	(16.00)***	(15.18)***	(16.01)***	(15.18)***	(14.45)***	(14.43)***
Change in Strategic Growth Options (ΔSGO)	0.428	0.427	0.032	0.032	0.156	0.145	0.375	0.427	0.376	0.427	0.407	0.407
	(6.18)***	(6.17)***	(0.29)	(0.29)	(1.88)*	(1.77)*	(5.98)***	(6.17)***	(5.99)***	(6.17)***	(5.29)***	(5.29)***
Multinationality (MULTI)^{L}	0.074	-0.158	0.118	-0.218	6.444	-1.546	0.085	-0.141	0.085	-0.175	0.092	0.002
	(1.97)**	(-0.86)	(1.78)*	(-0.83)	(3.82)***	(-0.81)	(2.58)***	(-0.77)	(2.52)**	(-0.93)	(1.71)*	(0.01)
Managerial Real Options Awareness (MROA)^{L}	0.596	0.540	0.485	0.457	0.087	0.084	0.335	0.310	0.509	0.469	0.729	0.639
	(3.27)***	(2.84)***	(1.82)*	(1.71)*	(7.83)***	(7.62)***	(3.49)***	(2.84)***	(3.25)***	(2.66)***	(3.15)***	(2.54)**
Interaction (MULTI*MROA)^{L}		0.614		0.601		8.556		0.599		0.652		0.503
		(2.94)***		(2.07)**		(8.99)***		(2.86)***		(3.13)***		(1.75)*
Systematic Risk (β)^{L}	-0.049	-0.048	-0.055	-0.054	-0.051	-0.047	-0.045	-0.048	-0.046	-0.048	-0.064	-0.064
	(-2.85)***	(-2.81)***	(-2.11)**	(-2.07)**	(-1.95)*	(-1.83)*	(-2.90)***	(-2.81)***	(-2.92)***	(-2.83)***	(-3.03)***	(-3.02)***
Firm Size (SIZE)^{L}	0.223	0.224	0.138	0.141	0.101	0.094	0.170	0.225	0.169	0.224	0.207	0.208
	(12.84)***	(12.90)***	(5.40)***	(5.48)***	(5.68)***	(5.29)***	(10.46)***	(12.96)***	(10.36)***	(12.86)***	(10.01)***	(10.05)***
Distress (DISTR)^{L}	0.204	0.204	0.244	0.244	0.210	0.207	0.182	0.204	0.182	0.204	0.176	0.176
	(26.67)***	(26.64)***	(19.69)***	(19.67)***	(17.71)***	(17.64)***	(26.56)***	(26.64)***	(26.55)***	(26.65)***	(19.57)***	(19.55)***
Leverage (LEV)^{L}	-2.344	-2.350	-1.727	-1.737	-1.861	-1.912	-2.157	-2.350	-2.155	-2.350	-2.322	-2.325
	(-49.99)***	(-50.07)***	(-22.99)***	(-23.09)***	(-24.12)***	(-24.98)***	(-49.97)***	(-50.09)***	(-49.91)***	(-50.04)***	(-41.20)***	(-41.24)***
Interaction (SIZE*LEV)^{L}	0.177	0.179	0.080	0.083	0.109	0.121	0.131	0.179	0.131	0.178	0.167	0.168
	(19.65)***	(19.79)***	(5.69)***	(5.86)***	(7.24)***	(8.08)***	(15.97)***	(19.82)***	(15.88)***	(19.75)***	(15.50)***	(15.57)***
Industry (IND)	0.015	0.016	0.023	0.024	0.024	0.020	0.016	0.016	0.016	0.016	0.023	0.024
	(1.92)*	(1.99)**	(1.91)*	(2.00)**	(1.91)*	(1.60)	(2.11)**	(2.00)**	(2.11)**	(2.00)**	(2.47)**	(2.52)**
Overall R^2	0.499	0.499	0.471	0.472	0.459	0.462	0.499	0.499	0.499	0.499	0.493	0.493
Wald chi^2	9096.68	9109.92	3129.85	3136.51	5856.54	5982.15	10446.21	9110.12	10440.47	9107.17	6083.24	6087.96
Model rho	0.378	0.378	0.641	0.641	0.654	0.667	0.374	0.378	0.374	0.378	0.462	0.462
N	58790		32870		1580		58790		58790		58790	

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

Model (1) shows our basic panel (2SLS) results as a benchmark. Model (2) uses a large subset of manufacturing firms, including domestic and multinational entities. We find that multinational switching can be positively related to performance and that such effect comes mainly from the interaction between multinationality and managerial awareness, in line with the findings reported in Tables 4 and 5. This result is valid for the sample combining both domestic and non domestic entities, and a second group of firms composed exclusively of manufacturing MNCs. Model (3) shows that such finding also holds for the sample composed of MNCs only. Models (4) and (5) use alternative definitions of managerial real options awareness (MROA), based on subsample analysis (dummy variables) first without the logarithmic transformation (A = 0, 1, 2) and then defined as a single dummy variable (0 non aware, 1 aware). Specifically, we have used dummy variables to capture low and high managerial real option awareness instead of the scale variable MROA and run subsample analysis. Model (6) presents results based on an alternative proxy for operating flexibility (OFLEX), specifically using investment with non-controlling-NCI (<50%) equity interest instead of ΔCapex. In all cases the results are essentially the same, confirming the robustness of our basic results.

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iv. Chapter 3.[***]
Multinationality and Managerial Real Options Awareness: Impact on Downside Risk and Upside Potential

Abstract

We revisit the strategy literature concerning the impact of multinationality on downside risk and upside potential (excess firm performance). We examine the mediating role of Managerial Real Options Awareness (MROA) and study the joint impact of multinationality, growth options and MROA on firm downside risk and upside potential. Based on a sample of US listed firms (1996-2009) we find that when a firm's growth options and degree of MROA are taken into consideration, multinationality significantly reduces downside risk and enhances firm performance. We also confirm a significant beneficial impact of strategic growth and operating options on downside risk. Multinational firms who are aware of their options are able to attain better downside risk management and upside potential. Absent MROA and related organizational capability, multinational operations do not guarantee lower downside risk (or better performance).

*** This chapter is based on joint work with Lenos Trigeorgis.

1. Introduction

The probability that the price of an asset will fall below a specified target is referred to as downside risk (*DR*). Rational investors care not only about attaining higher returns (through enhanced firm performance) but also about containing losses by reducing downside risk. Several downside risk measures have been examined and tested empirically by academics and practitioners alike. The most commonly used downside risk measures are semi-variance and lower partial moment (LPM). *DR* is a main improvement over traditional portfolio theory, which uses mean-variance optimization. In 1952 A.D. Roy in his seminal work on "Safety First" suggested maximizing the ratio "(E(R) - T)/DR", where E(R) is expected return, T is a "disaster level" or minimum acceptable ("target") return and DR is semi-standard deviation of returns.

Following such logic, managers and firms should seek ways to enhance upside potential (*UP*) or excess (above target) return while reducing downside risk, thus optimizing the ratio UP/DR leads to excess performance per unit risk (an asymmetric analogue to the reward to variability or Sharpe (1966) ratio used in portfolio theory). In this paper we test whether being multinational and being aware of one's options is one way of achieving such excess performance by reducing DR and/or enhancing UP. This is important particularly because there is a debate in existing strategy literature that this may not necessarily be the case. Reuer and Leiblein (2000) directly challenge the predictions of real options theory by asserting that there is no significant relationship between multinationality and DR performance in US manufacturing MNCs.

The benefits of multinationality are numerous. Multinational corporations (MNCs) not only exert significant influence on international relations and politics, but also provide the necessary infrastructure to support globalization and the integration of national economies into the international system through exports, foreign direct investment (FDI), capital flows, labor migration and the transfer of technology. MNCs have a competitive advantage by locating their businesses in multiple countries. There are several rational arguments for doing so. First, multinational operations may enable reducing taxes or trade tariffs. An American or European firm, for example, by moving operations to a plant in an Asian country, can gain access to the Asian market without having to pay import or export tariffs. Second, an MNC

may take advantage of a lower-cost location for its production facilities or better skilled or cheaper labor in specific regions. Third, an MNC may reach foreign markets more effectively through its diverse export distribution and operations network. These examples of multinational operations underline the flexibility advantage of MNCs and the shadow real options embedded in multinational networks (Kogut, 1984, 1985). Consistent with real options logic, multinationality and flexibility are performance driving variables that can significantly reduce MNC downside risk, while enhancing upside potential and future profitability.

Recent empirical research has examined whether multinational real options can reduce *DR* or enhance firm performance. Multinational operations switching, joint-venture agreements and international market entry have been examined under the real options lens with interesting implications (Tong and Reuer, 2007; Lee *et al.*, 2008). Real options theory (Kogut, 1984, 1985; Trigeorgis, 1996; Lee and Makhija, 2009) suggests that multinationality and real options flexibility should reduce downside risk and increase firm value. However, Reuer and Leiblein (2000) find no significant relationship between multinationality and downside risk. A key aspect not adequately considered in the literature concerns managers' explicit recognition of real options and how they are exercised in MNCs and more generally the role of knowledgeable management in optimizing the multinationality-performance relationship (Hennart, 2007).

Given ample evidence of real options practice in MNCs (e.g., Billington *et al.*, 2002; Hartmann and Hassan, 2006), it is interesting to assess the flexibility and performance implications of multinational real options in firms with explicit managerial attention (Barnett, 2008) and across firms with heterogeneous aptitudes to effective real options decision-making. If real options are an effective decision-making tool influencing managerial choices, it is reasonable to consider heterogeneity in managerial practices and awareness across MNCs, as suggested by the resource based view (RBV) and the dynamic capabilities view (DCV) of the firm (Barney, 1986; Teece and Pisano, 1994; Teece, Pisano and Shuen, 1997; Pitelis and Teece, 2009). Heterogeneity in managerial attention or awareness might explain differences in flexibility management among firms (Kogut, 1984; Reuer and Leiblein, 2000) and help clarify the conditional impact of multinational flexibility on *DR*, *UP* and excess firm performance. Benefits from multinational flexibility exercise can be fully realized only if the MNC has appropriate adaptive organizational capabilities and

managerial real options awareness to properly identify, cultivate and exploit real options opportunities.

We thus investigate the role of real options awareness as a managerial intangible resource leading to more effective real options decision-making in organizations, and examine how real options know-how interacts with multinational flexibility moderating the impact of multinationality on *DR*, on *UP* and on firm performance. Our notion of managerial real options awareness *(MROA)* is supported by observation of real options practice in MNCs (e.g., Triantis, 2005; Barnett, 2008) and by knowledge-based research concerning the role of managerial learning and flexibility in firm evolution and long-term performance (e.g., Kogut, 1984; Miller, 2002; Kogut, 2008).[46] [47] By managerial real options awareness *(MROA)* we refer to a firm's managerial aptitude to properly recognize, cultivate, access and effectively manage its real options using an informed, option-based view of decision-making. This presupposes management's specific ability to pay attention to real options (Barnett, 2005) and is accompanied by organizational investments in real options learning and decision support.[48] This managerial real options awareness construct should influence the nature of the relationship(s) between multinationality, growth options, *DR* and firm value.

We examine these effects in the context of a large sample of US listed firms differing in their degree of managerial real options awareness. In addition, going beyond previous research in the area, we examine the full spectrum of real option platforms available to MNCs (i.e., switching, growth and operating options) and assess their joint impact, in combination with managerial real options awareness, on *DR*, *UP* and firm performance. Using the analogue concept of upside potential (*UP*) defined as above-target performance, we test empirically the impact of a set of option-motivated explanatory variables not only on *DR* and *UP*, but also on excess performance to downside risk ratio (*UP/DR*).

We employ for this purpose a two-stage multivariate model of *DR* and *UP*, taking into account self-selection bias and endogeneity issues, accounting for the

[46] From a strategy perspective, this definition is in line with the RBV (Barney, 1986, 1991) and the DCV (Teece and Pisano, 1994).
[47] A subset of firms in the study are users or adopters of the real options "technology" (Mun, 2003; Trigeorgis, 2005).
[48] This is in line with the notion that effective real options management is heterogeneous across firms, so managers do not make uniform real options decisions in international business environments (Tong and Reuer, 2007; Certo *et al*., 2008).

determinants of both multinationality and managerial real options awareness through propensity score matching and Heckman estimation procedures (e.g., see Villalonga, 2004; Heckman, 1979). Results from a panel dataset of US listed firms for the 1996-2009 period confirm that when a firm's operating and strategic growth options and the degree of managerial real options awareness are taken into consideration, multinational management does reduce *DR* and enhance *UP* and firm performance even after controlling for other MNC drivers. We also confirm a significant impact of operating flexibility and strategic growth options. We find that the *DR* and *UP* impact of multinational flexibility is more pronounced for firms with a higher degree of managerial real options awareness. This confirms that the more effective the firm's organizational structure is in recognizing, managing and exercising corporate real options the better the ability to reduce *DR* and increase *UP* for the firm. It also underlines the role of knowledgeable management in generating "super-normal" returns for MNCs through effective management of their portfolio of multinational real options.

The remainder of the paper is organized as follows: the next section provides an overview of related literature on downside risk, multinationality and real options. Section 3 develops our testable hypotheses. A description of our methodology, data and models is given in Section 4. Section 5 provides a discussion and interpretation of our results, including robustness checks, endogeneity and selection bias tests. Section 6 concludes.

2. Literature

Portfolio theory and the notion of downside risk were developed in Markowitz (1952) who provides a quantitative framework for measuring portfolio risk and return. Although Markowitz developed a version of his portfolio theory based on downside risk measures, such as semi-variance, he favored the mean-variance portfolio optimization for which he became famous due to the simplicity and elegance of its mathematical formulation. At about the same time, Roy (1952) favored the downside risk measure suggesting that an investor would prefer safety of principal first and will set some minimum acceptable target (T) return to help conserve the principal.[49]

[49] Markowitz (1952) used the mean returns, variances and covariances of the assets in a portfolio to derive an efficient frontier. A rational investor is presumed to make a trade-off between risk and return assuming risk is bad

Roy's notion that a rational investor would prefer safety of principal first when dealing with risk is fundamental in the development of downside risk (*DR*) measures. The reward to variability ratio introduced by Roy (1952) allows an investor to minimize the probability of the portfolio return falling below a target (T). Markowitz (1959) showed that when returns are normally distributed, both the downside risk measure and variance provide the same answer. However, if returns are not symmetrically distributed only the downside risk measure provides the correct answer. Sharpe (1966) popularized the reward to variability ratio by setting the target return *T* equal to the risk-free rate (r_f). Later, Bawa (1975) and Fishburn (1977) introduced the lower partial moment (LPM) as a generalized measure of below-target (*T*) downside risk as a function of general investor risk tolerance coefficient (power) *a*.[50]

The Sharpe ratio, which is based on the standard deviation, does not differentiate whether the differential over the target return is produced above or below the target return (T). This is addressed by the notion of semi-variance which takes into account the asymmetry of risk. The calculation principle is the same as that of the variance, except that only the returns that are lower than the target return *T* are taken into consideration. It therefore provides an asymmetric measure of risk, which better captures the needs of investors who are particularly interested in the risk of their portfolio falling below a target return level. This notion is used to calculate the risk-adjusted return indicators that are more appropriate for asymmetrical return distributions. Based on these, Sortino and Van der Meer (1991) proposed the Sortino ratio which looks like the downside risk measure. Contrary to the Sharpe ratio, this measure does not penalize portfolios with returns that are above their target return. This idea was extended by Sortino, Van der Meer and Plantinga (1999) who considered the upside potential ratio. This is the potential for success to the risk of failure ratio, since the numerator is the upside potential and the denominator is downside risk. An advantage of using the upside potential ratio rather than the Sortino

and should be avoided. Roy's (1952) objective was to develop a practical method for determining the best risk-return trade-off. He did not believe that a mathematical utility function could be derived for an investor as a rational human decision maker. Roy referred to the minimum acceptable return as the "disaster level" and posited that an investor would prefer the investment with the smallest probability of going below this target level. By maximizing the reward to variability ratio [(r - T)/σ] the investor will select the portfolio with the lowest probability of going below the target level (T) for a given expected mean return (r) and risk level (σ). He used semi-standard deviation as a measure of downside risk.

[50] $LPM(a,T) = \frac{1}{N}\sum_{t=1}^{N} \max(T - R_t, 0)^a = \frac{1}{N}\sum_{R_t<T}(T - R_t)^a$

ratio is consistency in the use of the target reference rate for evaluating both upside profits and downside losses.

DR (*UP*) is a probability-weighted function of below (above) target performance outcomes. In contrast to traditional variance-based measures of risk that incorporate the entire distribution of firm return performance, *DR* focuses only on outcomes below the target value, while *UP* focuses only on outcomes above the target. Miller and Reuer (1996) discuss several rationales for moving from variance-based measures of risk to downside risk conceptualizations based on behavioral decision theory, finance studies and management research. Although empirical applications in strategy remain limited, they note that downside views of risk exist throughout the strategy literature (Aaker and Jacobson, 1987; Ansoff, 1965; Porter, 1985). Following discussions of *DR* in the early development of portfolio models in the finance literature, Harlow and Rao (1989) show that a downside risk model of equity returns explains returns better than the capital asset pricing model (CAPM). Moreover, *DR* explicitly incorporates the notion of reference levels, which behavioral decision theory identifies as a determinant of risk preferences (Kahneman and Tversky, 1979). Also, empirical research in management shows that decision makers tend to consider risk in terms of negative outcomes or hazards rather than as symmetric variability in outcomes as suggested by standard risk measures (Baird and Thomas, 1990; March and Shapiro, 1987). Ruefli, Collins, and LaCugna (1999) raise concerns about the concept validity of existing variance-based risk measures and the conclusions drawn from empirical studies using these measures.

Research in the field of *DR* and multinationality suggests that FDI and international joint ventures (IJVs), according to real options theory, enable a firm to avoid downside outcomes by shifting value-chain activities across different host country environments or by staging commitments (Kogut, 1989, 1991; Kogut & Chang, 1996). Such investments may also increase organizational complexity and bring about nontrivial coordination costs. Thus, the corporate risk effects of multinationality and IJVs are ultimately an empirical matter (Reuer and Leiblein, 2000).

Management and international strategy researchers view international joint ventures as being flexible and attractive from a risk standpoint because they entail lower initial capital outlays than wholly owned investments and enable firms to focus on core capabilities, access partners' skills and facilitate market entry (e.g., Contractor

and Lorange, 1988). More recently, scholars have suggested that joint ventures can reduce downside risk due to their option-like characteristics, given that firms can limit initial outlays and increase commitments later if a desirable opportunity materializes (Kogut, 1991). Although the attractiveness of IJVs has long been attributed to their presumed flexibility and risk containment benefits, no previous study has empirically examined their joint impact with other option characteristics (operating, strategic and network flexibility options) and managerial real options awareness on *DR* and *UP*.

In spite of considerable research that examined the relationship between multinationality, performance and *DR* in MNCs (e.g., Doukas and Travlos, 1988; Ramaswamy, 1995), it is generally agreed that the findings remain incomplete. Various authors found support for different competing theories of the MNC: internalization theory (Mishra and Gobeli, 1998), transaction costs (Leiblein, 2003), resources and dynamic capabilities (Leiblein, 2003; Teece, 2009), diversification (Chang and Thomas, 1989), and organizational learning (Kogut and Zander, 1993). The findings confirm that these theories are complementary in the context of multinational decision-making (Villalonga and McGahan, 2005). This specificity is also found in the performance literature based on the real options view (Allen and Pantzalis, 1996; Villalonga and McGahan, 2005; Tong and Reuer, 2007), where results are again incomplete.

A number of authors found that the association between multinationality and performance is negative (e.g., Chang and Thomas, 1989; Michel and Shaked, 1986; Denis *et al.*, 2002). Others found a positive and linear relationship, in line with the multinational network hypothesis (Vernon, 1971; Grant, 1987; Kim *et al.*, 1993; Seth *et al*., 2002; Kogut, 1984, 1985). Pantzalis (2001) provides evidence that investment in emerging markets can increase firm value as suggested by real options theory. Some of this evidence seems conditional. Reuer and Tong (2005) and Tong *et al.* (2008) suggest that this may depend on the specific emerging market and industrial segment if entry is accomplished through joint venture investments. Allen and Pantzalis (1996) find a positive linear relationship between multinational flexibility and firm value after accounting for the effects of intangibles and certain firm-specific attributes. Other researchers found that the relationship is curvilinear due to coordination problems, transaction costs and internalization issues (e.g., Sullivan, 1994; Gomes and Ramaswamy, 1999). Tong and Reuer (2007) find a curvilinear association between risk and firm international presence after incorporating the

determinants of FDI in the MNC performance model. A few studies reported a non-significant relationship or no association (Kumar, 1984; Kim and Lyn, 1986; Tallman and Li, 1996). Reuer and Leiblein (2000) find no significant relationship between multinationality and DR performance in US manufacturing MNCs, directly challenging the predictions related to the flexibility and downside risk management benefits of multinationality.

Kim, Hwang and Burgers (1993) find that international diversification lowers total risk (and increases returns), while Caves (1996) and Qian (1996) find that multinationality stabilizes MNC's income streams and lowers total risk. However, Reeb, Kwok and Baek (1998) find that internationalization increases systematic risk, as measured by beta. Villalonga (2004) helps explain the diversification discount using propensity score matching and elucidates that poor performers may go multinational in order to diversify risk, leading to a seeming negative relation between multinationality and performance, pointing the need to control for past performance. Kogut (1983,1984, 1989), Kogut and Kulatilaka (1994) and Trigeorgis (1996) put forth the multinational network flexibility hypothesis. According to Trigeorgis (1997), real options theory suggests that multinationality reduces downside risk. If an adverse development occurs in part of an MNC's operations, it can shift operations to other parts of its network.

Mitchell, Shaver and Yeung (1992) suggest that the risk of business failure is reduced for multinationals. Reuer and Leiblein (2000), however, find, based on a sample of 357 U.S. manufacturing firms, that "corporations with greater multinationality or greater investments in IJVs do not obtain lower levels of downside risk. In fact, firms investing in more IJVs experience higher levels of income stream risk and bankruptcy risk". This directly contradicts real options and *DR* theory predictions. Tong and Reuer (2007) and Driouchi and Bennett (2011) recognize that firm's heterogeneous factors and managerial aspects can be important determinants of downside risk in MNCs. We posit that MROA is an important moderating factor leading to a negative relationship between multinationality and downside risk, as predicted by real options theory.

The previous mixed, incomplete and in some cases contradicting findings in the literature suggest that economic and managerial effects predicted by one theory may interact with or dominate effects predicted by alternative theories of the MNC. This has led a number of transaction cost proponents to argue (based on transaction

costs, diversification and organizational learning arguments) that the multinationality-performance-*DR* relationship might be insignificant after all and could only be significant due to luck or superior management skills (Hennart, 2007). Hence, to more accurately determine the flexibility impact of multinationality on *DR* and *UP*, a number of factors, including past performance, need to be controlled for (Villalonga, 2004). For example, it may be that poorly performing firms go multinational to diversify, leading to seemingly a negative association between multinationality and performance. At the same time, good past performers may go multinational to leverage their flexibility and growth options advantage and enhance their risk management capabilities, leading to a positive association of multinationality with upside potential and negative with DR. The net result may not be clearcut. Controlling for past performance, as well as alternative theory determinants of multinationality and firm-specific attributes such as managerial real options awareness, may help reveal the true conditional relations, which real options theory predicts should be negative between multinationality and *DR* and positive for *UP*. The above factors relate also to self-selection and endogeneity issues, the role of intangibles and firm heterogeneous characteristics and managerial specificities, as well as industry factors in multinational operations (e.g., Tong and Reuer, 2007).[51]

This paper examines the joint impact of multinationality, growth options and managerial real options awareness on downside risk and upside potential, taking into account a number of relevant theoretical attributes. Such attributes are captured in a two-stage structural model of the MNC that considers the *DR* and performance implications of multinationality and real options awareness determinants. In accordance with real options theory (Kogut, 1984, Trigeorgis, 1996), the RBV (Barney, 1986) and the DCV (Teece and Pisano, 1994), we posit that the degree of managerial real options awareness present in MNCs plays a significant beneficial role in effective downside risk management of the MNC and extracting its full benefits. This key driver has not been taken into consideration adequately in prior empirical studies.[52] We thus focus on downside risk (the probability of a firm's *ROA* to be below its industry's median *ROA*) and average return on assets (*ROA*) as an indicator

[51] Brouthers *et al*. (2008) suggest that diversification and real options effects might be dominated by transaction costs motives in some situations (e.g., during specific time periods or for firms operating in specific economic regions) and vice-versa.

[52] The closest works addressing this issue are Tong and Reuer (2007) and Driouchi and Bennett (2011). Focusing exclusively on multinational switching options, these authors suggest that firm's heterogeneous factors and managerial aspects can be important determinants of downside risk in MNCs.

of performance, examining the full set of flexibility platforms (switching as well as growth and operating options) available to multinational firms to shed new light on the relation between multinationality and downside risk (as well as on firm performance) from a real options perspective. We suggest that firms that are managerially aware of their multinational flexibility options or have put in place an appropriate organizational infrastructure to devote managerial attention to cultivating and exercising their real options will likely exhibit a comparatively better ability to effectively manage and reduce downside risk exposure while achieving higher upside potential and better (positive) performance.

3. Hypotheses

The multinational nature of MNC operations and related infrastructure investments enable the MNC to take advantage of its network of operations in multiple countries and exercise a broad menu of real options: delay or time entry in a new market, expand or contract production via outsourcing, switch inputs or outputs through multi-country operations, switch operations or grow into new expanding or emerging markets. Trigeorgis (1996) categorizes the menu of such managerial real options into growth options conferring strategic flexibility and operating options providing operational flexibility resulting from previously exercised growth options.

In line with real options theory predictions, the value of multinational network flexibility and hence the value and performance of a multinational firm will be higher the broader the range of alternative choices (i.e., countries of operation) the MNC has. A multinational entity will have lower downside risk (*DR*) and higher upside potential (*UP*) the broader the range of alternative choices within its multinational network. If unexpected adversity occurs in a part of its extended network, the MNC can shift operations to other parts of the network, reducing *DR*. Similarly, if an unanticipated opportunity arises in another part of the network, the MNC can shift more resources there to enhance its *UP*. The relation between multinational flexibility and *DR* (or *UP* and performance) is likely nonlinear (logarithmic, based on the way multinationality is measured). As the number of foreign subsidiaries rises, the correlation structure among alternative country operations within the firm's portfolio mix increases and the risk management benefits

likely decline, with *DR* declining more steeply at first and less later on, as the number of foreign subsidiaries increases.

The more the alternative choices within the multinationality network, the greater the switching flexibility value conferred to the MNC. Specifically, the greater the number of countries with foreign operating subsidiaries, the larger the MNC switching flexibility value when local or global environmental factors vary. The diversity and geographic dispersion of global operations provides multinational firms with better hedging and arbitrage opportunities than domestic rivals in a changing global business environment. Multinationality thus provides a more potent platform for the "markets" in which the MNCs' operating and strategic options get exercised. A corporation's multinationality, as a flexibility enhancing platform, should therefore beneficially impact on MNC downside risk (i.e., reduce *DR*) and positively enhance MNC upside potential and performance.[53] This leads to the following:

Hypothesis 1: Multinationality, as a switching flexibility platform, helps reduce downside risk and enhances upside potential and firm performance.

The MNC holds a portfolio of operating and strategic growth options that benefit from global market uncertainty. Operating options consist of the operational choices in the realm of firms' real activities embedded in assets in place. Strategic growth options concern the long-term prospects of companies and their future value creation. Operating and strategic growth options are hence located in existing operating assets and strategic resources, respectively. The forward downside risk of an MNC in an uncertain business environment should be lower the greater the associated value of real options, while the upside potential should be higher. Specifically, the risk management, value and performance of an MNC will be higher the more uncertain the business environment facing the MNC's operating segments, the greater the MNC's operating flexibility and the greater the association of the real options specificity, reflecting exercise of past investment, expansion or switch options.

[53] At the same time, although more growth and operating options are embedded in more globalized operations, the relation between multinational flexibility and value may be nonlinear (e.g., logarithmic) since as the number of countries with foreign subsidiaries rises, the correlation structure among alternative country operations within the firm's portfolio mix increases lowering option value while coordination costs rise and marginal benefits likely decline.

Spawning from past growth opportunities that have been integrated in firm operations, operating options serve as risk management levers the firm can utilize within its internal operations to reduce corporate risk exposure and enhance profitability.[54] They effectively provide insurance and leveraging tools contained within an MNC's network of global operations. Because of the operational nature of these activities (embedded in investment, expansion or switching decisions from previous periods), it is appropriate to account for them in enhanced plants, property and equipment (Ramaswamy, 1995; Allen and Pantzalis, 1996; Ramezani *et al.*, 2002). Thus, changes in capital expenditures represent potential exercise of operating options. The firm's performance is thus a function of changes in these operating assets in place (ΔCapex), effectively representing exercise of past growth options converted into operating assets in place. By operating flexibility options in this context we refer to changes in operating assets in place or change in Capex.[55]

This argument is in accord with recent finance and accounting literature on capital investment and the determinants of stock returns which use ΔCapex or related variables such as total asset growth, accruals, and growth in sales as operating or strategic firm characteristics. For example, Titman *et al.* (2004) find that firms which substantially increase their Capex achieve lower stock returns. Anderson and Garcia-Feijoo (2006) find that growth in capital expenditures explains returns to portfolios sorted based on size and book-to-market and the cross section of stock returns. They argue that these findings are consistent with theoretical predictions (e.g., Berk, Green, and Naik, 1999) in which the exercise of investment-growth options results in changes in systematic risk and expected stock returns. Cooper *et al.* (2008) examine the relation between total asset growth and subsequent stock returns and confirm that ΔCapex is the most important component of total asset growth, particularly so for large firms. Liu, Whited and Zhang (2009), Li and Zhang (2010) and Lam and Wei (2011) also use Capex to investigate the investment-return relationship based on Q theory of investment. Cao *et al.* (2008) use PVGO and Capex as proxies of growth options and find that growth options help explain the trend in idiosyncratic volatility.

In parallel to this literature, we use operating options to refer to real options operating flexibility, proxying for exercising past growth options and turning them

[54] Operating options can take many forms. The options to delay production or shut down operations after a sudden decline in market demand are typical examples (Trigeorgis, 1996). The option to outsource operations to a low-cost location is another example of operating flexibility (Leiblein and Miller, 2003; Mol *et al.*, 2005).
[55] Capex refers to Capital Expenditures (CAPX in the Compustat data platform).

into assets in place. We refer to strategic growth options to mean strategic flexibility, involving creation of new option value. We assert that short-term changes in Capex are more likely to be indicative of potential operating options exercise. For robustness purposes we also use an alternative design where Capex is replaced by non-controlling investment (NCI).[56] NCI represents investments and advances to unconsolidated subsidiaries, affiliates and joint ventures in which the parent company has less than 50% control, scaled by total assets. This variable amounts to an equity option to expand/divest operations or upgrade existing or already established firm investments. It more clearly creates subsequent growth and flexibility for the firm. The above leads to the following:

Hypothesis 2: Operational flexibility reduces downside risk (while it increases upside potential and enhances MNC performance).

Based on real options theory (e.g., Trigeorgis, 1996), we also conjecture that the value and performance of an MNC will be higher, and the *DR* will be lower, the higher the firm's (pre)existing level of infrastructure or strategic growth options and the greater the recent increase in such strategic flexibility (i.e., the change in strategic growth options). Strategic growth options provide the platforms for exploiting company future growth opportunities. Unlike operating flexibility that concerns exercise of past growth options enhancing commitment in current plant and equipment, strategic growth options refer to future value creation and future expansion of business operations through newly considered strategic investments (Smit and Trigeorgis, 2004). These are reflected in strategic or infrastructure investments, such as FDI and R&D (Kester, 1984; Trigeorgis, 1996). In the context of multinationality, strategic growth options include market entry decisions and resources related to foreign direct investments (Li and Rugman, 2007; Fisch, 2008; Gulamhussen, 2009). They can take the form of acquisitions, greenfield projects, new partnerships or new joint-venture agreements. These types of investments are targeted to the creation of future growth opportunities and future strategic value. Recent enhancement in these investment platforms is indicative of improvement in the firm's growth options stock. Strategic growth options and growth options improvements should reduce downside risk and

[56] Compustat items #89 and #90.

positively contribute to MNC upside potential and performance. This leads to the following:

Hypothesis 3: The level of and change in strategic growth options are negatively related to firm downside risk (and positively related with MNC upside potential and performance).

The value of MNC flexibility can be fully realized only if MNCs can manage and exercise their strategic growth and operating options at the right time. A key premise of this paper is that the flexibility benefits of multinational operations are more pronounced for firms with greater managerial awareness to real options. We posit that familiarity with real options thinking and having in place adaptive organizational capabilities for decision-making under changing conditions is key to proper and effective exercise of real options. Managerial attention specificity leads to real options recognition and more effective management of multinational operations thus being a source of improved performance for organizations (Barnett, 2008). The ability to recognize and exploit strategic and operating flexibility platforms is essential for real options implementation.

Managerial real options awareness also enhances learning opportunities (Mascarenhas, 1982; Kogut, 1983). Once recognized and developed, real options become part of MNC value-creating resources. Strategic growth options capabilities contribute to asset renewal and the creation of new core competences and learning opportunities. Operating flexibility in turn helps reconfigure resources and develop new operating procedures. The integration of strategic growth options and operating flexibility enables the firm to adapt and take advantage of dynamic managerial capabilities in the face of uncertainty. Managerial real options awareness as a knowledge/learning factor contributes to value creation and the facilitation of options-based decision making in organizations. As a result, the MNC is more effective via its switch, growth and operating options in reducing downside risk and enhancing profitability.

A managerially aware firm is able to detect multinational switch, growth and operating options through real options knowledge acquisition and use real options decision-making more effectively. The “how”, “when” and “why” of exploitation fall within the domain of managerial capabilities specific to firm processes and practices. This dual specificity makes real options decision-making itself a valuable capability.

Real options awareness helps activate this capability after integrating options knowledge into the firm's systems and processes. Heterogeneity in managerial awareness levels leads to firm specificity of real options skills. A high level of awareness is associated with superior real options know-how and skills relative to firms with lower degrees of awareness. The ability to detect real option prospects is a prerequisite for options exploitation and indicative of a firm's capability to manage its real options. Real options awareness is therefore a tool for effective risk management and a source of value for MNCs. This leads to the following:

Hypothesis 4: A higher degree of managerial real options awareness enhances the beneficial impact of multinationality in reducing firm downside risk (while improving firm UP and long-term performance).

4. Methodology

4.1. Sample

Our panel dataset consists of accounting, financial, market and fundamental data on 5879 US firms (excluding financial institutions) with publicly available data in the Compustat disc platform over the period 1996-2009.[57] We started with all 9732 active (i.e., listed and operating) firms listed in the Compustat disc during the period under study. Inactive firms, delisted due to bankruptcy, mergers or liquidations are not included. Of these, all financial institutions (2503 firms), with SIC codes between 6000 to 6999, were excluded due to the regulatory specificity of the sector. From the remaining, 1350 firms were excluded due to missing accounting, market or fundamental data related to our explanatory and control variables. Since longitudinal data analysis is used, if a firm had missing figures in at least one year it was eliminated from our sample. Missing R&D observations were set to 0 rather than being excluded.

The final sample consists of 5879 US firms. Of these, 165 are categorized as being managerially aware of their real options, 158 firms were MNCs and the rest (5721) non-MNCs. Data on multinationality (*MULTI*) were collected by the authors from the *International Directory of Corporate Affiliations* of LexisNexis, Compact Disclosure data platform and the submitted financial statements of firms, obtained

[57] Our explanatory and control variables were collected from 1996 to 2004 while our dependent variables cover the period from 2005 to 2009 (5 years forward).

from the U.S. Securities and Exchange Commission (SEC).[58] The final sample included 158 multinational firms. This approach is consistent with prior research on multinational disadvantage of domestic firms (Ramaswamy, 1995; Gomes and Ramaswamy, 1999).

Information on the managerial real options awareness (*MROA*) measure was hand collected by the authors based on documentation available in the public domain, such as the popular press (e.g., the *Economist*, *Financial Times*, *CFO Europe*, *CFO Magazine* etc.),[59] related practice literature (e.g., Bowman and Moscowitz, 2001; Triantis and Borison, 2001; Billington *et al.*, 2002; De Neufville, 2003; Keefer, 2004; Smit and Trigeorgis, 2004), data from related consulting services firms (e.g., the Real Options Group, Decisioneering, Deloitte), and the International Real Options Conference database. Data on *MROA* was very rare or non-existent prior to 1996, the starting year of our research period.[60] In recent years, between 10 to 26 percent of Fortune 1000 firms state they used real options techniques for their real asset allocation providing factual evidence of managerial real options awareness in corporations (Ryan and Ryan, 2002; Graham and Harvey, 2001). Busby and Pitts (1997) report that out of the FTSE100 UK firms they surveyed, about 25% were interested in applying real options reasoning to monitor their investments. Ryan and Ryan (2002) find that 88.6% of companies they consulted only rarely or never used real options as a capital budgeting tool.

Although the option-based approach to managing investments might not have been a common practice in industry during this period, there is a cluster of firms that have been managerially aware of their real options. Using the aforementioned information sources and documentation, we obtained a representative sample of this population of aware firms and produced a procedure for categorization. The final sample included 165 real options aware firms. Such dataset is reflective of the current state of real options practice in industry and is a good step towards more complete and rigorous tests related to the explicit exercise of real options in firms. Due to

[58] Exhibit 21 of each firm's financial statements (available at www.sec.gov) includes information about subsidiaries. The authors collected data on subsidiaries and counted the number of foreign countries each multinational firm has subsidiaries in from LexisNexis, Compact Disclosure and SEC data sources.

[59] See also, among others, Borissiouk and Peli (2001) and Gupta (2002). This adoption activity dates from the mid-1990s (see *Business Week*, 1999; *CFO Europe*, 1999; Trigeorgis, 1999; *CFO Magazine*, 2001; De Neufville, 2003).

[60] The annual international real options conference and serious consulting activity (e.g., by PriceWaterhouseCoopers, Ernst & Young, Andersen Consulting/Accenture, Decisioneering, Deloitte Consulting and others) promoting real options awareness on a broad basis among MNCs and large US corporations started about this time.

heterogeneity of real options practice, firms were categorized into "high" or "low" awareness groups subject to the nature of the awareness specificity reported in our information sources (e.g., actual adoption cases and evidence of workshop attendance were indicative of high and low awareness, respectively). This distinction also stems from resource-based arguments. To ensure (inter-rater) reliability of the awareness construct, the categorization was done first independently and second in coordination by the authors for a number of occasions with comparable outcomes (see e.g. Schneider *et al*., 2002).

4.2. Dependent variables

Our dependent variables are mainly the downside risk (*DR*) measure, upside potential (*UP*), and the excess performance to downside risk ratio (*UP/DR*). Also, forward 3-year average return on assets (*ROA*) was used as an alternative long-term performance measure. The most general measure of *DR* is the Lower Partial Moment (LPM), developed by Bawa (1975) and Fishburn (1977) as a general family of below-target (*T*) downside risk measures (following Roy, 1952), with a general investor risk tolerance coefficient (or power), *a*. This family includes semi-variance (where the target *T* is the industry median or average) or its square root, below-mean semi-deviation ($a = 2$). This corresponds to stochastic dominance (for $a > 0$). The general LPM equation is:

$$LPM(a,T) = \frac{1}{N}\sum_{t=1}^{N} \max(T - R_t, 0)^a = \frac{1}{N}\sum_{R_t<T}(T - R_t)^a \quad (1)$$

where *N* is the number of observations, *T* is the target (here the industry median) return, *a* is the degree of the lower partial moment, R_t is the asset return during time period *t*, and *max* is a maximization function which chooses the larger of two items: $(T - R_t)$ or *0*. Note that $0 < a < 1$ represents a risk seeking behavior (risk lover investor); $a = 0$ represents the probability of below-target loss or value at risk; $a = 1$ represents a risk-neutral behavior, and $a > 1$ risk averse behavior (rational investor). Most importantly, when $a = 2$ eq. (1) gives the below-target semi-variance, when $a = 3$ it leads to semi-skewness while situations with $a \geq 4$ involve significant excess

skewness (higher moments). Thus, the general expression for downside risk in our context is given by:

$$DR(a) = \sqrt[a]{\frac{1}{N}\sum_{R_t<T}(T - R_t)^a} \quad (2)$$

where *a* is the degree of the lower partial moment, *N* is the number of observations, R_t here is ROA_t (the return on assets ratio in year *t*) and *T* is the target return, which in our context equals the industry median *ROA* (*IROA*). When *a = 2*, we get the standard measure of downside risk which is the below-median semi-deviation.

By analogy, upside potential (UP) measures the above-target (here, above-industry median *ROA*) performance, i.e.,

$$UP(a) = \sqrt[a]{\frac{1}{N}\sum_{R_t>T}(R_t - T)^a} \quad (3)$$

where *a* is again the degree of the lower partial moment, *N* is the number of observations, $R_t \equiv ROA_t$ is the return on assets and *T* is the target return equal to the industry median (*IROA*). When *a = 1*, we get the standard measure of upside potential which is the excess (above-target) returns.

Excess performance to downside risk (or reward to variability) ratio is also used as dependent variable, mainly as a robustness check of the validity of our findings. Several combinations of the *UP* to *DR* ratio can be used, depending on the value of *a* in eqs. (2) and (3). This ratio can be seen as the potential likelihood of success (i.e., *UP*) to the potential risk of failure (i.e., *DR*) ratio. *UP(a)/DR(a)* is our generalized measure of excess (above target) performance per unit *DR*. It is an extension of reward to variability or a measure of risk-adjusted returns. Rational investors have a preference for high (above-target) excess returns (e.g., exceeding the median performance of the industry) and an aversion to below-target performance (e.g., deviations below the industry median), preferring a higher *UP* to *DR* ratio. Specifically, *UP(1)/DR(2)* measures the excess (above-target) returns per unit (semi) standard deviation (as in Roy, 1952).

Downside risk and upside potential, as probability weighted functions of below and above target performance outcomes, respectively, emphasize performance

outcomes below or above a target level. This is in contrast to conventional variance-based measures of risk that capture the entire distribution of firm performance outcomes. Following earlier work by Miller and Leiblein (1996), Reuer and Miller (1996), Reuer and Leiblein (2000), Reuer and Tong (2003) and Driouchi and Bennett (2011) we specify *DR* (also *UP* and *DR/UP* ratio in this work) as a function of a firm's annual return on assets (*ROA*) relative to an industry target level that changes over time. The median *ROA* for a firm's two-digit Standard Industrial Classification (SIC) industry in the preceding year was used as proxy for this target level. None of the earlier papers, as far as we know, have also tested *UP* or *UP/DR* ratio empirically, making this one of the contributions of this paper.

4.3. Explanatory and control variables

To investigate the validity of our main hypotheses, we develop proxies for operating flexibility (*OFLEX*), strategic growth options (*SGO*) and change in strategic growth options (*ΔSGO*), multinationality (*MULTI*), managerial real options awareness (*MROA*), and examine their joint impact on our dependent variable(s). We control for the firm's systematic risk (beta), size, distress level (*DISTR*), financial flexibility (leverage), industry effects and endogeneity (past performance). We also include structural fixed year effects in our longitudinal sample. We specify and test the following two-stage multivariate model using panel data:

$$Y_{i,t} = c + bMULTI_{i,t-1} + dMROA_{i,t-1} + gOFLEX_{i,t-1} + hSGO_{i,t-1} + k\Delta SGO_{i,t} + mFFLEX_{i,t-1} + pSIZE_{i,t-1} + q(SIZE * FFLEX)_{i,t-1} + u\beta_{i,t-1} + vDISTR_{i,t-1} + yIND_{i,t} + zROA_{i,t-1} + e_i \quad (4)$$

where:

$Y_{i,t}$: firm *i*'s downside risk ($DR_{i,t}$), upside potential ($UP_{i,t}$), *UP/DR* ratio or 3-yr average forward *ROA* as of time *t*;

c: constant of the equation.

The explanatory variables are presented in the first row of eq. (4):

$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,[61]

$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,[62]

$OFLEX_{i,t}$: firm *i*'s operating flexibility (increase in Capex or *NCI*) as of year *t-1*;

where *Capex* is the (three-year period) average capital expenditure at year end minus the beginning-of-period average Capex, deflated by beginning-of-year total assets, and *NCI* is investments and advances to unconsolidated subsidiaries, affiliates and joint ventures in which the parent company has less than 50% control scaled by total assets,

$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,

$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options at year *t*.

The second row of eq. (4) lists the control variables:

$FFLEX_{i,t-1}$: firm *i*'s financial flexibility (market-value leverage) at time *t-1*,

$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,

$(SIZE*FFLEX)_{i,t-1}$: firm *i*'s interaction term between size and leverage at time *t-1*,

$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,

$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,

$IND_{i,t}$: firm *i*'s median industry value of the *Y* variable at time *t*,

$ROA_{i,t-1}$: firm *i*'s return on assets ratio at time *t-1*.

Multinationality (*MULTI*), a key explanatory variable in our study, reflects the diversity of a firm's global activities across multiple countries. As standard in the literature (Caves and Mehra, 1986; Allen and Pantzalis, 1996; Reuer and Leiblein, 2000), multinationality is defined as the natural logarithm of 1 plus the number (M) of foreign countries in which a firm has operating subsidiaries (*MULTI* = ln(1 + M)). For purely domestic or non-multinational firms (M = 0), the *MULTI* variable gets a value of zero.

The second key explanatory variable, the degree of managerial real options awareness (*MROA*), represents a new contribution to the literature. It represents a crucial missing link between real options implementation and *DR* (or firm

[61] In the first-stage regression this is instrumented by market concentration, intangibles, firm-specific volatility, R&D intensity and controlled for prior performance, prior size and prior level of multinationality, with the predicted value of *MULTI* then used in the second stage regression.

[62] In the first-stage regression this is instrumented by prior performance, prior size and prior level of multinationality, with the predicted value of *MROA* then used in the second stage regression.

performance) as it can have significant moderating effects. We categorize all firms in the sample into three main groups: (a) firms that are not aware of the real options logic, (b) firms with basic or low awareness of the real options logic, as evidenced from having attended managerial workshops training or conferences on the subject, and (c) firms with high awareness, namely firms that have used real options in forming their strategy and running their operations, as evidenced by utilizing consulting services by experts on the matter or by documented corporate adoption and practice (e.g., Nichols, 1994; Triantis and Borison, 2001; *CFO Magazine*, 2003; Keefer, 2004).

Variable *MROA* is estimated as the natural logarithm of 1 plus the value weight of its awareness group: group (a) "no awareness" has a weight of 0, group (b) "low awareness" has a weight of 1, and group (c) "high awareness" a weight of 2. The higher the degree of managerial real options awareness of a firm, the higher the value of its *MROA* variable. Firms with no real options awareness get a *MROA* value of zero. As robustness checks, alternative specifications of *MROA* with dummy designs, without the logarithm and using subsample analysis were also examined.

All independent variables are lagged by one period (*t-1*) to mitigate potential problems of endogeneity and reverse causality (Bromiley, 1991; Reuer and Leiblein, 2000). *ΔSGO* and *OFLEX* (when ΔCapex is used) represent changes between two successive periods, and thus are not lagged. *IND* is used to capture industry effects within the same period as the dependent variable and is not lagged. Fixed effects are also used to capture time variation, accounting for unobserved heterogeneity and variation at the firm level and capturing the effects of economy-wide variations or other unobserved factors.

4.4. First and second stage regressions

The type of regression used depends on the type of the dependent variable. In this regard, we run two-stage tobit multivariate panel data regressions when *DR, UP*, and *UP/DR* are used as a dependent variable and two-stage least squares (2SLS) multivariate panel data regressions when *ROA* is used as a dependent variable. In order to control for firm heterogeneous factors, endogeneity issues and account for alternative explanations of multinationality, the determinants of multinationality and managerial real options awareness are assessed in first stage regressions. In line with

prior research regarding the determinants of multinationality (e.g., Tong and Reuer, 2007; Grubaugh, 1987; Horst, 1972), based on market power, internalization/transaction costs, diversification, RBV and knowledge-based arguments, we test the impact on *MULTI* likelihood based on the following variable specification:

$$MULTI_{i,t-1} = c + bMCON_{i,t-2} + gINTAG_{i,t-2} + hVOLAT_{i,t-2} + kR\&D_{i,t-2} + mROA_{i,t-2} + nMULTI_{i,t-2} + qSIZE_{i,t-2} + e_i \quad (5)$$

where:

$MULTI_{i,t-1}$: firm *i*'s multinationality index at time *t-1*,

c: constant of the equation,

$MCON_{i,t-2}$: firm *i*'s market concentration at time *t-2*,

$INTANG_{i,t-2}$: firm *i*'s intangible assets at time *t-2*,

$VOLAT_{i,t-2}$: firm-specific volatility or business uncertainty for firm *i* at year *t-2*,

$R\&D_{i,t-2}$: firm *i*'s research and development (R&D) intensity at time *t-2*,

$ROA_{i,t-2}$: firm *i*'s return on assets ratio at time *t-2* (proxying for prior performance),

$MULTI_{i,t-2}$: firm *i*'s multinationality index at time *t-2*,

$SIZE_{i,t-2}$: firm *i*'s size (natural logarithm of total assets) at time *t-2*.

In the above first-stage regression, we use four instruments shown on the first line of eq. (5) (market concentration, intangibles, firm-specific volatility, R&D intensity) and three control variables (prior performance, prior multinationality and prior size) seen on the second line to tackle endogeneity. In accord with MNCs market power advantage hypothesis (Bain, 1956; Hymer, 1976), past size and market concentration increase the likelihood of going multinational. The firm's market power and ability to exploit shared growth options relative to competition for the given industrial structure is proxied by market concentration (*MCON*), measured as the square root of the firm's Herfindahl-Hirschman Index (HHI) if the firm has above-median *ROA*, and zero otherwise.

According to the internalization theory, a key motive for going multinational is cost efficiency. This aspect is captured by variable *INTANG*, which is the natural logarithm of the firm's ratio of intangible assets to total assets (Vernon, 1971; Buckley and Casson, 1976; Morck and Yeung, 1991). The theory of diversification

argues that a key motive for going multinational is risk diversification, reducing total firm-specific risk (Kim *et al*., 1993). Real options theory argues that volatility is beneficial for multinational flexibility, suggesting a reverse volatility effect. Firm-specific volatility (*VOLAT*) or business uncertainty is estimated from the standard deviation (σ) of firm equity returns based on the past 36 monthly stock returns. R&D intensity (*R&D*) is included based on arguments that a firm may go multinational to leverage knowledge, innovation and flexibility (Kogut and Zander, 1992, 1993). It is calculated using the natural logarithm of the ratio of R&D expenses to sales for each firm.

Managerial real options awareness (*MROA)* may also suffer from endogeneity, so in the first-stage regression it is instrumented using prior performance proxied by return on asset ratio ($ROA_{i,t-1}$), prior level of multinationality ($MULTI_{i,t-1}$) and prior level of firm size ($SIZE_{i,t-1}$) in line with RBV and DCV. Its predicted value is used in the second stage procedure.[63] [64]

Besides *MULTI* and *MROA*, specified above, we include three real options related independent variables to test our second hypothesis. Operating flexibility ($OFLEX_{i,t}$) embedded in assets in place is measured by the increase in capital investment (ΔCapex), proxying for the degree of exercising past growth options and turning them into (current) assets in place. It is estimated as the (three-year period) average capital expenditure at year end minus the beginning-of-period average Capex, deflated by beginning-of-year total assets.[65] For robustness purposes, firm non controlling interest NCI is also used as an alternative.[66]

Strategic growth options ($SGO_{i,t-1}$) represents the prior infrastructural capabilities the firm has put in place (at *t-1*) to create future strategic growth opportunities. It is measured in two alternative ways. The first (empirical or market-

[63] The explanatory variables are lagged because they do not contemporaneously affect the endogenous variables (MULTI and MROA). In first stage regressions the explanatory variables in the basic model (OFLEX, β, DISTR etc.) are excluded as they do not affect the instrumented/endogenous variables in a statistically significant way. Econometrically this is valid since in the first stage regressions at least one explanatory variable of the basic model is included.

[64] Kleibergen-Paap (2006) weak identification test and Stock-Yogo (2005) weak ID test were conducted. The results reveal that the underidentification and weak identification hypotheses are rejected reassuring that our first stage models are well identified. We also tested for issues of overidentification and instrumental variable relevance in our models using the Sargan, Anderson likelihood and Hansen-J econometric procedures; outcomes from these tests confirm that we used quality instruments.

[65] Capex: Compustat item #128 (CAPX), Total Assets: Compustat item #6 (AT).

[66] NCI is investments and advances to unconsolidated subsidiaries, affiliates and joint ventures in which the parent company has less than 50% control scaled by total assets;

implied model) involves inferring the value of strategic growth opportunities implied in the firm's current market value from:

$$V_{i,t} = \frac{CF_{i,t}}{k} + SGO_{i,t} \quad [\text{or} \quad SGO_{i,t} = V_{i,t} - \frac{CF_{i,t}}{k}] \quad (\textit{Implied SGO approach}) \qquad (6)$$

where $V_{i,t}$ is the market value for firm i at time t, $CF_{i,t}$ is the (perpetual) Operating Cash Flow at time t and k is the firm's cost of capital (WACC). As it is fundamental in business finance and valuation, this model is mainly discussed and presented for comparison. The second approach, more consistent with real options theory, involves regressing a number of theoretical option-driven independent variables on *SGO*, estimating the model parameters on recent 3-year industry data and using the estimated coefficients and current firm data to derive a predicted *SGO* score for each firm i at time t (*Instrumental Model SGO approach*).[67] In addition to this level of strategic growth options (predicted *SGO* score), $\Delta SGO_{i,t}$ is also included to capture recent enhancement (*change*) in firm strategic growth options value. *SGO* aims to captures creation of new growth options and their impact on downside risk and firm performance. Change in *SGO* accounts for creation of growth opportunities during the previous year and measures recent growth improvement and its impact on downside risk and performance currently.

The control variables used as independent constructs are seen in the second line of eq. (4). Most of these variables are standard in the finance literature in explaining returns. Each firm's market or systematic risk, beta ($\beta_{i,t-1}$), is estimated over the previous 36 monthly returns using the Sharpe-Lintner model (CAPM) as in Fama and French (1992). Firm size ($SIZE_{i,t-1}$) is measured as the natural logarithm of the book value of firm i's total assets in the previous period. $DISTR_{i,t-1}$ is a distress dummy that takes the value zero if book value of firm i is positive and one if the prior-period book value of firm i is 0 or negative, indicating that the firm is likely to be distressed.[68] Financial flexibility ($FFLEX_{i,t-1}$) is the leverage ratio measured in market value terms as the natural logarithm of total liabilities divided by the fiscal

[67] $SGO = f$ (firm-specific volatility, managerial flexibility/asymmetry, organizational slack, cash flow position, R&D intensity, cumulative sales growth, market power; fixed effects, industry effects, interactions). See Trigeorgis and Lambertides (2012) for further details. This SGO model is the one we mainly refer to for the rest of our analysis.

[68] Book value of the firm is measured as the book value of common equity (Compustat item #60).

year-end firm value (V = ME + LT) at time *t-1*.[69] $IND_{i,t}$ equals the median value of the dependent variable of the industry firm *i* operates in, used to capture industry effects. $ROA_{i,t-1}$ is the return on assets ratio of the previous period, as it is standard in the literature to be included in the model explaining *DR* to control for previous performance.

We run our second stage multivariate panel data regressions based on (all or parts of) eq. (4). Standard statistical tests (z-statistics and model Wald Chi-Square) are reported in Table 4 and analyzed in the next section. We anticipate the impact of all option-related variables (*OFLEX, SGO* and *ΔSGO*), as well as of multinationality (*MULTI*) and managerial real options awareness (*MROA*) to be negative on *DR* and positive on *UP, UP/DR* and forward *ROA*. These predictions are consistent with our hypotheses based on real options theory.

4.5. Selection bias and endogeneity issues

Apart from the above two-stage regressions, we perform robustness test comparisons of our main results, after controlling for self-selection and endogeneity issues using Heckman (1979)[70] and propensity score matching techniques (Rosenbaum and Rubin, 1983; Villalonga, 2004).[71] The Heckman correction, a two-step statistical approach, offers a means of correcting for non-randomly selected samples when firms have tendencies to self-select. Heckman's correction uses a normality assumption and provides a test and correction for sample selection bias. In the first stage, using a probit regression we obtain the predicted values of multinationality or managerial real options awareness for each individual firm.[72] In the second stage, we correct for self-selection by incorporating a transformation of these predicted probabilities as an additional explanatory variable, the Inverse Mills Ratio (*IMR*). [73]

[69] Total liabilities: Compustat item #81(LT). ME: fiscal year-end market value of equity measured by log[fiscal year-end price per share (Compustat item #199) multiplied by the number of shares outstanding (Compustat item #25)].

[70] The two-stage Heckman method was originally employed on cross-sectional data. It was subsequently extended by Heckman to be applied on panel data (see Manski and McFadden 1981, ch. 3). See also Wooldridge (1995), Tong and Reuer (2007) and Chung *et al.* (2010).

[71] See Villalonga (2004) for a detailed description of the procedure in the context of explaining the diversification discount.

[72] *MULTI* and *MROA* are treated as dummy variables taking the value of 1 if firm is multinational and 0 otherwise, and 1 if the firm is managerially aware of real options and 0 otherwise, respectively.

[73] A double-selection model (correcting for self-selection bias for both MULTI and MROA) is constructed as follows: we estimate a probit model for MULTI first. Upon generating the IMR term, this is included in a second probit equation explaining MROA. The appropriate IMR term from this equation is then included in the second stage equation (see Amemiya, 1985). This procedure is also done in reverse order, with similar results.

Propensity score matching involves reorganization of the dataset into a quasi-random sample based on the likelihood or propensity of a firm belonging to a certain category (being multinational or aware of its real options), given a set of known characteristics or covariates (e.g., past *ROA*). Propensity score matching is used here to address endogeneity issues (controlling for past performance) and to reduce selection bias (from studying a small sample of firms that are multinational or aware of their real options) by using a broader sample (including non-multinationals and non-aware firms) that allows matching groups based on these covariates or propensities.

Our propensity matching procedure was employed in two stages. In the first stage, we matched multinational and non-multinational firms based on their propensity scores using the predicted values from an explanatory logit model (that includes covariates controlling for past performance and other theory-based MNC drivers, as in eq. (5)) of the likelihood or propensity to go multinational. We implemented similar propensity matching for aware and non-aware firms and combined the matched random samples to perform the second stage regressions based on eq. (4).

5. Results

Table 1 provides descriptive statistics for our main variables. The median firm in our sample has a size of $175 million (=exp(5.169)) and a *ROA* of 1.6%. Based on the way *MULTI* is calculated (=ln(1+M)), the median firm in the sample has foreign subsidiaries in 15 (and the mean firm in 12) countries.

[INSERT TABLE 1 HERE]

Table 2 shows the distribution of our sample firms with a low vs. high degree of managerial real options awareness (*MROA*) among various sectors of the economy. The manufacturing sector (34%) and Chemicals and Pharmaceuticals (18%) exhibit the greatest awareness, followed by Natural Resources/Energy (22%) and Telecom (9%).

[INSERT TABLE 2 HERE]

Table 3 presents the correlation matrix among our explanatory and control variables. There is no clear evidence of serial correlation or multicollinearity. Size exhibits some small insignificant correlation with several variables, having significant correlation with *FFLEX*. We use an interaction term between size and leverage in our model (see eq. 4). A high positive correlation is observed between multinationality (*MULTI*) and managerial real options awareness (*MROA*). Multinationals tend to be more aware of latest or more sophisticated approaches and are more likely to have put in place an organizational real options infrastructure (as suggested by the first-stage regression results). This also motivates the inclusion of an interaction term among these two variables in our model, but its impact proved to be insignificant and thus it was excluded from the final model.

[INSERT TABLE 3 HERE]

The results of the second stage tobit multivariate panel data regressions on 5-year forward downside risk as dependent variable (setting *a=2* in eq. (2)), i.e., *DR(2)*, are shown in Table 4. The upper part of the table documents the impact of our real options driven independent variables on *DR* and the lower panel the impact of the control variables. The impact of the control variables is as predicted and broadly consistent with the literature (see particularly the last, complete Model 3' based on the *model SGO* of eq.4). Significance levels for all models were determined based on standard z-tests, with the corresponding z-statistics shown in parenthesis below each coefficient along with an indication of significance level. Model Wald Chi-Square statistics, along with Log-likelihood, shown at the bottom of each column, indicate the significance of model estimations. All models, as a complete set of variables, are statistically significant at 1%.

Model 0 in Table 4 documents the impact of the control variables, together with firm-specific business volatility (σ). The control variables (except *FFLEX* and its interaction with *SIZE*) are significant. Business uncertainty, measured by a firm's standard deviation of stock returns over the past 36 months, has a negative and significant association with *DR*, consistent with real options theory. Flexibility exercised in high risk environments tends to reduce *DR*. This motivates the inclusion of the real-option driven variables operating flexibility and strategic growth options

(*OFLEX* and *SGO*), as well as *MULTI* and *MROA* in models 1 to 3 (volatility is subsequently omitted from the table to avoid double-counting errors).[74]

Models 1 and 1' in Table 4 highlight the incremental impact of the two main explanatory variables, multinationality (*MULTI*) and managerial real options awareness (*MROA*), given the control variables. These two main real options variables, individually and jointly, seem to help significantly reduce *DR* (beyond the above control variables), consistent with our main hypotheses (H_1 and H_4). The control variables retain their sign when adding explanatory variables to the model, confirming their significant role in helping explain the impact of the main explanatory variables. The interaction of *FFLEX* with size and *SIZE* itself have a significant negative impact (with a higher coefficient than *FFLEX* itself), suggesting that the net effect of *FFLEX* on *DR* is negative. That is, financial leverage may reduce the downside risk for equity holders due to their limited liability option. This logic may help explain why in some cases these three control variables may not follow the predicted signs.[75] The association between financial flexibility, size and *DR* might be negative partly because firms with higher market value of equity (which lowers the leverage ratio measured in market value) may have lower *DR*. Alternatively, it may be that less risky firms can raise more funds from internal sources, needing less external funds to borrow.

Models 2 and 3 in Table 4 show the results incorporating the incremental impact of the other option-driven explanatory variables, *OFLEX*, *SGO* and *ΔSGO.* For comparison and robustness purposes, models 2 and 2' in Table 4 use the *"Implied SGO"* from current market values based on eq. (6), while models 3 and 3' are based on the option-theory instrumented *"Model SGO*" approach described in footnote 21. Models 3 and 3' confirm that operating flexibility (*OFLEX*), reflecting an increase in capital expenditures [or investments and advances to unconsolidated subsidiaries, affiliates and joint ventures in which the parent company has less than 50% control], indicating exercise of past growth options, has a significant negative impact on *DR*. Moreover, based on the *"option model-predicted SGO*" of models 3 and 3', both prior

[74] Firm-specific uncertainty (σ) is included in the first stage regressions (in *MULTI* and *Model SGO*).
[75] This might suggest that the relationship between *FFLEX* and *DR* might be curvilinear due to coordination issues and other cost considerations, and that the structuring features of multinational optionality may lead to more effective coordination inducing a positive association between *FFLEX* and *DR* (i.e., it might be more effective to coordinate and manage optionality in more leveraged firms).

strategic growth options (*SGO)* as well as an increase in strategic flexibility (*ΔSGO*) result in lower *DR*, in line with Hypothesis 3.

The results in all models (1' – 3') also validate Hypothesis 4 concerning the significant role of managerial real options awareness (*MROA*) in reducing downside risk. *MROA* is categorically negative and significant (at least at 5%) in all models. The role of multinationality is also important. *MULTI* appears to have a negative and significant (at least at 5%) impact on *DR* in all models (1 – 3'), validating Hypothesis 1. Furthermore, when both *MULTI* and *MROA* are included in the model (1' – 3') their beneficial impact on reducing *DR* is even stronger (the coefficient of *MULTI* increases when *MROA* is added in the model). This reveals that the *DR* reduction is not an intrinsic characteristic shared by all firms with multinational operations. Rather, a beneficial negative impact of multinational flexibility on *DR* is achieved for those MNCs that have high managerial awareness (and potentially the organizational capability) to effectively exploit their corporate real options to mitigate *DR*.[76] Absent *MROA*, the rising coordination costs of multinational operations might lead to increased or insignificant impact on MNC downside risk. This may help explain the findings of Reuer and Leiblein (2000) that seemed to be contradictory to real options theory predictions. Our overall conclusion is that multinational firms that are managerially aware of their options and possibly have a real options capability in place are better able to manage the *DR* of their operations.

[INSERT TABLE 4 HERE]

In order to further test the validity of our hypotheses, regarding the impact of our explanatory and control variables on firm performance (measured by forward 5-year average *ROA*), we run 2SLS regressions according to eq. (4). The results of the second stage multivariate panel data regressions explaining firm performance measured by forward (5-year average) *ROA* are presented in Table 5. As in Table 4, the upper part of the table presents the impact of our real options driven independent variables on firm performance and the lower panel the impact of the control variables. The impact of the explanatory variables on forward *ROA* is exactly the opposite of that in Table 4 on DR as predicted. The impact of all of these variables on firm

[76] This suggests that these firms might be more hedging active (see Carter *et al*., 2003).

performance is significantly positive (at 10% or higher for *MROA* and at 1% for all other variables), validating Hypotheses 1 – 4. These findings confirm that our results are robust overall, since the *DR* impact is the negative mirror of *ROA*.

The impact of the control variables is also broadly consistent with the literature. Model 0 in Table 5 shows the impact of these control variables, together with firm-specific business volatility (σ). All of the control variables have a significant impact on firm performance as predicted. Business uncertainty has a positive and significant impact on *ROA*, consistent with real options theory. This motivates the inclusion of the real-option driven variables operating flexibility and strategic growth options (*OFLEX* and *SGO*), as well as *MULTI* and *MROA* in models 1 to 3.

Models 1 to 3' in Table 5 show the results incorporating the incremental impact of all option-driven explanatory variables, showing that addition of these variables does not generally affect the impact of the control variables on *ROA*. Our conclusion is that multinational firms that are managerially aware of their options are able to attain better performance (measured by forward 5-year average *ROA*). This is consistent with Hennart's (2007) conjecture regarding how superior managerial characteristics might contribute to superior MNC performance.

[INSERT TABLE 5 HERE]

Eq. (2) gives a general expression for *DR* given the degree *a* of the lower partial moment. *DR* in the strategy literature uses $a = 2$. However, it is interesting to examine the impact of our independent variables at different levels of downside risk moments or power (i.e. $a=1$, $a=2$ and $a=3$). Table 6 shows robustness results of two-stage tobit regressions based on eq. (4) at different levels of *a*. The four columns in the middle of Table 6 labeled *DR(2)* are the same as the last four columns of Table 4, presented for comparison. Our Table 6 results indicate that even for different levels of *a*, significance of main coefficients still holds (with the same signs as in Table 4). Generally we do not observe any remarkable pattern, apart from the fact that many of the coefficients on *DR(1)* are lower than those on *DR(3)*, but higher than those on *DR(2)*. This means that as *a* increases, coefficients may first decrease and then increase with a higher degree *a*. However, higher values of *a* ($a > 3$) do not follow this pattern (results not presented).

[INSERT TABLE 6 HERE]

Table 7 presents the results of tobit two-stage regressions using panel data on 5-year forward Upside Potential as dependent variable. *UP* is calculated based on eq. (3) using three different levels of *a* (*a=1*, *a=2* and *a=3*). The common definition of *UP* in the literature on excess returns uses *a = 1*. Explanatory real options driven variables all have a significant and positive impact on *UP* as expected, validating Hypotheses 1 – 4 concerning impact on upside potential and performance. There is a significant pattern in these results suggesting that the higher the moment of *UP* the higher the coefficient and thus the bigger the impact on the upside potential gain. As far as the control variables are concerned, they exhibit a similar impact on *UP* as they do on *ROA* (see Table 5).

[INSERT TABLE 7 HERE]

More importantly, the upside potential to downside risk ratio more succinctly summarizes the combined effect of our explanatory variables on both DR and UP at different levels of *a*. Table 8 shows the results of our basic model (eq. (4)) using *UP/DR* ratio as a dependent variable and confirms that our main findings remain significantly valid. A standard use of *UP/DR* in the literature would define *a = 1* for *UP* and *a = 2* for *DR*. This "excess performance to downside risk ratio" captures the idea of how investors and managers would behave, striving for excess performance (above-target) profitability while simultaneously wanting to minimize their downside risk exposure. We again observe that all our explanatory variables have a significant positive impact on *UP/DR* ratio while our control variables retain their significance and predicted impact (as in Table 7). There is a pattern in these results suggesting that the higher the moment of *UP* (numerator in the ratio) when *DR(2)* (denominator in the ratio) is kept constant the higher the coefficient and thus the bigger the impact on upside potential.

[INSERT TABLE 8 HERE]

In all five tables reporting our regression results (Tables 4 – 8), the column headed *"Heckman Method"* shows the coefficients of basic Model 3' (described in footnote 22) "corrected" for self-selection bias under the Heckman Method, as discussed in the methodology section of the paper. This model includes an additional variable (*IMR*) to correct for this bias. If *IMR* is significant it means that there is some selectivity bias in our sample and the results are corrected, i.e., we control for selectivity bias. With the inverse Mills ratio included the coefficients on the independent variables represent more consistent estimates of the population in eq. (4). The results are qualitatively consistent with our earlier basic findings indicating that self-selection is not a major issue.

The column headed *"Propensity Score"* in Tables 4 – 8 shows our propensity score matching findings for Model 3'. The overall conclusions regarding our main explanatory variables (reached under both our basic panel data two-stage regressions and the Heckman correction method) also hold under the propensity score tests. The propensity score models have a more restricted sample and hence less predictive power. The overall results are consistent with our earlier predictions, validating Hypotheses 1-4.

Additional variable robustness tests on the basic panel regressions confirm similar results. For example, we have used dummy variables to capture low and high managerial real option awareness instead of the scale variable *MROA* and also run subsample analysis with comparable results.[77] The findings are also robust to inclusion or exclusion of the control variable that uses market data (β) or the variable that controls for industry effects (*IND*).[78] A number of interaction effects were also examined. Concerning the moderating effect of *MROA*, we find that the interaction between *MROA* and *OFLEX* has significant and negative (at 1%) impact on *DR*, implying that managerially aware firms may be more effective in operational hedging and exercising their past growth options.[79] We also find a significant negative association between the interaction of *MULTI and SGO* and firm performance,

[77] The impact of low real options awareness was positive but insignificant in the second-stage regressions, however, suggesting that superficial knowledge without broader organizational capabilities may not be sufficient to ensure superior performance.

[78] The analysis was also done using cross-sectional data and the results broadly resemble those in Table 4. However, preliminary tests (Durbin-Watson, Fama-McBeth procedure and subsample analysis) indicate that the analysis using panel data regressions accounting for fixed-year effects is more suitable.

[79] A positive relationship is observed between *MROA* and *SGO*, potentially suggesting that managerially aware firms may have already exploited much of their growth potential. This accords with findings from Bernardo *et al.* (2007) and Bernardo and Chowdry (2002).

confirming the non-additive interaction effects of multiple portfolio options (Trigeorgis, 1993).[80]

The overall conclusion based on all above procedures is that after accounting for endogeneity, selection-bias, industry and fixed year effects, multinationality, as a flexibility platform, reduces downside risk and enhances upside potential, particularly for firms with higher managerial real options awareness. A higher degree of MROA is associated with lower *DR* and higher firm performance, moderating favorably the impact of multinationality. Operational flexibility and strategic growth options also help reduce *DR* and enhance firm upside potential in a multinational context. [81]

6. Conclusion

This study offers important insights into the joint performance dynamics of real options flexibility in MNCs, highlighting the impact of managerial real options awareness as a flexibility implementation trigger and a risk management tool in multinational operations. Existing research in this area has not explicitly considered this managerial linkage in the structural performance and risk management of the MNC. In this paper we specifically focus on *DR*, *UP*, the *UP/DR* performance ratio, and on forward *ROA* as indicators of MNC performance, while examining the full set of flexibility platforms available to the MNC and their determinants. We explicitly incorporate strategic growth, operating and multinational network switching options under one comprehensive explanatory framework. Beyond these structural real options MNC characteristics, we specifically consider the moderating effect of the managerial real options awareness variable on multinationality, *DR* and *UP*-performance relationship, highlighting both the logic and process of real options management in MNCs.

[80] As a robustness test we use 3-year average forward skewness (based on stock returns) as a Y variable. Results reveal that SGO increases skewness while OFLEX does not affect skewness in a statistically significant manner. Multinationality in itself does not have a positive impact on skewness (consistent with similar related results on DR), though its net effect on skewness is positive and significant at 1% through its strong positive interaction with MROA. To examine whether our option variables may affect performance through positively influencing skewness, we perform 2SLS regressions where we we use the predicted score of past skewness as an instrument variable to explain forward average ROA (instead of using the options variables directly), controlling for SGO, industry effects and other variables. Results confirm that SGO and Skewness are significantly and negatively associated with average forward ROA, consistent with the option-based hypothesis that investors may be willing to accept lower short-term average returns (ROA) in exchange for desireable growth option and skewness attributes.

[81] Joint tests were conducted to test if our explanatory variables are altogether jointly statistically significant (apart from the individual t-tests shown in tables). Results (all $Chi^2(6) > 147.98$) confirm that our explanatory variables are jointly statistically significant at a significance level of 1% (p-value = 0 for all models tested) supporting the validity and strength of our models.

The overall findings confirm our main thesis that multinationality, when supplemented with managerial real options awareness, can be a significant source of competitive advantage for MNCs. Multinational firms that are managerially aware of their options are able to attain lower *DR* and higher *UP*. Based on accounting, financial, market and fundamental data on US listed firms for the period 1996-2009, we show that when both growth options features and the degree of real options awareness are taken into consideration, multinationality lowers *DR* and affects firm *UP* positively. This contradicts the main conclusion of Reuer and Leiblein (2000) which questioned the applicability of real options theory in the MNC context. Our main findings lend new support to the validity of real options theory and help clarify the managerial conditions for its applicability. We confirm a significant impact of operating flexibility and strategic growth options on MNC downside risk and *UP* as predicted by real options theory. Our main conclusion is that the beneficial impact of multinational flexibility on downside risk and firm upside potential is brought out and is more pronounced for firms with a higher degree of managerial real options awareness. Absent real options awareness and related organizational adaptive capability, mere multinational operations do not guarantee lower *DR* or improved *UP* as suggested by transaction costs economics. Our findings thus help explain the mixed and inconclusive results in prior literature.

The above findings should be interpreted with some caveats. The dataset includes those MNCs which have invested in developing a managerial real options awareness and companies which have not, based on public and secondary information during the period 1996-2009. Extending the study period post-2009 to include the later period of global financial instability and heightened uncertainty might provide additional insights into the real options characteristics of multinational investment activities. However, going back prior to 1996 may result in a different structural period with lower or little managerial real options awareness.

We should also acknowledge that our key explanatory variables MULTI and MROA embed significant conceptual and practical difficulties in measuring. The notion of multinationality (and multinational flexibility) has evolved and may mean different things to different people depending on focus. Our perspective is more appropriate when looking at multinationality as a network of flexible switching operations (options). Managerial awareness is a limited, first attempt to measure the tip of the iceberg involving a more general and deeper adaptive organizational

capability. This study was limited by lack of systematic public data regarding these measures. Thus the only way to acquire needed data was via hand-collection of attributes that could be rather readily obtained and categorized (e.g., the number of foreign subsidiaries or whether there was public evidence of low or high managerial awareness). This procedure was time-consuming and may contain human or categorization errors. We made attempts to correct for selection bias and endogeneity issues acknowledging that a limited number of data regarding these variables is used.

We should also caution that foreign business operations may add own skewness and contribute to the resulting impact on multinational performance independent of the multinational switching option flexibility. We leave it for future research to control for foreign or global skewness factor or relative global Tobin's Q (see e.g. Doidge, Karolyi and Stulz, 2004) to account for a potential automatic relationship between foreign business skewness and multinationality.

Our view is that this relationship is not automatic but it materializes through the exercise of switching and other related real options. We cannot readily control for such an automatic relationship (if it exists) but have argued that the effect of enhanced skewness on performance is taking place through option related variables (including MULTI and MROA). Skewness plays an important role in the broader area of investment decisions (including real options and multinationality) and the relation of performance and skewness is indeed very important and relevant. In effect we examine the drivers of enhanced skewness (including MULTI, MROA and other option-related variables) and their relation with firm performance. The above issues can also be examined at the industry level through extended future datasets since different industry-related restrictions and characteristics may result in differential findings.

Despite the limited time frame of our study, the resulting implications for multinational finance and MNC risk management are quite evident. Firms should make investments in learning, knowledge acquisition and awareness building, developing an organizational real options capability to effectively exploit the benefits of MNC flexibility in their operating and strategic decision processes. This should enable more effective planning, structuring and managing of their global network of operations to take better advantage of changes in input prices, demand and other environmental factors. Multinational organizations need to develop adequate organizational systems and practices to proactively deal and cope with uncertainty

and effectively manage and exercise their multinational real options. Managerial awareness and effective adaptive capability may equip MNCs with the necessary decision apparatus to effectively manage their global risk exposures and benefit from differentials in global factor markets.

Our overall results confirm that effective option-based management of multinational operations can result in both lower downside risk and enhanced upside potential. The ability of management to recognize and effectively manage real options can determine the success of MNC international strategy. When real options are developed and exploited appropriately through increased managerial awareness, minimal *DR* exposure and improved *UP* is likely to follow. However, this depends on firm specific characteristics, the drivers of FDI and the determinants of real options awareness and learning. Acquiring the necessary knowledge and putting in place necessary infrastructure investments to enhance real options awareness within organizations should be a priority on managers' agendas in these times of uncertainty.

Our results are consistent with the theoretical predictions of real options theory, suggesting that effective real options decision-making can be a source of competitive advantage for multinational firms in an uncertain and changing global market environment. These findings also help address some recent questions raised by a number of strategic management scholars regarding the pertinence of real options management in business strategy (e.g., Coff and Laverty, 2001; Carr, 2002; Adner and Levinthal, 2004; Reuer and Leiblein, 2000; Tong and Reuer, 2007), and call for further theoretical and empirical research that goes beyond the basic real options logic to also consider behavioral, structural and infrastructural elements of real options management in corporate decision-making.

TABLES

Table 1. Descriptive statistics

Variable	Mean	Median	S.D.
DR	0,257	0,011	1,076
MULTI	2,590	2,810	1,350
MROA	0,870	0,693	0,202
OFLEX	0,330	0,030	0,200
SGO	0,630	0,490	1,290
FFLEX	-1,315	-0,988	1,169
SIZE	5,045	5,169	2,831
β	0,950	0,890	0,500
DISTR	0,120	0,001	0,321
ROA	-0,152	0,016	0,718
σ	1,906	0,424	0,899

The overall sample consists of 5879 firms listed in Compustat database during 1996-2005. Of these, 165 firms were classified as managerially aware; 158 were MNCs and the rest (5721) were domestic (non-MNC) firms.
DR: downside risk measuring below–target (e.g. industry median ROA) performance $DR = \sqrt{\frac{1}{5}\sum_{ROA<IMROA}(MROA - ROA)^2}$
where *IMROA*: industry median ROA over subsequent 5 year period
MULTI: degree of multinationality, *MROA*: degree of managerial real options awareness, *OFLEX*: operational flexibility measured as the change in capital expenditures (Capex), *SGO*: strategic growth options, measured by regressing option-related variables on *SGO* (instrumental model approach) based on recent 3-year industry data {*SGO* = f (business uncertainty, asymmetry, organizational slack, firm growth, cash flow coverage, market power, R&D intensity)}, *FFLEX*: financial flexibility captured by leverage measured as (the natural logarithm of) total liabilities divided by firm market value, *SIZE*: size measured as the natural logarithm of total assets, *β:* beta calculated based on 36 monthly returns, *DISTR*: distress proxy (dummy with value of 1 if book value is negative or zero and 0 otherwise), *ROA*: Return on assets ratio, *σ*: firm-specific volatility or business uncertainty calculated based on 36 monthly returns.

Table 2. Distribution of firms with Managerial Real Options Awareness (MROA)

	MROA			
Sector	Low	High	Total	
Manufacturing	34	22	56	34%
Telecommunications	7	8	15	9%
Food & Drinks	4	1	5	3%
Chemicals & Pharma	13	16	29	18%
Electricity & Energy	13	5	18	11%
Petroleum Refining	4	6	10	6%
Mining Oil & Gas	3	6	9	5%
Other	17	8	25	15%
Total	93	72	165	

Table 3. Correlation matrix

Variable	*MULTI*	*MROA*	*OFLEX*	*SGO*	*FFLEX*	*SIZE*	*β*	*DISTR*	*ROA*	*σ*
MULTI	1.0000									
MROA	0.7282	1.0000								
OFLEX	-0.0003	-0.0004	1.0000							
SGO	-0.0408	-0.0555	-0.0060	1.0000						
FFLEX	0.0206	0.0269	-0.1004	-0.1584	1.0000					
SIZE	0.2561	0.3157	-0.0327	-0.3127	0.3025	1.0000				
β	0.0247	0.0168	-0.0329	0.0666	-0.1032	0.1048	1.0000			
DISTR	-0.0251	-0.0354	-0.0285	0.1938	0.1245	-0.2610	-0.0013	1.0000		
ROA	0.0360	0.0474	0.0162	-0.3626	0.0845	0.3810	-0.0102	-0.4372	1.0000	
σ	-0.0032	-0.0045	-0.0041	0.0068	-0.0046	-0.0002	0.0084	0.0067	-0.0027	1.0000

The overall sample consists of 5879 firms listed in Compustat database during 1996-2005. Of these, 165 firms were classified as managerially aware; 158 were MNCs and the rest (5721) were domestic (non-MNC) firms.

DR: downside risk measuring below–target (e.g. industry median ROA) performance

$$DR = \sqrt{\frac{1}{5}\sum_{ROA<IMROA}(MROA - ROA)^2}$$

where *IMROA*: industry median ROA over subsequent 5 year period

MULTI: degree of multinationality, *MROA*: degree of managerial real options awareness, *OFLEX*: operational flexibility measured as the change in capital expenditures (Capex), *SGO*: strategic growth options, measured by regressing option-related variables on *SGO* (instrumental model approach) based on recent 3-year industry data {*SGO* = f (business uncertainty, asymmetry, organizational slack, firm growth, cash flow coverage, market power, R&D intensity)}, *FFLEX*: financial flexibility captured by leverage measured as (the natural logarithm of) total liabilities divided by firm market value, *SIZE*: size measured as the natural logarithm of total assets, *β:* beta calculated based on 36 monthly returns, *DISTR*: distress proxy (dummy with value of 1 if book value is negative or zero and 0 otherwise), *ROA*: Return on assets ratio, *σ*: firm-specific volatility or business uncertainty calculated based on 36 monthly returns.

Table 4. Tobit two-stage regressions using panel data on 5-year forward Downside Risk as dependent variable (DR(2) on ROA)

					Implied SGO		Model SGO		Heckman	Propensity
Independent Variables	Predicted	Model 0	Model 1	Model 1'	Model 2	Model 2'	Model 3	Model 3'	Method	Score
Multinationality (MULTI)^{L}	–		-0.436 (-10.65)***	-0.573 (-16.68)***	-0.491 (-16.38)***	-0.007 (-2.45)**	-0.008 (-3.83)***	-0.001 (-2.40)**	-0.007 (-2.14)**	-0.003 (-2.22)**
Managerial Real Options Awareness (MROA)^{L}	–			-0.809 (-38.67)***	-1.085 (-39.44)***	-0.028 (2.24)**	-0.083 (-3.53)***	-0.029 (-2.12)**	-0.027 (-2.10)**	-0.057 (-2.34)**
Operating Flexibility (OFLEX)	–				-0.241 (-2.80)***	-0.241 (-2.63)***	-0.219 (-11.16)***	-0.059 (-2.20)**	-0.066 (-2.74)***	-0.256 (-6.44)***
StrategicGrowth Options (SGO)^{L}	–				0.021 (3.36)***	0.058 (2.53)**	-0.049 (-12.16)***	-0.004 (-3.19)***	-0.006 (-3.30)***	-0.067 (-8.38)***
Change in Strategic Growth Options (ΔSGO)	–				-0.012 (-1.87)*	-0.050 (-2.39)**	-0.007 (-1.54)	-0.031 (-1.63)*	-0.033 (-1.62)*	-0.014 (-1.65)*
Financial Flexibility (FFLEX)^{L}	–	-0.028 (-1.25)	0.034 (2.24)**	-0.038 (-1.96)**	-0.100 (-4.00)***	0.015 (0.18)	-0.010 (-2.88)***	-0.028 (-1.97)**	-0.028 (-1.98)**	-0.023 (-3.72)***
Firm Size (SIZE)^{L}	–	-0.027 (-5.22)***	-0.070 (-24.02)***	-0.018 (-4.55)***	0.004 (0.95)	0.009 (0.48)	-0.033 (-9.93)***	-0.002 (-0.88)	-0.004 (-1.45)	-0.016 (-6.89)***
Interaction (SIZE*FFLEX)^{L}		0.004 (1.19)	-0.005 (-2.31)**	0.003 (0.15)	0.006 (1.91)*	-0.003 (-0.31)	-0.003 (-4.12)***	-0.003 (-2.00)**	0.003 (2.04)**	0.006 (4.93)***
Systematic Risk (β)^{L}	+	0.034 (6.35)***	0.023 (5.70)***	0.021 (4.09)***	0.040 (5.81)***	0.102 (5.25)***	-0.002 (-1.97)**	0.009 (5.07)***	0.011 (5.37)***	0.002 (0.69)
Distress (DISTR)^{L}	+	-0.039 (-1.93)*	-0.029 (-2.19)**	0.029 (1.94)*	0.035 (1.91)*	-0.011 (-0.16)	0.009 (19.68)***	0.004 (0.71)	0.001 (0.89)	0.016 (16.69)***
Industry (IND)		0.106 (3.18)***	-0.135 (-5.65)***	0.042 (1.65)*	-0.060 (-1.35)	-0.035 (-3.10)***	0.098 (12.38)***	-0.011 (-1.35)	-0.007 (-0.88)	0.125 (8.85)***
Return on Assets (ROA)^{L}	–	-0.449 (-11.93)***	-0.419 (-13.58)***	-0.513 (-15.90)***	-0.518 (-13.11)***	-0.962 (-5.48)***	-0.397 (-7.89)***	-0.217 (-10.54)***	-0.216 (-10.56)***	-0.482 (-4.86)***
Business Uncertainty (σ)^{L}	–	-0.039 (5.16)***								
Selection Bias correction - Inverse Mill's Ratio (IMR)									-0.016 (-2.34)**	
Wald chi^2		470.42***	1830.77***	2542.25***	3383.10***	160.67***	1022.05***	240.18***	249.29***	441.47***
Log likelihood		251.64	215.70	162.07	75.99	62.98	100.19	119.86	120.15	219.39

*p<0.10, **p<0.05, ***p<0.01
^{L} lagged (t-1)
z-statistics are in parentheses

Model 2', Model 3', Heckman Method and Propensity Score use the predicted value of *MULTI* as an instrumental variable using $MULTI=f(MCON_{i,t-1}, INTANG_{i,t-1}, \sigma_{i,t-1}, RD_{i,t-1}, ROA_{i,t-1}, MULTI_{i,t-1}, SIZE_{i,t-1})$

$DR_{i,t}$: firm *i*'s downside risk measuring below–target (e.g. industry median ROA) performance $DR = \sqrt{\frac{1}{5}\sum_{ROA<IMROA}(IMROA - ROA)^2}$
where *IMROA*: industry median ROA over subsequent 5 year period
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$FFLEX_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry downside risk level at time *t*
$ROA_{i,t-1}$: firm *i*'s Return on Assets ratio at time *t-1*.
$\sigma_{i,t-1}$: firm-specific volatility or business uncertainty for firm *i* in year *t-1*,
$MCON_{i,t-1}$: firm *i*'s market concentration at time *t-1*,
$INTANG_{i,t-1}$: firm *i*'s intangible assets at time *t-1*,
$RD_{i,t-1}$: firm *i*'s research and development (R&D) intensity at time *t-1*.

Table 5. Two-stage least squares (2SLS) regressions using panel data on forward (5-year average) ROA as dependent variable

					Implied SGO		Model SGO		Heckman	Propensity
Independent Variables	Predicted	Model 0	Model 1	Model 1'	Model 2	Model 2'	Model 3	Model 3'	Method	Score
Multinationality (MULTI)^L	+		0.036	0.023	0.019	0.011	0.006	0.015	0.021	0.006
			(5.76)***	(3.57)***	(2.91)***	(2.22)**	(2.93)***	(3.50)***	(2.78)***	(2.47)**
Managerial Real Options Awareness (MROA)^L	+			0.441	0.422	0.021	0.093	0.042	0.044	0.111
				(8.43)***	(7.94)***	(7.88)***	(2.62)***	(1.63)*	(1.67)*	(3.01)***
Operating Flexibility (OFLEX)	+				0.313	0.120	0.467	0.365	0.369	0.469
					(11.75)***	(10.96)***	(14.83)***	(3.35)***	(3.39)***	(13.57)***
StrategicGrowth Options (SGO)^L	+				-0.082	-0.036	0.105	0.017	0.015	0.105
					(-37.71)***	(-5.66)***	(16.60)***	(3.39)***	(3.35)***	(15.24)***
Change in Strategic Growth Options (ΔSGO)	+				0.025	0.013	0.003	0.160	0.159	0.006
					(14.81)***	(2.53)**	(10.05)***	(3.58)***	(3.54)***	(3.81)***
Financial Flexibility (FFLEX)^L	–	-0.039	-0.038	-0.039	-0.006	0.005	-0.044	-0.158	-0.159	-0.033
		(-8.00)***	(-7.97)***	(-8.04)***	(-1.08)	(0.19)	(-8.29)***	(-5.57)***	(-5.60)***	(-5.56)***
Firm Size (SIZE)^L	+	0.127	0.128	0.130	0.108	0.007	0.039	0.005	0.007	0.042
		(57.42)***	(57.69)***	(58.34)***	(43.06)***	(11.44)***	(15.94)***	(10.98)***	(11.45)***	(15.37)***
Interaction (SIZE*FFLEX)^L		-0.018	-0.019	-0.019	-0.022	-0.008	-0.003	-0.011	-0.011	-0.005
		(-17.26)***	(-17.46)***	(-17.46)***	(-19.32)***	(-2.80)***	(-2.95)***	(-3.77)***	(-3.80)***	(-4.08)***
Systematic Risk (β)^L	–	-0.013	-0.013	-0.013	-0.007	-0.032	-0.006	-0.028	-0.029	-0.007
		(-5.82)***	(-5.82)***	(-5.85)***	(-2.88)***	(-6.15)***	(-3.24)***	(-6.89)***	(-6.95)***	(-3.75)***
Distress (DISTR)^L	–	-0.012	-0.012	-0.012	-0.014	-0.004	-0.003	-0.006	-0.007	-0.003
		(-24.78)***	(-24.77)***	(-24.70)***	(-26.07)***	(-4.18)***	(-4.24)***	(-4.43)***	(-4.48)***	(-2.76)***
Industry (IND)		1.617	1.604	1.615	1.558	0.220	0.860	0.229	0.246	0.907
		(28.93)***	(28.70)***	(28.91)***	(26.16)***	(2.92)***	(16.58)***	(2.94)***	(3.09)***	(15.84)***
Business Uncertainty (σ)^L	+	0.002								
		(4.65)***								
Selection Bias correction - Inverse Mill's Ratio (IMR)									0.014	
									(0.98)	
Overall R^2		0.199	0.201	0.206	0.269	0.369	0.446	0.542	0.543	0.496
Wald chi^2		9245.73***	9266.45***	9351.19***	9869.11***	3330.05***	2052.77***	3363.90***	3463.22***	1756.16***

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

Model 2', Model 3', Heckman Method and Propensity Score use the predicted value of *MULTI* as an instrumental variable using $MULTI=f(MCON_{i,t-1}, INTANG_{i,t-1}, \sigma_{i,t-1}, RD_{i,t-1}, ROA_{i,t-1}, MULTI_{i,t-1}, SIZE_{i,t-1})$

$ROA_{i,t-1}$: firm *i*'s forward long-term (5-year average) Return on Assets ratio as of time *t-1*.
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$FFLEX_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry downside risk level at time *t*
$\sigma_{i,t-1}$: firm-specific volatility or business uncertainty for firm *i* in year *t-1*,
$MCON_{i,t-1}$: firm *i*'s market concentration at time *t-1*,
$INTANG_{i,t-1}$: firm *i*'s intangible assets at time *t-1*,
$RD_{i,t-1}$: firm *i*'s research and development (R&D) intensity at time *t-1*.

Table 6. Robustness on DR(a): Tobit two-stage regressions using panel data on forward (5-year average) Downside Risk as dependent variable

		DR(1)				DR(2)				DR(3)			
		Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity
Independent Variables	Predicted	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score
Multinationality (MULTI)^{L}	–	-0.004 (-3.19)***	-0.002 (-2.70)***	-0.009 (-1.98)*	-0.002 (-1.61)*	-0.008 (-3.83)***	-0.001 (-2.40)**	-0.007 (-2.14)**	-0.003 (-2.22)**	-0.010 (-3.38)**	-0.001 (-2.26)**	-0.008 (-1.65)*	-0.001 (-1.67)*
Managerial Real Options Awareness (MROA)^{L}	–	-0.021 (-4.66)***	-0.070 (-2.28)**	-0.090 (-2.38)**	-0.067 (-2.27)**	-0.083 (-3.53)***	-0.029 (-2.12)**	-0.027 (-2.10)**	-0.057 (-2.34)**	-0.031 (-4.70)***	-0.066 (2.23)**	-0.090 (-2.33)**	-0.063 (-2.22)**
Operating Flexibility (OFLEX)	–	-0.038 (-6.69)***	-0.087 (-2.47)**	-0.077 (-2.18)**	-0.087 (-3.47)***	-0.219 (-11.16)***	-0.059 (-2.20)**	-0.066 (-2.74)***	-0.256 (-6.44)***	-0.394 (-6.11)***	-0.089 (-2.32)**	-0.079 (-2.18)**	-0.090 (-3.33)***
StrategicGrowth Options (SGO)^{L}	–	-0.028 (-2.94)***	-0.031 (-3.32)***	-0.034 (-2.41)**	-0.032 (-3.32)***	-0.049 (-12.16)***	-0.004 (-3.19)***	-0.006 (-3.30)***	-0.067 (-8.38)***	-0.036 (-2.76)***	-0.032 (-3.17)***	-0.034 (-2.25)**	-0.032 (-3.17)***
Change in Strategic Growth Options (ΔSGO)	–	-0.039 (-3.81)***	-0.032 (-1.62)*	-0.038 (-1.72)*	-0.033 (-1.61)*	-0.007 (-1.54)	-0.031 (-1.63)*	-0.033 (-1.62)*	-0.014 (-1.65)*	-0.036 (-3.27)***	-0.008 (-2.28)**	-0.085 (-1.65)*	-0.008 (-1.69)*
Financial Flexibility (FFLEX)^{L}	–	-0.022 (-3.37)***	-0.054 (-2.89)***	-0.054 (-2.90)***	-0.054 (-2.87)***	-0.010 (-2.88)***	-0.028 (-1.97)**	-0.028 (-1.98)**	-0.023 (-3.72)***	-0.038 (-3.47)***	-0.049 (-2.33)**	-0.049 (-2.34)**	-0.049 (-2.31)**
Firm Size (SIZE)^{L}	–	-0.036 (-8.20)***	-0.017 (-4.08)***	-0.018 (-4.39)***	-0.017 (-4.06)***	-0.033 (-9.93)***	-0.002 (-0.88)	-0.004 (-1.45)	-0.016 (-6.89)***	-0.038 (-7.44)***	-0.016 (-3.60)***	-0.018 (-3.87)***	-0.016 (-3.58)***
Interaction (SIZE*FFLEX)^{L}		-0.002 (-12.83)***	-0.005 (-2.47)**	0.005 (2.46)**	0.005 (2.45)**	-0.003 (-4.12)***	-0.003 (-2.00)**	0.003 (2.04)**	0.006 (4.93)***	-0.002 (-11.46)***	-0.003 (-1.84)*	0.003 (1.82)*	0.004 (1.81)*
Systematic Risk (β)^{L}	+	0.003 (1.16)	0.006 (2.29)**	0.015 (3.29)***	0.006 (2.29)**	-0.002 (-1.97)**	0.009 (5.07)***	0.011 (5.37)***	0.002 (0.69)	0.005 (1.39)	0.004 (1.67)*	0.033 (2.24)**	0.004 (1.65)*
Distress (DISTR)^{L}	+	0.011 (7.40)***	0.004 (5.86)***	0.004 (5.74)***	0.004 (5.85)***	0.009 (19.68)***	0.004 (0.71)	0.001 (0.89)	0.016 (16.69)***	0.011 (6.92)***	0.004 (4.58)***	0.004 (4.47)***	0.004 (4.58)***
Industry (IND)		0.079 (8.53)***	0.062 (1.81)*	0.059 (1.73)*	0.062 (1.80)*	0.098 (12.38)***	-0.011 (-1.35)	-0.007 (-0.88)	0.125 (8.85)***	0.066 (8.38)***	0.037 (1.49)	0.035 (1.42)	0.036 (1.48)
Return on Assets (ROA)^{L}	–	-0.021 (-14.45)***	-0.095 (-3.74)***	-0.095 (-3.72)***	-0.095 (-3.73)***	-0.397 (-7.89)***	-0.217 (-10.54)***	-0.216 (-10.56)***	-0.482 (-4.86)***	-0.024 (-14.66)***	-0.090 (-3.09)***	-0.089 (-10.56)***	-0.090 (-3.10)***
Selection Bias correction - Inverse Mill's Ratio (IMR)				0.018 (1.96)*				-0.016 (-2.34)**				-0.016 (-2.34)**	
Wald chi^{2}		3116.81***	149.77***	154.47***	148.83***	1022.05***	240.18***	249.29***	441.47***	2226.21***	112.91***	249.29***	108.52***
Log likelihood		324.50	107.85	108.04	107.31	100.19	119.86	120.15	219.39	283.75	101.58	120.15	100.91

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

Model 2', Model 3', Heckman Method and Propensity Score use the predicted value of *MULTI* as an instrumental variable using $MULTI=f(MCON_{i,t-1}, INTANG_{i,t-1}, \sigma_{i,t-1}, RD_{i,t-1}, ROA_{i,t-1}, MULTI_{i,t-1}, SIZE_{i,t-1})$

$$DR_{i,t} = \sqrt{\frac{1}{5}\sum_{ROA<IMROA}(MROA - ROA)^2}$$

$DR_{i,t}$: firm *i*'s downside risk measuring below–target (e.g. industry median ROA) performance
where *IMROA*: industry median ROA over subsequent 5 year period
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$FFLEX_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry downside risk level at time *t*
$ROA_{i,t-1}$: firm *i*'s Return on Assets ratio at time *t-1*.
$\sigma_{i,t-1}$: firm-specific volatility or business uncertainty for firm *i* in year *t-1*,
$MCON_{i,t-1}$: firm *i*'s market concentration at time *t-1*,
$INTANG_{i,t-1}$: firm *i*'s intangible assets at time *t-1*,
$RD_{i,t-1}$: firm *i*'s research and development (R&D) intensity at time *t-1*.

Table 7. Tobit two-stage regressions using panel data on forward (5-year average) Excess Performance/Upside Potential as dependent variable

		UP(1)				UP(2)				UP(3)			
		Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity
Independent Variables	Predicted	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score
Multinationality (MULTI)^{L}	+	0.003 (2.33)**	0.003 (1.91)*	0.004 (1.78)*	0.006 (2.26)**	0.004 (2.89)***	0.004 (2.05)**	0.008 (2.12)**	0.011 (2.33)**	0.004 (2.79)***	0.005 (2.03)**	0.009 (2.19)**	0.012 (2.31)**
Managerial Real Options Awareness (MROA)^{L}	+	0.019 (2.50)**	0.043 (2.45)**	0.042 (2.43)**	0.054 (1.65)*	0.023 (2.43)**	0.066 (2.45)**	0.064 (2.42)**	0.081 (1.64)*	0.025 (2.38)**	0.079 (2.42)**	0.077 (2.39)**	0.097 (1.71)*
Operating Flexibility (OFLEX)	+	0.052 (2.89)***	0.008 (2.25)**	0.009 (2.31)**	0.020 (2.56)**	0.081 (2.35)**	0.007 (2.16)**	0.003 (2.08)**	0.040 (1.99)**	0.100 (2.27)**	0.018 (2.34)**	0.013 (2.24)**	0.080 (2.14)**
StrategicGrowth Options (SGO)^{L}	+	0.025 (6.81)***	0.002 (2.13)**	0.002 (2.17)**	0.004 (2.03)**	0.028 (4.05)***	0.003 (2.16)**	0.004 (2.22)**	0.013 (2.07)**	0.030 (3.35)***	0.033 (2.16)**	0.047 (2.22)**	0.018 (2.08)**
Change in Strategic Growth Options (ΔSGO)	+	0.005 (1.72)*	0.003 (1.73)*	0.003 (2.08)**	0.003 (1.69)*	0.008 (2.32)**	0.005 (2.21)**	0.005 (1.78)*	0.006 (1.77)*	0.009 (2.25)**	0.006 (2.23)**	0.006 (1.71)*	0.007 (1.71)*
Financial Flexibility (FFLEX)^{L}	–	-0.007 (-2.27)**	-0.007 (-2.64)***	-0.006 (-2.62)***	-0.014 (-1.69)*	-0.013 (-2.21)**	-0.004 (-2.30)**	-0.004 (-2.28)**	-0.119 (-2.71)***	-0.016 (-2.14)**	-0.022 (-2.13)**	-0.017 (-2.10)**	-0.010 (-2.48)**
Firm Size (SIZE)^{L}	+	0.019 (12.40)***	0.008 (3.47)***	0.008 (3.54)***	0.011 (3.84)***	0.025 (8.43)***	0.011 (3.34)***	0.011 (3.45)***	0.014 (3.72)***	0.027 (7.42)***	0.012 (3.08)***	0.013 (3.21)***	0.016 (3.41)***
Interaction (SIZE*FFLEX)^{L}		0.002 (3.49)***	0.005 (2.54)**	0.005 (2.52)**	0.013 (1.68)*	0.004 (3.38)***	0.002 (2.20)**	0.002 (2.16)**	0.002 (1.70)*	0.005 (3.35)***	0.002 (1.92)*	0.001 (1.82)*	0.009 (1.64)*
Systematic Risk (β)^{L}	–	-0.005 (-2.55)**	-0.004 (-3.11)***	-0.004 (-3.19)***	-0.007 (-4.51)***	-0.004 (-1.71)*	-0.007 (-3.94)***	-0.007 (-4.07)***	-0.011 (-5.56)***	-0.009 (-2.36)**	-0.009 (-4.18)***	-0.009 (-4.33)***	-0.014 (-5.75)***
Distress (DISTR)^{L}	–	-0.008 (-7.61)***	-0.009 (-2.26)**	-0.010 (-2.30)**	-0.002 (-1.64)*	-0.014 (-6.12)***	-0.002 (-2.42)**	-0.002 (-2.49)**	-0.003 (-2.54)**	-0.018 (-5.67)***	-0.003 (-1.68)*	-0.004 (-2.55)**	-0.004 (-2.56)**
Industry (IND)		0.009 (0.28)	0.010 (0.40)	0.011 (0.42)	0.032 (1.95)*	0.009 (0.24)	0.002 (0.14)	0.003 (0.18)	0.019 (1.82)*	0.011 (0.29)	0.004 (0.03)	0.013 (1.58)	0.017 (1.74)*
Return on Assets (ROA)^{L}	+	0.194 (14.02)***	0.087 (6.55)***	0.088 (6.53)***	0.090 (5.66)***	0.271 (9.86)***	0.152 (8.03)***	0.151 (8.01)***	0.160 (7.50)***	0.317 (7.26)***	0.187 (8.11)***	0.186 (8.09)***	0.197 (7.64)***
Selection Bias correction - Inverse Mill's Ratio (IMR)				-0.004 (-1.75)*				-0.007 (-1.78)*				-0.010 (-1.78)*	
Wald chi^{2}		2652.92***	102.62***	103.27***	100.08***	1530.12***	143.10***	144.56***	152.49***	1298.80***	145.90***	147.69***	156.88***
Log likelihood		1647.77	1347.51	1347.79	903.49	2695.18	1170.33	1170.91	793.03	965.80	1071.61	1072.31	724.71

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

Model 2', Model 3', Heckman Method and Propensity Score use the predicted value of *MULTI* as an instrumental variable using $MULTI=f(MCON_{i,t-1}, INTANG_{i,t-1}, \sigma_{i,t-1}, RD_{i,t-1}, ROA_{i,t-1}, MULTI_{i,t-1}, SIZE_{i,t-1})$

$UP_{i,t}$: firm *i*'s upside potential measuring above–target (e.g. industry median ROA) performance where *IMROA*: industry median ROA over subsequent 5 year period

$$UP_{i,t} = \sqrt{\frac{1}{5}\sum_{ROA>IMROA}(ROA - IMROA)^2}$$

$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$FFLEX_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
$SIZE_{i,t-1}$: firm *i*'s size (total assets) at time *t-1*,
$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry upside potential level at time *t*
$ROA_{i,t-1}$: firm *i*'s Return on Assets ratio at time *t-1*.
$\sigma_{i,t-1}$: firm-specific volatility or business uncertainty for firm *i* in year *t-1*,
$MCON_{i,t-1}$: firm *i*'s market concentration at time *t-1*,
$INTANG_{i,t-1}$: firm *i*'s intangible assets at time *t-1*,
$RD_{i,t-1}$: firm *i*'s research and development (R&D) intensity at time *t-1*.

Table 8. Tobit two-stage regressions using panel data on forward Excess Performance/Upside Potential to Downside Risk Ratio as dependent variable

		UP(1)/DR(2)				UP(2)/DR(2)				UP(3)/DR(2)			
		Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity	Model SGO		Heckman	Propensity
Independent Variables	Predicted	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score	Model 3	Model 3'	Method	Score
Multinationality (MULTI)^{L}	+	0.025 (2.27)**	0.015 (2.75)***	0.010 (2.59)***	0.004 (2.66)***	0.031 (2.29)**	0.018 (2.74)***	0.013 (1.62)*	0.002 (1.87)*	0.035 (2.32)**	0.020 (2.75)***	0.014 (1.63)*	0.002 (1.66)*
Managerial Real Options Awareness (MROA)^{L}	+	0.057 (2.37)**	0.066 (2.38)**	0.084 (1.72)*	0.016 (2.23)**	0.073 (2.47)**	0.083 (1.74)*	0.106 (1.82)*	0.086 (2.56)**	0.083 (2.53)**	0.093 (1.72)*	0.119 (1.89)*	0.007 (1.84)*
Operating Flexibility (OFLEX)	+	0.048 (1.64)*	0.069 (1.83)*	0.065 (1.78)*	0.029 (2.35)**	0.057 (1.61)*	0.081 (1.79)*	0.076 (1.74)*	0.030 (2.24)**	0.062 (1.61)*	0.088 (1.78)*	0.082 (1.72)*	0.017 (1.74)*
StrategicGrowth Options (SGO)^{L}	+	0.009 (1.65)*	0.007 (2.47)**	0.006 (2.37)**	0.009 (2.23)**	0.010 (1.62)*	0.009 (1.74)*	0.007 (2.37)**	0.003 (2.08)**	0.011 (1.61)*	0.010 (2.48)**	0.008 (2.37)**	0.003 (2.08)**
Change in Strategic Growth Options (ΔSGO)	+	0.005 (1.75)*	0.004 (2.17)**	0.003 (2.16)**	0.003 (1.71)*	0.006 (2.25)**	0.005 (2.18)**	0.004 (2.16)**	0.003 (1.66)*	0.006 (2.25)**	0.005 (2.18)**	0.005 (2.16)**	0.003 (1.70)*
Financial Flexibility (FFLEX)^{L}	–	-0.015 (-1.73)*	-0.018 (-1.75)*	-0.017 (-2.38)**	-0.037 (-2.16)**	-0.018 (-1.62)*	-0.023 (-2.53)**	-0.021 (-1.71)*	-0.020 (-2.53)**	-0.021 (-2.42)**	-0.025 (-1.75)*	-0.023 (-1.73)*	-0.002 (-1.71)*
Firm Size (SIZE)^{L}	+	0.001 (2.29)**	0.010 (1.84)*	0.012 (2.06)**	0.030 (2.00)**	0.011 (2.25)**	0.013 (1.84)*	0.015 (2.08)**	0.003 (1.63)*	0.001 (2.24)**	0.014 (1.88)*	0.016 (2.13)**	0.003 (1.71)*
Interaction (SIZE*FFLEX)^{L}		-0.004 (-2.13)**	-0.005 (-1.90)*	-0.005 (-1.99)**	-0.003 (-4.42)***	-0.006 (-2.16)**	-0.006 (-1.95)*	-0.006 (-1.93)*	-0.003 (-3.59)***	-0.007 (-2.18)**	-0.007 (-1.98)**	-0.007 (-1.96)**	-0.003 (-3.45)***
Systematic Risk (β)^{L}	–	0.006 (1.48)	0.004 (0.85)	0.005 (0.99)	-0.002 (-1.96)**	0.007 (1.34)	0.004 (0.72)	0.005 (0.86)	-0.003 (-2.31)**	0.007 (1.24)	0.004 (0.62)	0.005 (0.77)	-0.004 (-3.01)***
Distress (DISTR)^{L}	–	-0.007 (-2.45)**	-0.008 (-2.39)**	-0.007 (-2.34)**	-0.009 (-1.61)*	-0.007 (-1.77)*	-0.005 (-2.00)**	-0.004 (-2.15)**	-0.001 (-1.63)*	-0.002 (-1.68)*	-0.003 (-1.69)*	-0.001 (-2.04)**	-0.001 (-1.64)*
Industry (IND)		-0.169 (-0.24)	-0.607 (-0.76)	-0.637 (-0.79)	0.064 (2.31)**	-0.093 (-0.15)	-0.483 (-0.67)	-0.514 (-0.72)	0.061 (2.36)**	-0.058 (-1.01)	-0.481 (-0.67)	-0.515 (-0.71)	0.167 (2.15)**
Return on Assets (ROA)^{L}	+	0.029 (1.91)*	0.026 (1.58)	0.026 (1.65)*	0.012 (2.73)***	0.037 (1.99)**	0.034 (1.65)*	0.032 (1.57)	0.015 (3.03)***	0.042 (2.03)**	0.038 (1.68)*	0.036 (1.60)	0.015 (3.15)***
Selection Bias correction - Inverse Mill's Ratio (IMR)				-0.085 (-1.64)*				-0.105 (-1.75)*				-0.117 (-1.61)*	
Wald chi^{2}		29.02***	25.86***	28.24***	133.33***	29.48***	26.18***	28.65***	120.62***	29.76***	26.54***	29.10***	135.09***
Log likelihood		3843.19	3520.66	3519.48	7839.87	5750.92	5181.05	5179.81	6768.38	6709.18	6019.45	6018.18	7163.76

**p<0.10, **p<0.05, ***p<0.01*
^{L} *lagged (t-1)*
z-statistics are in parentheses

Model 2', Model 3', Heckman Method and Propensity Score use the predicted value of *MULTI* as an instrumental variable using $MULTI=f(MCON_{i,t-1}, INTANG_{i,t-1}, \sigma_{i,t-1}, RD_{i,t-1}, ROA_{i,t-1}, MULTI_{i,t-1}, SIZE_{i,t-1})$

$$UP_{i,t} = \sqrt{\frac{1}{5}\sum_{ROA>IMROA}(ROA - IMROA)^2}$$

$$DR_{i,t} = \sqrt{\frac{1}{5}\sum_{ROA<IMROA}(MROA - ROA)^2}$$

$UP_{i,t}$: firm *i*'s upside potential measuring above–target (e.g. industry median ROA) performance
$DR_{i,t}$: firm *i*'s downside risk measuring below–target (e.g. industry median ROA) performance
where *IMROA*: industry median ROA over subsequent 5 year period
$MULTI_{i,t-1}$: firm *i*'s degree of multinationality at time *t-1*,
$MROA_{i,t-1}$: firm *i*'s degree of managerial real options awareness at time *t-1*,
$OFLEX_{i,t}$: firm *i*'s operational flexibility (increase in capital expenditures) in year *t*,
$SGO_{i,t-1}$: firm *i*'s preexisting strategic growth options at time *t-1*,
$\Delta SGO_{i,t}$: firm *i*'s change in strategic growth options in year *t*,
$FFLEX_{i,t-1}$: firm *i*'s market-value leverage at time *t-1*,
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$\beta_{i,t-1}$: firm *i*'s systematic risk (beta) at time *t-1*,
$DISTR_{i,t-1}$: firm *i*'s distress indicator (dummy) at time *t-1*,
$IND_{i,t}$: firm *i*'s median industry upside potential level at time *t*
$ROA_{i,t-1}$: firm *i*'s Return on Assets ratio at time *t-1*.
$\sigma_{i,t-1}$: firm-specific volatility or business uncertainty for firm *i* in year *t-1*,
$MCON_{i,t-1}$: firm *i*'s market concentration at time *t-1*,
$INTANG_{i,t-1}$: firm *i*'s intangible assets at time *t-1*,
$RD_{i,t-1}$: firm *i*'s research and development (R&D) intensity at time *t-1*.

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