

International investment decisions under uncertainty: Contributions of real options theory and future directions

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Abstract

We undertake a critical literature review to facilitate academic dialogs regarding decisions under uncertainty in international business settings and highlight the growing focus on international investments as conveyers of real options. Our literature review (1) provides a systematic overview of uncertainty types considered in this literature, real options identified as particular to international investments, and valuation approaches used and (2) highlights key methodological approaches used for testing real options models applied to international investments, and the controversies in this regard. This study draws on the above to shed light on important avenues for future research including (a) the need for more fine-grained and diverse measures of uncertainty in the international context, (b) an emphasis on clarifying the value effects of combinations of real options, and (c) the necessity of further consideration of the costs of options along with the value.

Keywords: multinational corporations, international business, foreign direct investment, real options theory, uncertainty

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INTRODUCTION

International expansion is one of the most crucial strategic decisions confronted by a firm, as it involves significant investment and bears far-reaching consequences for firm performance. Such investments are exposed to heightened uncertainty stemming from diverse exogenous sources, such as unanticipated fluctuation in currency exchange rates, unexpected changes in host market demand and political instability (Campa, 1993; Allen & Pantzalis, 1996; Tong & Reuer, 2007; Belderbos & Zou, 2009; Chung, Lee, Beamish, & Isobe, 2010; Cuypers & Martin, 2010), making it valuable for firms to retain flexibility in choosing from alternative courses of action that best suit newly emerging and unanticipated conditions. International situations amplify the uncertainty faced by firms (Lee & Makhija, 2009a, 2009b; Chung et al., 2010), which in turn increases the need for real options in foreign investments. All else being equal, due to the higher risk associated with international investments than comparable domestic investments, international decisions present a strong case for managers to employ real options reasoning. It is for this reason that international business (IB)

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researchers increasingly draw on real options logic to understand how multinational firms can best structure their international investments.

According to real options theory, firms can structure investments in ways that 'keep their options open' under uncertainty (McDonald & Siegel, 1986; Dixit, 1989; Kogut, 1991; Dixit & Pindyck, 1994; Bowman & Hurry, 1998), and preserve future decision rights (Kogut, 1991; Tong & Reuer, 2007). Real options investments enhance upside potential through preferential access to currently unknown future growth opportunities embedded in the markets in which they operate, or reduce downside risk by allowing the firm to abandon initial investments at low cost (Kogut, 1991; Kogut & Kulatilaka, 1994a; Tong, Reuer, & Peng, 2008). Foreign direct investments (FDI) are also characterized by such real options. FDI can be structured as a foothold into a foreign market, holding the option open for subsequent incremental or full scale commitment in this location (Kogut & Chang, 1996; Tong, Reuer, & Peng, 2008; Belderbos & Zou, 2009). Structuring FDI as a trial entry into host countries can also cushion downside risk of future investments (Tong & Reuer, 2007). If conditions in the foreign country become adverse to its strategy, the firm can stop investing and limit losses to the (relatively low) sunk costs associated with the discontinued project (McGrath, 1997). It can also shift sales to other existing investment locations to take advantage of higher prices or increasing demand (Lee & Song, 2012). In this way, IB researchers employ real options logic in order to understand how international investments can be structured to provide the firm with strategic flexibility under uncertainty and competition (Smets, 1993; Lee & Makhija, 2009a, 2009b; Cuyppers & Martin, 2010; Tan & Wang, 2010; Azevedo & Paxson, 2014).

International investments provide some unique advantages for the testing of real options arguments, which might explain the recent burgeoning of research on this topic. The significant levels of a variety of uncertainties characterizing the international context (e.g., economic crisis in Asian countries in the late 1990s, exchange rate volatility in Latin American countries, institutional and demand volatility in BRICs, banking crisis of the United States and Europe in 2007, etc.) allows researchers to better account for this critical element of real options valuation. The types of real options associated with international investments (e.g., growth and switching) have complementary attributes that facilitate our ability to compare and contrast the conditions under which their value increases, thus improving our understanding of how the nature of real options relates to or matches a particular form of uncertainty. Finally, the variety of international investments possessed by the typical multinational enterprise (MNE) facilitates detailed consideration of intricate issues pertaining to real options such as interacting and competing options.

Due to the highly suitable conditions of IB for real option research, studies on international investments using a real options lens have been on the rise. An assessment of this body of work that allow us to clearly recognize key issues and problems relating to real option arguments applied to the international context would be highly valuable. In contrast to reviews of real options studies in strategic management (e.g., Li, James, Madhavan, & Mahoney, 2007; Tong & Reuer, 2007; Driouchi & Bennett, 2012), the few reviews in the international arena (e.g., Li, 2007; Ahsan & Musteen, 2011) do not focus on identifying superior approaches and best practices in the literature, highlighting critical theoretical 'holes' in real options logic that require further investigation, and clarifying major pitfalls such as 'reinventing the wheel' through excessive replication.

The purpose of this article is to address these limitations. We examine the extant literature by (1) employing a systematic framework that takes into account IB-specific uncertainties as the primary driver for real options value and their connection to the types of real options embedded in international investments, (2) considering the pros and cons of key methodological approaches used thus far for testing real options models for international investments, and (3) shedding light on important avenues for future research. To accomplish the goals above, we review over 113 articles published in a wide range of journals that focus on economics, finance, strategic management, and IB, in order to gain a

comprehensive understanding of this literature. While the great majority of these articles are empirical, ~15% are theoretical in nature. We begin below by examining how researchers have addressed, both theoretically and empirically, key elements of the real options approach with respect to international investments, beginning with uncertainty as the primary driver for real options value, and followed by a discussion of the types, valuation, and exercise of real options. Finally, we present an agenda for further research.

REVIEW OF THE LITERATURE

In this section, we review the literature on real options relating to international investments. To do so, we begin by outlining the key precepts of real options logic, and then discuss the application of this logic to FDI in IB. Next, in order to do justice to the large number of studies using a real options approach for international investments, we employ a systematic framework for reviewing this literature, treating different types of real options embedded in international investments as a predictor, uncertainties in the international environment as a moderator, and the value and exercise of real options as outcomes.

Real options approach to decision making under uncertainty

Real options logic has become an important theoretical tool in analyzing the causes and consequences of an investment under high uncertainty. This theory suggests that under conditions of high uncertainty, firms can use various types of strategic investments to 'keep their options open' (Kogut, 1991; Dixit & Pindyck, 1994; Chi & McGuire, 1996; Folta, 1998; Chi, 2000; Schwartz & Trigeorgis, 2001; Kumar, 2005; Tong, Reuer, & Peng, 2008; Cuypers & Martin, 2010). Real options embedded within an investment enable the firm to redirect its strategy with reduced penalty as new market information emerges, competitors' actions revealed, and uncertainty is resolved, such as increasing the investment, changing the nature of the investment, or withdrawing it completely.

This logic of real options applies particularly to decision making under uncertainty. Myers (1977) paved the way to analyze an organization's investment decisions by real options thinking and stimulated a volume of scholarly works of this regard. He noted that many corporate assets or projects contain growth opportunities for future choice with call options that can be later abandoned, deferred, expanded, or contracted in response to changing circumstances. In the similar vein, Kogut (1991) argued that joint ventures are undertaken in order to intentionally create flexibility and so may be viewed as call options, which carry future decision rights. Sanchez (1993) argued that the 'option lens' applies to firm's resource allocation, sense making, learning, and strategic positioning. Similarly, Bowman and Hurry (1993) viewed the capabilities and assets of an organization as a bundle of options for future strategic choices and thus modeled capital investments as a series of 'option chains.' So managers use real options logic to position assets across a wide variety of possible future market states (Amram & Kulatilaka, 1999), and the claims on future rents enable firms to buffer against the risk of failure (McGrath, 1997). And flexibility embedded in toehold investment prevents firms from being exposed to sunk-cost or irreversible investment risks in developing myriad capabilities (Bowman & Hurry, 1993; Amram & Kulatilaka, 1999).

The discussion above suggests strong consensus by international scholars that, consistent with other types of firm investments, embedded options within FDI can provide valuable flexibility to firms under uncertainty. Nonetheless, it is important to note that firms face a number of unique types of uncertainties in the international context that differ significantly from the market-related uncertainties typically discussed in the mainstream literature, including exchange rate volatilities, country-level uncertainties such as those stemming from institutional or governmental flux, and local demand

uncertainty. In addition, FDI are characterized by a set of options that are distinct from those identified for other types of investments, which can be grouped into switching and growth options. The next three sections therefore focus specifically on these unique international elements of real option investments. Since uncertainty is the starting point of real options logic, we review this issue first in the section below, followed by a discussion of the nature of real options in international investments, and then their valuation (Figure 1).

Uncertainties in IB

Uncertainty in production costs, market demand, and institutions, is a key issue for firms to address (Kogut, 1991; Folta, 1998; Vassolo, Anand, & Folta, 2004; Kumar, 2005; Santoro & McGill, 2005; Jones & Yeoman, 2009; Elango, 2010). The notion of uncertainty refers to the inability to anticipate future developments in events that are exogenous or endogenous to the firm. When future events are associated with uncertainty, the best approach to take at the time of investment becomes less clear. There is a danger of being locked into one course of action that could turn out to be inappropriate as circumstances unfold. Under these conditions, an investment characterized by options that enable a firm to take advantage of unanticipated opportunities would be valuable to the firm.

Real options theory assumes that managers are able to write contracts that provide implicit or explicit claims on future follow-on opportunities (Chi & McGuire, 1996). The preferential claim allows firms to benefit by exercising the option when uncertainty is resolved favorably and to limit downside risk by killing the option when uncertainty is resolved unfavorably. In essence, MNEs are able to derive real options value from their international investments by responding to favorable and unfavorable change in uncontrollable environmental factors in asymmetrical ways (Allen & Pantzalis, 1996; Tang & Tikoo, 1999; Miller & Folta, 2002; Lee & Song, 2012). The real options literature puts particular emphasis on the exogenous uncertainty faced by a firm, rather than on sources of uncertainty that are endogenous to the firm (Ahsan & Musteen, 2011).

In contrast to endogenous uncertainty, the creation and resolution of exogenous uncertainty is unaffected by the actions of the firm (Roberts & Weitzman, 1981; Chi & Seth, 2002), making it more difficult to assess its impact in advance to structuring the investment. For instance, volatility in currency exchange rates is exogenous to the firm since these rates are determined in atomistic markets

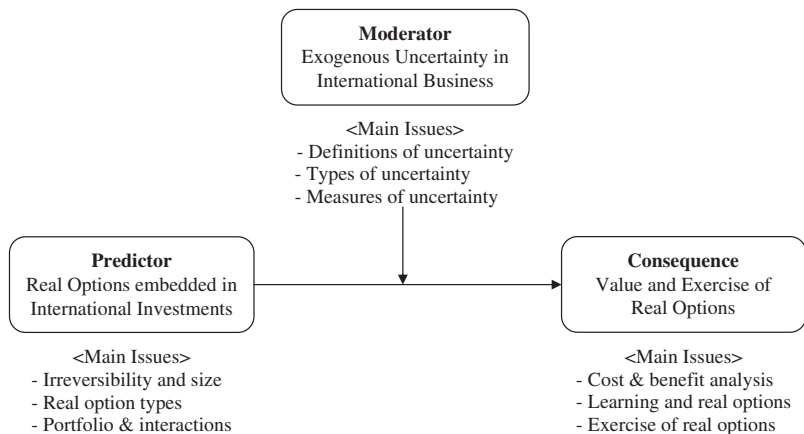


FIGURE 1. A FRAMEWORK FOR REAL OPTIONS THEORY IN THE INTERNATIONAL CONTEXT

over which it has little control (Campa, 1993; Pantzalis, Simkins, & Laux, 2001; Cuypers & Martin, 2010). In contrast, endogenous uncertainty is believed to be more under the control of firms, and can be reduced by engaging in learning activities (Roberts & Weitzman, 1981; McDonald & Siegel, 1986; Folta, 1998; Chi & Seth, 2002; Cuypers & Martin, 2010). Findings by Tong and Reuer (2006) confirm this, showing that exogenous uncertainty relating to a country's property rights or political instability leads firms toward the explicit option to acquire stakes in their international joint ventures, whereas endogenous uncertainty stemming from cultural differences among partners is not. By the same token, Cuypers and Martin's (2010) empirical comparison of exogenous uncertainty (exchange rate volatility, demand fluctuation, and institutional change) and endogenous uncertainty (relating to capabilities, resources, and culture) in international joint ventures (IJVs) in China showed that IJV partners choose minority ownership under each type of exogenous uncertainty, but none of the types of endogenous uncertainty. These findings underscore the role of exogenous uncertainty as the key driver of the value of real options investments.

The types of uncertainties identified by researchers as relevant for international investments fall into several levels of analysis, including uncertainty relating to the economic connections among countries, such as exchange rate volatility (Campa, 1993, Goldberg & Kolstad, 1995, Belderbos & Zou, 2009), uncertainty at the country level, including economy-wide flux (Lee & Makhija, 2009a, 2009b) and institutional risk (Grewal & Tansuhaj, 2001; Lee, Beamish, Lee, & Park, 2009; Chung et al., 2010), as well as uncertainty related to more localized elements within host countries, such as market or industry demand movements (Campa, 1993; Goldberg & Kolstad, 1995; Kumar, 2005). The different approaches in the literature to uncertainty relating to the international context are discussed below.

Exchange rate uncertainty

Numerous researchers have noted that rapid and unanticipated changes in the value of host countries' currencies have the potential to affect a firm's operation and performance in foreign markets (Belderbos & Zou, 2009, Lee & Makhija, 2009a, 2009b). For example, Campa (1993) studied the impact of exchange rate volatility on foreign entry, and Lee and Makhija (2009a, 2009b), and Cuypers and Martin (2010) studied the impact of unexpected exchange rate fluctuations in domestic markets on real options value or real option based behavior of MNEs. Huchzermeier and Cohen (1996), Pantzalis, Simkins and Laux (2001), and Miller and Reuer (1998a, 1998b) examined the real option value effects of such asymmetrical responses to differing unanticipated movements in exchange rates (i.e., appreciation [vs.] depreciation). Similarly, Lee and Song (2012) assessed whether MNEs reallocate production levels of subsidiaries differently depending on whether they are located in countries characterized by currency depreciation or appreciation. The findings of these studies support the importance of real options investments under exchange rate uncertainty.

Since uncertainty reflects unanticipated change, its measurement poses significant problems since it is not easily captured. Thus, a critical issue with regard to exchange rate uncertainty is the way in which it is measured. In this respect, we find that two approaches have been predominantly used by researchers examining exchange rate uncertainty. One is the approach adopted by Campa (1993) and Goldberg and Kolstad (1995), in which the standard deviation of monthly exchange rates is used to capture the impact of exchange rate volatility on FDI entry. Belderbos and Zou (2009) also use annual volatility of exchange rates of nine Asian countries before and after Asian economic crisis during 1995–1999 to examine the impact of exchange rate uncertainty on foreign subsidiary exits. To explain FDI timing, type and mode of entry, Hauser's (2005) measure in this regard takes into account the yearly standard deviation of monthly residuals in a country, divided by the mean exchange rate level for the year. This method is also employed by Darby, Hallett, Ireland, and Piscitelli (1999). Song, Makhija, and Lee (2014) also employed this method for computing exchange rate volatility in their study on differences between within- and across-country flexibility.

A second approach, seen in more recent studies, involves a more sophisticated econometric method to capture volatility. An example is Lee and Makhija (2009a, 2009b) who study of the impact of exchange rate volatility of Korean currency on the real options value of international investments of Korean MNEs using a generalized autoregressive conditional heteroskedasticity (GARCH) model to compute annual volatility in exchange rates using monthly foreign exchange of Korean currency and stock price of Korean MNEs. A GARCH model offers significant advantages over the standard deviation approach discussed above. One advantage is that it better captures the unanticipated change in exchange rates that gives rise to uncertainty. Another advantage in employing a GARCH model in real options research is that it enables to control for any trends that might exist for each period in the time series data (Folta & O'Brien, 2004). Cuypers and Martin's (2010) measurement of exchange rate volatility as the ratio of the difference between average annual official rate and average annual parallel rate out of average annual official rate can be applied to the contexts where a central government plans and intervene official exchange rates in its domestic market.

Country-level uncertainty

Some real options researchers have identified and utilized conditions of significant and abrupt change in the macroeconomic environment of a given country context as an important source of uncertainty and relevant for testing real options arguments. For instance, Chung and Beamish (2005), Grewal and Tansuhaj (2001), and Chung et al. (2010) use the backdrop of the Asian economic crisis during 1997–1999, during which local stock prices fell precipitously and unexpectedly in each country affected by an average of 50%. Interestingly, Chung and Beamish (2005) find that during this period, wholly owned greenfield subsidiaries are more likely to survive than greenfield JVs and acquired wholly owned subsidiaries. Lee and Makhija (2009a) also use the context of the Korean economic crisis that occurred in late 1997 to assess whether firms used their international investments flexibly to accommodate the uncertainty. These studies employed a natural experiment approach to study the effects of unanticipated change in a country's macroeconomic context on real options investments.

A number of other studies compare countries in terms of the relative uncertainty of their particular macroeconomic environments. In this regard, Hauser (2005) utilize the EUROMONEY country risk index to study effects of differing levels of host country risk on ownership level in IJVs. By the same token, Erramilli and D'Souza (1995) create a dummy variable that distinguishes between entries into low-risk and high-risk countries for their study on FDI entry strategies. Cuypers and Martin (2010) consider the effects of institutional riskiness for IJVs, based on whether or not they operate in special economic zones or open coastal cities. Reuer and Tong (2005) examine risk relating to property rights and political upheaval for the explicit option to acquire in an IJV. These studies all use existing measures of institutional or country risk to assess uncertainty.

Demand uncertainty

Changes in a host country's industry structure or fluctuations in local market demand can be highly unanticipated, and may require the firm to rapidly adapt its operations to these newly emerging conditions. For this reason, researchers have also focused on industry- or demand-level uncertainties within a host country. For example, Folta and Miller (2002) argue that the level of demand uncertainty and size of the market have a combined effect on option value. To assess product market uncertainty, Kogut (1991) measured the difference between actual and forecasted shipment growth rates in order to examine the value of real options associated with international joint ventures. He found that such uncertainty influenced the value of these options, which were a platform investment to monitor the market. Campa (1993) and Goldberg and Kolstad (1995) use a similar approach to examine the influence of uncertain market demand on FDI entry timing. On the other hand, some other scholars have measured demand uncertainty with Likert-type questions that reflect the potential size and

growth rate of the target market. Although an unusual approach in the literature, an example of this is Brouthers and Dikova's (2010) study of a sample of Western European firms entering the emerging economies of Eastern Europe.

The types of uncertainty in the international environment considered by researchers are illustrated in Table 1.

Real options embedded in international investments

The nature of real options embedded in international investments typically fall into two categories – growth and switching. Below we discuss the nature and characteristics of each of these types of options as well as the measures used to assess them.

Growth options

Due to their ability to minimize firm outlays, minority investments, strategic alliances, or joint ventures are thought to help firms retain flexibility under high exogenous uncertainty as compared with majority investments or acquisitions (Kogut, 1991; Folta, 1998; Chi, 2000; Tong, Reuer, & Peng, 2008; Cuypers & Martin, 2010; Li & Li, 2010; Reuer & Tong, 2010). For example, Kogut (1991) found that firms tend to choose international joint ventures as growth options under high demand uncertainty level and adjust the choice according to the changing market condition. Similarly, Chi (2000) and Chi and McGuire (1996) argue that strategic alliances as growth options investments are low-cost vehicles for learning about and from partners. Tong, Reuer, and Peng (2008) find that minority international joint ventures carry more growth options value, from their empirical analysis of Stern Stewart's annual rankings of the 1,000 largest US publicly traded companies based on their Market Value Added. Relevantly, Reuer and Tong (2010) find that established firms are more likely to form partnerships with firms after an initial public offering due to more visibility of firms having an initial public offering, which can help investors recognize the embedded growth opportunities and garner their alliance activities. Cuypers and Martin (2010) also find that exogenous uncertainty related to exchange rates, demand, or institution in Chinese context leads foreign multinational corporations to choose minority joint ventures with Chinese firms. Similarly, Li and Li (2010) also find that MNEs tend to choose more flexible rather than more committed ownership strategies that allow for future adjustment of investment decisions under high uncertainty in China.

Switching options

While growth options focus on the growth potential in a host country market, the option to switch reflects a need for change in the firm's current strategies from one country to another. When an MNE faces an unpredictable foreign environment, it has difficulty in adapting its strategy to new circumstances, which can in turn negatively affect its overall international operations and performance (Rivoli & Salorio, 1996). Under these circumstances, it needs to be able to reallocate resources flexibly to other host countries in response to abrupt changes in any given host country. The external uncertainty faced by the firm may be due to fundamental shifts in the level of demand or the relative costs of inputs. These abrupt changes in factor and product markets require it to hastily adjust or even radically reconfigure its value chains in response to new opportunities for, or threats to, profitable production (Kogut, 1991).

A bundle of investments can in fact enhance options to switch operations across countries, allowing the firm to change its strategies in line with environmental fluctuations. In particular, research shows that firms gain operational flexibility through cross-country shifts in its value chain activities when operating or market conditions in one country becomes much less advantageous (Allen & Pantzalis, 1996; Tang & Tikoo, 1999). In that regard, Allen and Pantzalis (1996), Lee and Makhija (2009b),

TABLE 1. UNCERTAINTY TYPES AND MEASURES IN THE INTERNATIONAL REAL OPTIONS LITERATURE

| <i>Uncertainty type</i> | <i>Measurement</i> | <i>Dependent variable</i> |
|---|--|-----------------------------------|
| Exchange rate uncertainty | | |
| Campa (1993) | Standard deviation of the monthly change in exchange rate | FDI entry |
| Goldberg and Kolstad (1995) | Standard deviation of exchange rates over rolling samples of twelve quarters of data, normalized by the mean within the interval | FDI entry |
| Kogut and Chang (1996) | Real exchange rates between Yen and Dollar over time | FDI timing/entry |
| Hauser (2005), Lee and Song (2012), Song, Makhija, and Lee (2014) | Yearly standard deviation of monthly residuals in a country, divided through the mean of the exchange rate level in that year | FDI timing/type entry mode |
| Cuypers and Martin (2010) | Parallel market premium = $\frac{\text{laverage annual official rate} - \text{average annual parallel rate}}{\text{average annual official rate}}$ | IJV ownership |
| Belderbos and Zou (2009) | Annual volatility of exchange rates of nine Asian countries before/after Asian economic crisis 1995–1999 | Exits of foreign subsidiaries |
| Lee and Makhija (2009a, 2009b) | Annual volatility of exchange rates of Korean won relative to US dollar over times | Real options value |
| Macroeconomic shocks | | |
| Chung and Beamish (2005) | Economic crisis in five Asian countries | IJV Divestment |
| Grewal and Tansuhaj (2001) | Asian economic crisis in Thailand | Performance |
| Chung et al. (2010) | Asian economic crisis | New subsidiaries |
| Dikova et al. (2013) | Unexpected financial crises in the countries | Switching (vs.) growth options |
| Institutional flux | | |
| Cuypers and Martin (2010) | Location in special economic zone or open coastal cities | IJV ownership |
| Reuer and Tong (2005) | Risk relating to property right and political conditions | Explicit option to acquire in IJV |
| Country risk | | |
| Erramilli and D'Souza (1995), | A dummy variable that distinguishes between entries into lower-risk and high-risk countries | IJV ownership |
| Hauser (2005) | A composite risk variable, the Euromoney country risk index | Entry time/modes |
| Brouthers, Brouthers, and Werner (2008) | Three Likert-type questions regarding the stability of the political, social and economic conditions, the risk of repatriating income, and the risk of government actions against the firm | Entry mode/performance |
| Demand uncertainty | | |
| Kogut (1991) | Difference between actual and forecast shipment growth rates | JV buyouts |
| Campa (1993) | Standard deviation of the monthly change in demand | FDI entry |
| Goldberg and Kolstad (1995) | Standard deviation of market demand over rolling samples of twelve quarters of data, normalized by the mean within the interval | FDI entry |
| Brouthers and Dikova (2010) | Demand uncertainty measured with two Likert-type questions about potential size and growth rate of the target market | Entry mode choice |
| Li and Li (2010) | Squared standard error of sales growth during the previous 5 years | Entry mode |

Note: FDI = foreign direct investments; IJV = international joint ventures; JV = joint ventures.

and Tang and Tikoo (1999) find the real options value of multinationality or high breadth of FDI. Also consistent with this argument, it has been reported that a broader network of countries enables firms to arbitrage markets by shifting production factors across national borders and by transferring resources within their network of affiliates located in one or more foreign countries (Kogut & Kulatilaka, 1994b; Tang & Tikoo, 1999; Lee & Makhija, 2009a; Chung et al., 2010). FDI characterized by options to switch across countries allow the firm to mitigate effects of major currency swings and corresponding economic exposure that bring about changes in relative factor costs across national environments (Allen & Pantzalis, 1996; Kogut & Chang, 1996; Miller & Reuer, 1998a, 1998b). Relevantly, Huchzermeier and Cohen (1996) find the enhanced value of switching value chain activities following cross-country currency swings. Recently, Chung et al. (2010) examined MNEs' exit decision from the across-country switching options perspective and commonly argued that MNEs having more switching options in their FDIs have less exit rates among their foreign subsidiaries. Similarly, Lee and Song (2012) found that MNEs are able to relocate their production volume from more costly locations to less costly ones. On the other hand, Reuer and Leiblein (2000) and Tong and Reuer (2007) raised the possibility that MNEs may not enjoy the value of multinationality due to complex management and costly coordination of dispersed operations across countries. On the other hand, Dikova, Smeets, Garretsen, and van Ees (2013), found that switching options are more helpful than growth options when firms are faced with unexpected financial crises in the countries in which they operate.

Note that these two types of options contrast greatly – while growth options imply limited levels of investment initially, switching options require significant levels of investments diversified across countries. They also imply greatly contrasting levels of ownership and control within the firm's FDI portfolio. Relevantly, Song, Makhija, and Lee (2014) examined contrasting impact of two types ownership on the real options value of multinationality from two options perspective.

Table 2 summarizes these key options types embedded in international investments as discussed in the IB literature.

Real options benefits of international investments

Thus far we have identified the differing forms of uncertainty associated with the international environment highlighted by researchers and the types of options they have attributed to international investments. In this section, we consider the key dependent variable of the relationship between uncertainty and real options – the value derived by firms from their real options investments. Researchers typically consider real options value from the point of view of enhanced upside potential and minimized downside risk.

Upside potential

Chi and McGuire (1996) argue that the presence of an explicit option clause in joint ventures will depend on three conditions: (1) the level of uncertainty, (2) the anticipation of a change in the relative bargaining power between the two parties during their collaboration, and (3) *ex ante* asymmetry among both parties in their expected pay-offs of the option. Based on this logic, Chi and McGuire (1996) and Chi (2000) developed empirical real options models to rigorously investigate the conditions under which options provided by JVs are valuable. Both studies concluded that the real options value of a JV is higher when partners have divergent expectations of the value of the joint assets. On the one hand, the partner with higher valuation is willing to pay a higher price than the other partner, which results in a mutually beneficial trade in their stakes. On the other hand, if partners have similar valuation with respect to the joint venture, the option to acquire cannot be realized and partners cannot benefit from any trade in their stakes, thereby leading to lower value of the option to acquire.

TABLE 2. OPTIONS TYPES IN THE INTERNATIONAL REAL OPTIONS LITERATURE

| <i>Research</i> | <i>Investment type</i> | <i>Option type</i> | <i>Dependent variables</i> |
|--|------------------------|--------------------|--|
| Campa (1993) | FDI | Growth | FDI entry under demand, exchange rate uncertainty |
| Chi and McGuire (1996) | Strategic alliances | Growth | Smaller share in JVs is positively related to market, partner-related, legal uncertainty |
| Chi (2000) | Strategic alliances | Growth | Learning and valuing Joint ventures |
| Reuer and Tong (2005), Tong, Reuer, and Peng (2008) | Joint venture | Growth | Growth options value of IJVs: (1) No. of JVs; (2) No. of minority JVs; (3) No. of non-core JVs; (4) No. of JVs in developing countries |
| Cupyers and Martin (2010) | Joint venture | Growth | IJV ownership under exogenous and endogenous uncertainty |
| Li and Li (2010) | Joint venture | Growth | MNEs tend to choose more flexible ownership strategies under high uncertainty in China |
| Reuer and Tong (2010) | Partnership | Growth | Firms tend to form partnership with firms after an initial public offering to seek for growth opportunities |
| Kogut and Kulatilaka (1994b), Huchzermeier and Cohen (1996), Lee and Makhija (2009a) | FDI | Switching | The impact of exchange rate uncertainty and switch across countries |
| Allen and Pantzalis (1996), Tang and Tikoo (1999) | FDI | Switching | Value of multinational flexibility by FDI breadth and depth |
| Reuer and Leiblein (2000), Tong and Reuer (2007) | FDI/Joint ventures | Switching | Downside risk reduction effect of multinationality and IJVs |
| Chung et al. (2010) | FDI | Switching | Divestment of foreign subsidiaries in five Asian crisis-stricken countries during Asian economic crisis 1995–1999 |
| Dikova et al. (2013) | FDI | Switching/Growth | Switching options are more helpful than growth options when firms face unexpected financial crises in their host countries |
| Song, Makhija, and Lee (2014) | FDI | Growth/Switching | Real options value of differing levels of FDI breadth and ownership |

Note: FDI = foreign direct investments; IJV = international joint ventures; JV = joint ventures; MNE = multinational enterprise.

Researchers have developed multiple measures to assess real option value. For example, Tobin's q is used as a standardized measure of the value ascribed to a firm by investors. In a typical Tobin's q formula, the denominator (i.e., book value of total assets) represents the investment input in the firm, and the numerator (i.e., market value of common stock + book value of preferred stock + book value of debt) captures the value created by the firm with these inputs (Lee, Makhija, & Paik 2008; Lee & Makhija, 2009a, 2009b). While alternative measures such as return on equity or return on asset are expected to differ across firms depending on the risk of the firm, Tobin's q is a 'forward looking' measure that adjusts for such risk. Since the market value of the firm depends on the growth potential of the firm, as well as the efficiency of management to actualize it, Tobin's q as a performance measure has been suggested to be more appropriate than other short-run measures such as return on equity or return on asset (Lee, Makhija, & Paik, 2008). Similarly, stock ratio is also used to assess forward-looking value of the firm, measured by market value over book value of common stock (Folta & O'Brien, 2004). Nonetheless, these measures have also been criticized for the fact that they reflect values generated by multiple firm activities and not just those relating to real options. These confounding effects are thought to reduce the appropriateness of Tobin's q and similar measures for assessing real options value (Tong & Reuer, 2007). In an effort to address this criticism, Bulan (2005) eliminated Tobin's q models using observations with more than 20% changes in book value to control for possible M&A activities.

Some other ways to measure additional value associated with real options have also been introduced in the international literature. For example, in order to measure the value of flexibility derived from firms' international investments, Allen and Pantzalis (1996), Thomas and Eden (2004), and Song, Makhija, and Lee (2014) use the firm's excess market value, or the ratio of market value plus the book value of debt minus total assets, all divided by total net sales. They extract the excess market value of each MNE from the averaged excess market value of all the domestic firms in the same industry, which reflects the value of multinational flexibility of the MNE. Tong and Reuer (2007), and Tong, Reuer, and Peng (2008) decompose the value of the firm into the value of assets in place and the value of future growth opportunities (V_{GO}), which is measured by the firm's total market value (V) less the capitalized value of its current earnings stream (i.e., current earnings/discount rate). Thus, a firm's growth option value is computed as V_{GO}/V .

While the measures above impute flexibility through assessment of additional value created by an option under uncertainty, Lee and Makhija (2009a) developed new measures in order to assess actual operational flexibility created by options within international investments. One such measure of operational flexibility is the use of a firm's preexisting export platform investments for sales to new customers when faced with environmental uncertainty. To assess this, they subtracted the firm's export sales to its foreign subsidiaries and to existing long-term customers from its total export sales, and then divided the resulting value by the firm's total export sales. A second measure captured the extent to which the firm actually shifted its production or sales from one foreign investment location to another in response to increases in uncertainty.

Downside risk

A firm's investments may also provide options that limit the likelihood of below-target performance outcomes, referred to as downside risk (Miller & Reuer, 1996; Reuer & Leiblein, 2000). Thus, several measures of downside risk have been utilized in order to assess whether options embedded in international investments to reduce the firm's downside losses. Miller and Reuer (1996) argue that downside risk measures should explicitly incorporate the notion of reference (i.e., target or aspiration) levels and therefore address decision makers' tendency to consider risk in terms of negative outcomes or hazard rather than as variance in outcomes, as is typical in empirical research in the field. Thus, in contrast to traditional variance-based measures of risk that incorporate the entire distribution of firm

performance, more recent measures of downside risk intend to solely capture organizational outcomes below some target values (Reuer & Leiblein, 2000; Tong & Reuer, 2007).

Reuer and Leiblein (2000) used three measures of downside risk operationalized by return on asset, return on equity, and financial beta to examine whether firms are able to take advantage of international wholly owned investments and IJVs to reduce their downside losses. Surprisingly, they found that neither type of investment reduced downside risk. They attributed lack of significant effects to multinational complexity and costly coordination over foreign subsidiaries. Using the same measures, Tong and Reuer (2007) investigated the relationship between multinationality and downside risk, moderated by ownership level at the FDI portfolio level and cultural distance between host and home countries. They found that multinationality has a U-shaped relationship to downside risk. Based on these findings, the authors argued that downside risk initially falls as firms enter more foreign countries, and later rises due to high coordination costs of highly dispersed operation across country borders. In a similar vein, Driouchi and Bennett (2010) explored the relationships between real options awareness, managerial learning and the risk implications of switching options in multinational operations. They found that MNEs with high managerial awareness about their real options are better able to reduce their downside risk through the breadth of their international investments.

Table 3 presents the various measurements for real options value found in the current literature.

Exercise of real options

While real options value can be assessed in various ways, as discussed above, researchers have also explored the conditions affecting how real options are actually exercised. Indeed, the IB literature has

TABLE 3. VALUATION OF REAL OPTIONS IN THE INTERNATIONAL REAL OPTIONS LITERATURE

| <i>Measure/description of measure</i> | <i>Relevant research</i> |
|---|---|
| Tobin's q (Market value of common stock + book value of preferred stock + book value of debt)/(book value of total assets) | Lee and Makhija (2009a, 2009b) |
| Excessive market value (Market value of common stock + book value of debt – total assets)/total net sales | Allen and Pantzalis (1996), Thomas and Eden (2004), Song, Makhija, and Lee (2014) |
| Stock ratio Market value/book value of common stock | Folta and O'Brien (2004) |
| Abnormal returns Abnormal cumulative return | Kumar (2005), Tang and Tikoo (1999) |
| Downside risk Below-target performance: ROA, ROE, Beta | Kogut and Kulatilaka (1994a), Miller and Reuer (1996), Reuer and Leiblein (2000), Tong and Reuer (2007) |
| Economic exposure Sensitivity of the firm's cash flow to changes in exchange rate | Pantzalis, Simkins, and Laux (2001) |
| Growth options value Difference b/w a firm's market value and the capitalized value of its current earnings stream, discounted at a fixed rate | Tong, Reuer, and Peng (2008), Tong and Reuer, (2007) |
| Market value subtracting capital invested and present value of current level EVA, scaled by market value | |

Note: ROA = return on asset; ROE = return on equity; EVA = economic value added.

identified a number of factors affecting the exercise decision in terms of timing, mode, and conditions. We discuss these below.

Exercise timing

The issue of timing in the exercise of a real option plays an essential role in determining how these actually provide firms with value. In general, the literature suggests that an option is valuable when it allows the firm to wait until uncertainty is resolved before committing fully in terms of its investment, particularly in industries, which are characterized by irreversible investments and high sunk costs (e.g., Campa, 1993; Folta & O'Brien, 2004). Consistent with this logic, in examining factors that influence the timing of international investments, scholars such as Dixit (1989), Campa (1993), Goldberg and Kolstad (1995) found that when macro-economic conditions are highly volatile, MNEs tend to delay investment. This is consistent with real options logic in that the value of the option to wait increases under high uncertainty. Others have found that it is when exogenous uncertainty associated with initial investment is resolved or reduced, or when preemptive advantage associated with competition gets larger, that firms are motivated to invest overseas and increase entry into foreign markets (Rivoli & Salorio 1996; Kulatilaka & Perotti, 1998; Miller & Folta 2002; Folta & O'Brien, 2004). Along with timing, the mode of entry also influences the value derived by the firm from its real option investment. Brouthers, Brouthers, and Werner (2008), Tong, Reuer and Peng (2008), and Cuypers and Martin (2010) examine the influence of high exogenous uncertainty on the types of entry modes that are preferred. They find that minority, alliance, or small-sized investments provide firms with better ability to wait until the uncertainty is resolved.

Exercise conditions

Real options theorists have drawn upon financial options arguments to identify the appropriate conditions of exogenous uncertainty influencing the timing of exercising options and assessing the value-enhancing effects of options such as buyout or divestment of initial investments. Indeed, the literature suggests that more positive external signals play a stronger role in motivating firms to exercise options in the international arena. As an example of how changes in uncertainty impacts the exercise of real options, Kogut (1991) found that the timing of IJV buyouts is more influenced by favorable market signals reflecting unexpected growth than unfavorable market signals. Chung et al. (2010) and Lee and Song (2012) examined the relationship between favorable changes in host countries' exchange rates and subsequent increase in FDI by MNEs. Using panel data of Japanese FDI in Asian countries during the Asian economic crisis in the late 1990s, Chung et al. (2010) test to see if Japanese MNEs actually increased export sales or employment in their foreign subsidiaries to take advantage of depreciating currencies in Asian countries stricken by the crisis. Similarly, Lee and Song (2012) considered whether MNEs actually shift their production according to exchange rate fluctuations in host countries and if their across-country shifts of production lead to better performance. With a Korean FDI data set, they found that foreign subsidiaries respond to favorable and unfavorable change in exchange rates in asymmetric ways, relocating their production from costly subsidiaries to less costly ones via the international network of their parent firm. Similarly, Dikova et al. (2013) found that firms faced with an unexpected economic crisis in a host country benefited from the ability to quickly shift their operations to other host countries.

Researchers in IB have also studied the influence of changing uncertainty on the exercise of real options. For example, Fisch (2009b) tested the effect of receding uncertainty on increases in employment, and found that up to a certain level of uncertainty firms tend to defer their investments, but after they perceive the reduction of such uncertainty they exercise their options. Belderbos and Zou (2009) examined the conditions and timing of foreign subsidiaries' option to divest in response to adverse macroeconomic change. Using a sample of Asian manufacturing affiliates of Japanese

electronics MNEs, they found that low correlations in exchange rates among foreign subsidiaries or solely existing subsidiaries lead to delayed exits even under the influence of hostile macroeconomic conditions such as high labor cost in host countries. On the other hand, Fisch and Zschoche (2011) found from Germany MNEs that their foreign subsidiaries relocate their employment in flexible responses to differing labor cost growth rates across countries. These studies suggest that both exogenous uncertainty and time-dependent learning can affect exercise (investment) decisions in accordance with firms' perceptions of uncertainty over time.

Table 4 summarizes the extant literature on the exercise of real options investment.

AVENUES FOR FURTHER RESEARCH

The IB literature has long recognized the importance of managing uncertainty, having focused for decades on the uncertainty surrounding firms' overseas expansion into new and unknown markets, the need to deal with ongoing economic and political flux characterizing each of these markets, and the magnified difficulties in coordinating investments across multiple contexts. While a real options perspective has only relatively recently been employed in this literature, it has highlighted the benefits of building in *a priori* managerial flexibility into international investments to address this uncertainty. Our review shows substantial progress in the development and application of a real options lens to IB over the past 20 years. At the same time, a number of issues that require additional consideration from researchers have also emerged from this review. Drawing on our review of the literature above, in this section we identify and discuss these areas with suggestions for future directions in research.

Better assessment of uncertainty

Considering that uncertainty is the starting point for a real options argument, precise assessment of the impact of exogenous uncertainty on real options value and firm behaviors requires that the nature of uncertainty relevant for the investment is clearly identified and appropriately measured. According to real options logic, flexibility is valuable only under conditions of unanticipated change in the environment. Thus, careful consideration of the contextual factors and external conditions within which the international investments are located is critical for appropriately assessing their real options value. Our review indicates that empirical studies do not always adequately control for or fully assess the uncertainty of the firm's environment, even though more recent studies have better captured the appropriate types of uncertainty for testing their real options arguments (e.g., Belderbos & Zou, 2009; Lee & Makhija, 2009a, 2009b).

Measuring uncertainty

Since exogenous uncertainty is the critical feature of any real options argument, the measures used for uncertainty should reflect the actual contexts in which investment decisions are made by managers. For example, switching options, which facilitate the firm's movements across countries, are likely to be more valuable in the face of exchange rate volatility than other types of uncertainties, while growth options are more relevant for country-specific uncertainties relating to demand or competition. In this regard, the fact that Reuer and Leiblein (2000) look at growth options relating to JVs in the context of exchange rate volatility may explain their non-significant findings regarding the value of JV-related options.

We suggest that the choice of specific measures for uncertainty should go with the actual contexts where investment decisions are made by managers. For that purpose, research efforts must be directed to identify and measure more meaningful sources of uncertainty, which are relevant to key decision making at the appropriate unit of analysis. Specifically, country-level uncertainty would be less important than business level uncertainty from a manager's standpoint if initial real options investment

TABLE 4. EXERCISE OF REAL OPTIONS THE INTERNATIONAL REAL OPTIONS LITERATURE

| Research | Dependent variables | Independent variables |
|---|--|---|
| Kogut (1991) | JV buyouts | JV as strategic options to expand in case of receiving unexpected and favorable signals of product market responses |
| Kogut and Chang (1996) | FDI entry | Prior entries, industry concentration ratio, shipment rates, real exchange rates |
| Chi and McGuire (1996) | Real options value in JVs | Real option value in JVs is influenced by market, partner, legal uncertainty |
| Chi (2000) | Option to acquire/divest | The acquisition/divestiture price is specified <i>ex ante</i> in the initial contract or negotiated <i>ex post</i> |
| Folta and Miller (2002) | Timing of acquisition (additional increase) in biotechnology JVs | More value of underlying asset and more number of parties is positively associated with option exercise. Uncertainty is negatively related |
| Miller and Folta (2002) | Timing of exercise | Timing of exercise is influenced by, current dividends, exercise price, residual resource value, discount rate, call option value, compound (vs.) simple option |
| Reuer (2002) | Uncertainty + JV buyout | Explicit option to acquire JV equity under the influence of property rights-related, diversification-related uncertainty, not by cultural uncertainty |
| Vassolo, Anand, and Folta (2004) | Abandonment of collaborative ventures | Alliance divestment is influenced by industry uncertainty, technological distance between the focal alliances and the parent's portfolio of other alliances, and technological distance b/w the firm and the focal alliance |
| Kumar (2005) | Timing of exercise (IJV acquire/divest) | The value of acquiring and divesting a venture is influenced by the degree of technological and demand uncertainty (negative), and degree of rivalry |
| Belderbos and Zou (2009) | Increase in employment | Exercise of options (increase in employment) will be done by the interplay of uncertainty level and time stage (earlier [vs.] later) |
| Chung et al. (2010) | Subsidiary expansion/contraction | Abrupt fluctuation in exchange rates affects expansion or contraction in subsidiary number in specific areas |
| Xu, Zhou, and Phan (2010) | Sequential acquisitions in China | Resolved valuation uncertainty through information gathering facilitates sequential acquisitions after a toehold purchase at the beginning |
| Fisch and Zschoche (2011) | Cross-country shifts of employment | Foreign subsidiaries relocate their employment in flexible responses to differing labor cost growth rates across countries |
| Lee and Song (2012) | Cross-country shifts of productions | Foreign subsidiaries shift their productions in flexible responses to differing exchange rate volatility level across countries |
| Brouthers, Brouthers, and Werner (2008) | Entry mode choice/performance | Entry mode choices based upon both real options and transaction cost logic under influence of asset specificity and investment uncertainty enhance firm performance |

Note: FDI = foreign direct investments; IJV = international joint ventures; JV = joint ventures.

is expected to facilitate organizational learning to cope with endogenous uncertainty. In this sense, frequently used measures of uncertainty in recent studies should be reexamined carefully. For instance, in spite of its aforementioned advantages recognized in the real options literature as capturing 'skedasticity' or 'volatility' in a time trend associated with macro-economic factors including foreign exchange rates (e.g., Lee & Makhija, 2009a, 2009b), a GARCH model may not apply well in measuring features of uncertainty that directly affect managerial decisions at the firm level. More than often, the availability of sufficient past data for a time series estimation can limit the applicability of the GARCH model to theoretically meaningful or greater degree of uncertainty in the contexts relevant to real options arguments (e.g., novelty and hyper-uncertainty in entrepreneurship).

Hence, putting aside issues of data availability, we suggest that future real options research (1) use multiple measures for capturing uncertainty, including standard deviation, realized volatility, and/or perceived uncertainty by decision makers, that can be compared with GARCH for robustness checks, (2) investigate temporal aggregation issues with different intervals (e.g., monthly [vs.] weekly estimates), and (3) recognize and measure different sources of uncertainty more directly related to firm-level decisions (e.g., fluctuations in prices of intermediate goods instead of prices of general commodity or raw materials).

Correlation within and between differing types of uncertainty

In addition to measuring the form of uncertainty relevant for the real options investment, it is important to consider the correlations among different sources and forms of uncertainty. This point is made by Kogut and Kulatilaka (1994b), who note the negative effects of potential correlation of uncertainty measures among countries on overall volatility and real options value. For instance, during the Asian economic crisis in 1997, at least five countries in the East Asian region of the world had significant unexpected plunges in the value of their currencies at approximately the same time (Grewal & Tansuhaj, 2001; Lee & Makhija, 2009a, 2009b). This case clearly shows that a relatively large region of the world, encompassing multiple countries, can have highly correlated uncertainty. In order to address this issue empirically, Belderbos and Zou (2009) and Chung et al. (2010) examination of Japanese FDI into Asian countries during the 1997 Asian economic crisis took into account the correlations of annual exchange rates of a host country of a foreign subsidiary with other host countries in which the parent firm also had subsidiaries. Similarly, the relationship between two countries in the European Union, such as Germany and France, is not expected to be the same as that of India and France. We therefore suggest, at the very least, the inclusion of a regional dummy for regions with high correlation in uncertainty to help address this correlation issue.

In addition to accounting for correlations among a given type of uncertainty, as in the examples above, correlations between different types of uncertainty can also be taken into consideration. For example, Goldberg and Kolstad (1995) suggest that MNEs should invest in a location characterized by high correlation between export demand and exchange rate shocks since producing in such locations helps to insulate MNEs from currency-related uncertainty. Such approaches will lead to refinement in the ways in which uncertainty is theoretically treated and empirically examined. As more than one type of uncertainty naturally coexist in the international context, such investigations will enrich the real options literature in IB.

Further examination of nature of options embedded in international investments

In addition to the issue of uncertainty, it is important to improve our approaches for examining the options associated with international investments. Below we discuss the issues of investment size and ownership, as well as the issue of option combinations.

Size and ownership of investment

While much of the real options literature relating to international investments has focused on small-sized investments, we believe there is need for further work substantiating the real options value of such investments. Although a small investment helps to reduce the problems of irreversible commitment, other side-effects with respect to the valuation and exercise of real options should also be considered. One such issue relates to the difference between an investment that has been minimized through a shared ownership stake and an investment that is wholly owned but purposefully limited. For example, Fisch (2009a) found that for a sample of German MNEs' foreign subsidiaries, a small-scaled unshared investment carries future decision rights to engage in more internationalization, whereas shared ownership level (i.e., joint venture) does not carry real options value, but instead affects the firm's ability to control its investment consistent with internalization theory. In contrast, a study by Brouthers and Dikova (2010) finds that real options theory does not at all apply to small-scaled investments. Since these findings are in contrast to conclusions of other IJV studies, the potential interplay between unshared and shared ownership level deserves further study in terms of their real options value.

It would also be worthwhile to further investigate the potentially contrasting effects of sharing equity for international investments. Researchers have stressed that shared ownership allows the firm to limit associated downside risk while preserving upside potential as the environment changes (Tong, Reuer, & Peng, 2008; Cuypers & Martin, 2010). However, when a firm's ownership share is high, it will limit the firm's ability to benefit from such flexibility. In addition, foreign subsidiaries with shared ownership with other local firms make it difficult for headquarters to exert control over them and exercise options as necessary (Lee & Chung, 2007; Tong & Reuer, 2007). Such contrasting effects of IJVs have not been adequately considered in the literature.

Our review suggests that further work can also enhance our understanding with respect to switching options. In principle, MNEs' international networks of subsidiaries provide strategic flexibility that facilitates an immediate response to downside risks. Firms with production facilities located in multiple countries can respond to adverse changes in any given country such as exchange rate volatility (Kogut & Kulatilaka, 1994b; Reuer & Leiblein, 2000) and increased political risks (Makhija, 1993). However, in reality production cannot be shifted elsewhere with the ease implied in the switching option perspective. Because MNEs' operations involve investments that result in the ownership and operation of productive facilities, divesting foreign operations in times of economic crisis may not always be the best strategic option for MNEs. In the case of downside risks, such as economic crises, MNEs are more likely to continue producing and investing in a given location because investors' horizons are typically long term and their deep involvement with the host economies after the investment is made (Lipsey, 2001). In addition, the implementation of decisions to transfer production is not typically so clear-cut (Lee & Makhija, 2009a). There are significant transaction costs associated with the myriad of country-specific transactions in a given subsidiary, including those associated with suppliers, customers, distributors, and government agencies, among others (Hitt, Hoskisson, & Kim, 1997). This makes it difficult to determine the actual costs of switching production from one location to another. In addition, the specific characteristics of the firm's operations in different host countries determine how easily production can actually be transferred to an alternative location (Rangan, 1998; Lee & Makhija, 2009a). Production in different countries must be fairly similar in nature, otherwise the option benefits are outweighed by the costs of reconfiguring the factory and retraining workers. Indeed, abandoning investments with ease has not been documented by the empirical IB research. Thus, a deeper consideration of the conditions under which switching options are valuable for the firm will enrich the literature.

Portfolio or combination of options

While options such as portfolio and compound options may also exist, the IB literature has not considered these in any significant manner. Considering that firms often undertake multiple projects,

their strategic decisions can be viewed as bundles of resource-investment alternatives or real options (Bowman & Hurry, 1993). Indeed, research suggests that the value of a portfolio of real options can have super-additive or sub-additive properties, determined by the correlations of underlying assets, uncertainty types, and organizational constraints (Vassolo, Anand, & Folta, 2004). For example, Anand, Oriani, and Vassalo (2007) note that high technological uncertainty leads the value of the underlying assets to be negatively correlated, possibly requiring firms to have a wider portfolio of options to increase switching options value. In contrast, under high market uncertainty, firms will benefit from positively correlated underlying assets to increase growth options value. While these researchers highlight the contrasting effects of options within a portfolio of investments, others stress the interactions among different options embedded in a single investment, resulting in complementary or conflicting effects on real options value. For example, a study by Folta and O'Brien (2004) finds that the relative value of deferral and growth options within the same investment is influenced by separate conditions. While uncertainty levels up to the 94th percentile deter entry into a new industry, industry growth potential and preemptive advantages tend to enhance the value of growth options and thus shorten the time to enter. By the same token, Oriani and Sobrero (2008) find that in the presence of cumulative technologies, deferral options may be suboptimal as they can lead to lock-out.

We believe that both lines of inquiry have tremendous scope for application in the international context. The value of an MNE's overall portfolio of international real options investments is likely to be different from the aggregated value of each individual investment, since not all options provide value under the same conditions of uncertainty, and instead may reduce flexibility under some conditions. In this respect, options may compete with each other in some ways where the value of one type of option is negatively correlated with the value of another type of option in a portfolio, thereby reducing the overall value of the portfolio. In addition, despite the fact that researchers have noted that international investments can have more than one option – often stressing switching and growth options in this regard – virtually all prior empirical work has focused only on one option at a time. If multiple options embedded in the same investment have divergent effects, this approach is unlikely to depict a complete picture. Indeed, the unique characteristics of these two different types of real options create important tradeoffs. While growth options reflect a firm's intention of continuing a given strategy, switching options underlie the desire to adaptively change its strategy (Bowman & Hurry, 1993). We believe that these contrasting aspects and interactions between different options provide important new research opportunities for understanding the real options value of international investments.

More fine-grained evaluation of value and costs of real options

Valuation of real options

There is currently a dearth of formal valuation research, which measures the primary attributes of the Black–Scholes model such as exercise price, value of underlying assets, and maturity relative to uncertainty. Even though some scholars (e.g., Folta, 1998; Folta & Miller, 2002; Folta & O'Brien, 2004) have tried to measure exercise price in the context of governance choices, we find that there has been relatively little applied research in IB examining the impact of other attributes (i.e., maturity, expected cash flow, and exercise price) of the Black–Scholes model. Instead, early real options studies have adopted real options logic to explain managerial decisions in international investments or technology choices – and more recently, entrepreneurial actions (e.g., Lee, Peng, & Barney, 2007) – in the face of uncertainty. In this sense, management scholars have been more interested in measuring uncertainty and applying the analogy of real options, neglecting other dimensions of the Black–Scholes model. As a general rule, the absence of empirical studies fully examining critical aspects of real options value and the relationships predicted by the theory, particularly maturity or exercise price and option value in real options theory, represents a research opportunity for IB scholars.

Costs of real options

Real options theorists are also concerned about whether multinationality is always value-enhancing, since some have assumed that firms can shift production from one subsidiary to other subsidiaries when needed and the costs of shifting options are low (Reuer & Leiblein, 2000; Tong & Reuer, 2007). However, due to some obstacles to realizing the benefits of multinational operations, multinational flexibility may not be achieved automatically or efficiently as breadth increases. Managing a highly dispersed set of international investments imposes higher coordination costs on the firm. These costs are likely to increase the uncertainty of future earnings and thus undermine the total value of a firm's growth potential, including operating flexibility (Doukas & Pantzalis, 2003). Likewise, the burden associated with multiple transactions among geographically diverse units increase transaction and governance costs (Allen & Pantzalis, 1996; Tong & Reuer, 2007), which lead to organizational inefficiencies (Lu & Beamish 2004), consistent with predictions of transaction costs economics. Further investigation of the value and costs associated with MNEs' international networks will provide important insights for better understanding the tradeoffs that may exist in this regard. Furthermore, the IB literature can benefit from comparisons of the costs of different types of options. For instance, Chi and Seth (2009) report that the bargaining costs arising from divergent objectives of IJV partners can hamper MNEs' ability to respond to future environmental changes and reduce the flexibility value of an IJV. In this sense, future studies can consider the difference between the cost of coordinating partners' effort in a joint venture and the cost of coordination associated with an acquisition mode of foreign market entry.

Consideration of behavioral effects on real options decisions

Although a vast body of research in the field has stressed that firms differ significantly in their resources and capabilities, this notion has not much informed the literature on real options. However, the effective structuring and exercise of real options investments involve specific firm capabilities that differ among firms. As has been stressed in the IB literature, internationalization is inherently difficult due to the organizational complexity of managing far-flung subsidiaries and contextually embedded information. Since all firms are not equally successful in internationalization, we would expect that variations in their ability to engage in IB will also come into play in the effective management of their real options investments. We elaborate below on the value of integrating firm heterogeneity into the real options literature.

Accounting for firm heterogeneity

Theories in IB and strategic management strongly suggest that capability differences among firms lead to significant variation in firm decisions and outcomes, as well as cause them to be differentially successful in the marketplace (Barney, 1986, 1991; Buckley & Casson, 1998). Firms vary in their ability to adapt to new foreign environments (Johanson & Vahlne, 1977), recognize new information and engage in innovation (Cohen & Levinthal, 1990), work with alliance partners (Contractor & Lorange, 1988), and engage in learning (Makhija & Ganesh, 1997). Such capabilities can also influence firms' ability to structure and exercise options effectively. Nonetheless, the majority of the ROT literature as applied to international investments has not focused on the role of heterogeneity or asymmetry among firms, which can influence, for instance, behavioral choices relating to the tradeoff between strategic commitment and flexibility or in timing investments appropriately in an uncertain market.

Heterogeneity in capabilities may lead different firms facing the same opportunity and uncertainty to display different investment choices in relation to option creation or exercise (Tong & Reuer, 2006; Tong, Reuer, & Peng, 2008; Cuypers & Martin, 2010). It is important to take into account such

asymmetric responses to exogenous shocks stemming from variances in firms' resources and capabilities when examining the effects of uncertainty on real options value. For instance, using a data set of Thai firms, Grewal and Tansuhaj (2001) discovered that firms' organizational capabilities had differential influences on their performance during the Asian economic crisis in late 1990s. They find that greater market orientation of a firm, referring to its ability to gather and use market-related information, reduced its performance after the crisis, whereas greater strategic flexibility, pertaining to its ability to proactively or reactively respond to market threats and opportunities, positively influenced performance. They argue that market orientation is a capability that is not as useful under the conditions of flux characterizing an economic crisis, whereas firms' capability for adapting to rapidly changing conditions is particularly relevant in this regard.

It is important to recognize that firms have differential cost structures that can also influence the management of their real options. Even though costs are assumed to be symmetric or zero in early real option game models, accounting for asymmetrical costs enables identification of different strategic equilibrium such that the lowest-cost firm would enter first or acquire growth options. For instance, Pawlina and Kort (2006) examine the impact of investment cost asymmetry on the value and exercise strategies of firms under imperfect competition and show that a marginal increase in the investment cost for the firm with the cost disadvantage can enhance the firm's own value while the presence of identical firms can result in a socially less desirable outcome than a cost asymmetric situation. More generally, non-standard real option game models (Azevedo & Paxson, 2014) relax several assumptions and constraints on firm heterogeneity and incorporate *ex ante* and *ex post* asymmetries in information, cost, and capability. For example, Smit and Trigeorgis (2004) consider the rate of learning as firm specific and asymmetric between duopoly firms who make a strategic R&D investment in an innovative new production process or invest earlier in production capacity reducing future production costs.

Similarly, Kong and Kwok (2007) model *ex ante* asymmetries on both the sunk costs and revenue flows in duopoly and investigate the value of real options and strategic interaction of investment decisions. With asymmetry on both the sunk costs and revenue flows, they show that simultaneous entry or preemption by the high-cost firm is possible especially when the preemptive thresholds of the two firms coincide. This phenomenon is called 'non-zero probability of mistake' in the real options literature. In comparison, Hsu and Lambrecht (2007) focus on the information asymmetry between a new entrant and the incumbent where the new entrant has complete information about the incumbent, but the incumbent does not know the precise value of the new entrant's investment costs. They find that even a small probability of being preempted gives the informationally disadvantaged firm an incentive to invest at the breakeven point where it is indifferent between investing and being preempted.

This body of work suggests that a wide set of asymmetries between firms can have important and interesting influences on their real options strategies. Since the international context is even more complex than domestic contexts, with greater potential for seeing capability differences among firms across national contexts and more variation in competitive conditions, it is vital to consider how these factors interact with international sources of uncertainty in a way that influences the value of real options investments. Research that incorporates these elements can help us to understand in more detail how international real options investments should be managed.

Accounting for variations among managers

Differences in managerial capability may also affect the firm's ability to manage its real option investments. For example, Barnett (2008), Coff and Laverty (2008), and Schwartz and Trigeorgis (2001) note that the theoretical value of real options approach may not be realized in practice if managers, in pursuing their own interests, misuse their discretion and do not follow the optimal exercise policies that are often implicit in option valuation. By the same token, Barnett (2008) points

out that the costs and organizational complexities involved in creating and holding multiple options are part of the price of the option, yet lack of attention or commitment are often overlooked as drawbacks to maintaining a portfolio of options. More recently, Driouchi and Bennett (2010) found that MNEs that have high managerial awareness about their real options are able to reduce their downside risk through multinationality and organizational slack, but MNEs without such awareness are not fully able to benefit from their switching options in multinational operations. These findings suggest the importance of drawing from the resource-based view and agency theory in order to take into account firm and managerial capabilities in exercising real options.

Since perceiving and responding to exogenous uncertainty and opportunities significantly affects firm value and performance, managers' ability to recognize and select opportunities plays an important role (Barnett, 2008). However, managers cannot gather all possible information from their environment due to limited attention and information processing capacities (Cuypers & Martin, 2007). As a result, managers are not able to make completely accurate representations of their complex environments on which their decisions and actions are based. In light of this, we expect that decision makers' subjective perception of uncertainty, and thereby their valuation of options, is dependent on their incentives, abilities, and experiences from prior investments. It is thus critical that future research take into account organizational and psychological factors that may complicate the application of real options logic and point to the proper boundaries of real options theory (Adner & Levinthal, 2004). Decision-making theories encompassing bounded rationality may help to inform this line of inquiry.

Examination of firms' international investments in fact provides a number of important opportunities for studying managerial capabilities with respect to decisions under uncertainty. Since MNEs vary significantly in the number of international investments they have, it becomes possible to study how this affects managers' decision making, particularly with respect to how managers deal with information overload and complexity in making decisions about the structuring and exercise of real options. For example, we may find that the complexity ensuing from investments across a greater set of diverse national contexts results in more mistakes in structuring and exercising options by managers than when investments are in fewer countries, or that the ability to exercise more options (from more investments) has the greater beneficial effect. Another interesting question stems from the location of the decision maker. While scholars have tended to assume that decision making vis-à-vis these investments is concentrated at headquarters, MNEs may also relegate decisions to local managers for their international investments. It may be that local managers make better decisions regarding the exercise of options, or instead, that their localized knowledge is inadequate for decisions relating to the firm as a whole. In this regard, cultural influences on managers' decision making can also be considered. For example, collectivism can influence how information is gathered and shared among managers, while variations in risk propensity may influence how and when options are exercised. Since relatively little work has been done on these issues, such investigations will not only help to understand the role of management for international real options investments, but will also shed light on the management of other types of investments.

Sub-optimality of options exercise

Despite theoretical predictions that real options can be exercised in an appropriate amount of time, some researchers have pointed out the risk of inappropriately prolonged exercise (McGrath, 1999; Adner & Levinthal, 2004). The phenomenon of such prolonged exercise is closely related to the notion of escalating commitment in organization theory. More generally, the timing and conditions of options exercise is closely related to the boundary conditions of real options theory. Recent debate on sub-optimality of options exercise is triggered by a growing realization that even though the ability to wait

and see until uncertainty resolution drives real options value, the question remains as to how long any given option can and should be held.

This concern is further ignited by Adner and Levinthal (2004) who argued that well-structured abandonment (i.e., a pre-specified maturity date after which the option expires) is a crucial condition of any kind of options investment, be it financial or real, and proposed that it is necessary to distinguish between ‘investments with real options’ and ‘real options investments.’ They further stressed that real options are not only a matter of investment implementation, but also a theoretical point of view about retaining flexibility based on well-structured abandonment policies. They warned of ‘option traps’ that hinder the abandonment of opportunities from, for example, psychological biases regarding sunk costs and escalating commitment. In response, McGrath, Ferrier, and Mendelow (2004) criticized Adner and Levinthal’s arguments as restricting the boundaries of real options reasoning. Instead, they suggested a more extended view of flexibility, which in fact allows for flexible adjustment with path-dependent strategic choice and changes. Zardkoohi (2004) agreed with McGrath, Ferrier, and Mendelow’s suggestion that Adner and Levinthal’s approach to real options investment may reduce the value of real options theory for strategic decision making.

CONCLUSION

The IB literature has long recognized the importance of managing uncertainty, having focused for decades on the uncertainty surrounding firms’ overseas expansion into new and unknown markets, the need to deal with ongoing economic and political flux characterizing each of these markets, and the magnified difficulties in coordinating investments across multiple contexts. While a real options perspective has only relatively recently been employed in this literature, it has highlighted the benefits of building in *a priori* managerial flexibility into international investments under uncertainty. Our review of how a real options lens has been applied in IB shows substantial progress in developing and utilizing this perspective over the past 20 years. Nonetheless, there are a number of issues that require additional consideration from researchers.

We undertake this review in order to highlight the growing focus in the literature on international investments as conveyers of real options as well as to isolate the particular features of this approach. Researchers have noted that MNEs’ ability to structure their international investments in a manner that enhances their flexibility would be very valuable in the face of the significant exogenous uncertainty characterizing the international context. To examine this work, we first identified multiple types of uncertainty unique to the international context and their measures, we distinguished types of real options embedded in international investments, and examined methods utilized in this literature for assessing real options value and exercise. Our examination reveals that, while a real options approach has contributed significantly to our understanding of how MNEs can develop investment strategies to deal with uncertainty, there is still much room for advancement and extension of this work.

We identify five areas for future research, including (a) the need for more fine-grained and diverse measures of uncertainty relating to the international context, (b) the importance of considering firm heterogeneity in resources and capabilities, managerial capabilities and bounded rationality, that can influence the ability to manage real options investments, particularly in the more complex international context, (c) the need to differentiate between different types of small-scale international investments, that have thus far tended to be lumped together in this literature, (d) an emphasis on clarifying the value effects of combinations of real options, since these are particularly relevant for international investments, and (e) the necessity of considering the costs of options along with the value created for a more complete understanding of how they work.

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