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What makes and what does *not* make a real option? A study of equity shares in international joint ventures

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Abstract
This paper examines the boundaries of real options logic, with an application to joint ventures (JVs). We distinguish between forms of uncertainty that are resolved endogenously and those that are resolved exogenously, and theorize that only exogenous uncertainty will have the impact predicted by real options theory on a foreign investor's choice of how large an equity share to take in a JV. We theorize that macroeconomic and institutional variables generate exogenous uncertainty whereas, by contrast, cultural distance and choices pertaining to corporate scope and product or process development activities involve endogenous sources of uncertainty that investors can both assess and act upon without having to "wait and see". Using a sample of 6472 Sino-foreign JVs, we find support for our predictions. We discuss and implement proper methods to test for the existence of null effects, as is relevant to establish the boundaries of a theory such as real options theory. We draw implications for research and practice on JVs – specifically equity share decisions, which deserve more attention – and real options, including suitable uses and desirable extensions of the concept.
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INTRODUCTION

With greater international competition and the rise of emerging-market economies, multinational firms increasingly face highly uncertain foreign environments in which to do business. Accordingly, the emphasis in management and international business research has shifted towards how firms can compete and adapt in environments where they face various sources of uncertainty (e.g., Campa, 1994; Henisz & Delios, 2001; Krishnan, Martin, & Noorderhaven, 2006; Martin, Swaminathan, & Mitchell, 1998). This points to a need to specify conditional relationships between sources of uncertainty and a firm's expansion strategy, as a firm's strategy should be in line with the nature of the uncertainties it faces (Miller, 1992). While this may entail a variety of entry modes and other risk-handling initiatives, one that has sustained much interest among international business scholars is the use of foreign joint ventures (JVs) and related cooperative strategies (e.g., Beamish & Banks, 1987; Contractor & Lorange, 2002). Furthermore, above and beyond the choice between JVs and alternative

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modes or initiatives, a JV's setup, and specifically decisions about its ownership, have substantive consequences under uncertainty (e.g., Gatignon & Anderson, 1988).

Hence uncertainty should also determine how much ownership firms seek over their foreign JVs, and how they use JVs to expand sequentially (e.g., Aharoni, 1966). In this paper we define JVs as equity-based collaborative arrangements whereby two or more organizations contribute resources, including equity, in a separate legal entity meant for the joint pursuit of economic goals (Gulati, 1995; Martin & Salomon, 2003). We focus on international joint ventures (IJVs), which are subject to substantial uncertainty from exchange rate, cultural and institutional sources, among others. This makes IJVs particularly suitable for our purpose. However, we believe that our arguments are also relevant for other (domestic) JVs insofar as they face various sources of uncertainty.

While numerous scholars have looked at the conditions under which JVs are more or less appropriate relative to extreme ownership solutions such as non-equity alliances or wholly owned subsidiaries (e.g., Contractor & Lorange, 2002; Gulati, 1995; Hennart, 1988; Oxley, 1997, 1999; Pisano, 1990; Sampson, 2004), we look at the determinants of the distribution of JV ownership among partners, which is a far less studied aspect of JVs.[1] We use a real options perspective, as this is highly appropriate to explain the strategies of firms in highly uncertain environments (Bowman & Hurry, 1993), and specifically JV ownership stake decisions (Chi & McGuire, 1996) and international contexts (Li, 2007).

The concept of real options has elicited considerable enthusiasm in recent years among scholars and practitioners of strategic investments, especially those investments that may encompass multiple stages subject to intervening events. Investments such as research projects, taking out patents, subcontracting, founding new businesses, expanding internationally, and entering into JVs have been classified as real options (e.g., Kester, 1981; Li, 2007; Reuer & Leiblein, 2000; Van Mieghem, 1999). The widespread use of real options logic, combined with the fact that a gap between theoretical and empirical work continues to exist in this area (Reuer, 2002), leaves open questions about the conditions under which real options logic is indeed applicable. At the same time, it is important to examine what variables are indeed suitable predictors within a real options framework, for both theoretical and empirical reasons.

Theoretically, Adner and Levinthal (2004a, b) called for further attention to the boundaries for the application of real options theory to strategic decision-making. They argued that the assumptions underlying the real options model are violated if variables such as the end date of the underlying project are discretionary:

> Because much attention in the management literature is focused on the ways in which the firm can affect outcomes and variances …, it is important to examine what happens to the applicability of options logic as we move away from a world of wait and see to a world of "act and see," in which uncertainty resolution is endogenous to firm activity. (Adner and Levinthal, 2004a: 76)

This question is especially relevant when applying real options logic to the study of JVs, because JVs represent both investments with implications for each participating firm's overall corporate strategy and performance, and a choice of a governance mode that itself may encourage strategic or opportunistic behavior among partners. Moreover, the literature on JVs has looked at how JVs can be used as vehicles both to "wait and see" and to "act and see". For example, Aharoni (1966) argued that JVs could be used to limit a firm's exposure to uncertainty, while other studies have looked at how firms can improve their performance through learning in JVs (e.g., Cuypers, 2009; Kogut, 1988; Mitchell & Singh, 1992; Mody, 1993). This makes JVs all the more suited to investigate the issues raised by Adner and Levinthal (2004a, b). Whereas Adner and Levinthal (2004a, b) focus on the duration of the investment and the issue of project drift, we focus on uncertainty, which is a key reason for using JVs to enter international markets (Kogut, 1991) and to make real options investments in general.

Empirically, while some studies of JVs have found support for predictions derived from real options theory, others have not. Indeed, two prominent studies by Folta (1998) and Reuer and Leiblein (2000), found deviations from real options predictions with respect to the effect of uncertainty on JV formation and the downside-risk consequences of JVs, respectively.

We aim to address the above theoretical and empirical conundrums by developing and testing hypotheses about which sources of uncertainty are indeed, or are not, associated with JV equity shares consistent with real options theory. In so doing, we contribute to the real options literature by examining, theoretically and empirically, the extent to which real options logic accurately describes equity

shares in IJVs. Specifically, we examine whether various forms of uncertainty predict the distribution of equity stakes in IJVs in the way that real options logic suggests, depending on whether or not the uncertainty can be resolved endogenously. We also contribute to the JV literature at large in several ways. We explicate the conditional effect of uncertainty on JV ownership, thus complementing literature about the choice of entry mode. We thus refine the analysis of uncertainty as a determinant of JV strategy. In general, our study advances the understanding of how JVs are structured under conditions of uncertainty.

BACKGROUND

Real Options

Simultaneously with the increasing popularity of financial options in the 1970s, it was realized that an analogy exists between organizational resources investments and financial options (Myers, 1977). Bowman and Hurry (1993) argued that the option lens can be very useful to study the strategies of organizations, since the capabilities and assets of an organization can be seen as a bundle of options for future strategic choices. These options are called "real options" and can be defined as contingent investment commitments in an asset or capability, rather than in a financial contract, which secure decision-making rights in the future (Trigeorgis, 1993).

Numerous insights and techniques from financial option pricing have spilled over to the valuation of organizational resources investments. Prominently, they imply that the traditional net present value (NPV) approach to value investments does not fully capture the value of management's flexibility to adapt to unexpected market developments. Such flexibility can increase the investment's upside potential while limiting its downside losses relative to management's initial expectations under passive management (Trigeorgis, 1995). This does not mean that the traditional NPV approach to valuing investments should be put aside, but instead that it should be extended to take into account both a passive NPV component and a dynamic option value component (Pindyck, 1988). The value of the real options component of an investment is a function of the same parameters that determine the value of a financial option (Seth & Kim, 2001).

However, not every investment or decision is an investment in real options. The two different value components can be captured in a different way because they require a different size of investment. On the one hand, the passive NPV component requires a large investment in order to capture as much cash flow as possible. On the other hand, the dynamic option component can be captured with a smaller investment. This distinction can be applied to JVs too.

JVs and the Option to Acquire

Kogut (1991) was the first to apply real options theory to IJVs. He argued that firms can capture the upside potential of a JV by buying out the partner in a later stage when favorable information becomes available. At the same time, taking a lower share in the JV limits the downside risk. The option to acquire can be explicit, but this is not a necessity. Even when there is no *ex ante* contractual specification of which party holds the acquisition right and of the strike price, it remains possible for both parties to negotiate the acquisition of the other party's share at a price that is agreed upon later under specific conditions. Hence JVs have at least an embedded implicit call option to acquire a partner's stake (Chi & Seth, 2001).

Following Kogut (1991), several other scholars have looked at JVs from a real options perspective (e.g., Chi & McGuire, 1996; Chi & Seth, 2001; Reuer, 2000, 2002; Reuer & Koza, 2000; Reuer & Leiblein, 2000; Reuer & Tong, 2005). One of the key findings is that the options embedded in JVs will have an impact on the distribution of the equity stakes. On the one hand, if the investor tries to capture the static NPV part (s)he will take as large a share as possible, to fully capture the future cash flows. In the extreme, this will lead to an acquisition instead of a JV (Seth & Kim, 2001). On the other hand, an investor who aims to capture the dynamic real options part will invest in a smaller share of the JV because this limits the downside risk while leaving open the opportunity to capture the upside potential of the JV (see Chi & McGuire, 1996; Reuer, 2002). Thus a JV contains an implicit or explicit call to acquire the other party's stake, and we can expect the firm investing in the call option to take a smaller share in a JV.

Real Options Theory and Uncertainty

One of the most prominent concepts in real options theory is uncertainty.[2] Two broad streams of research (Reuer, 2002) address JV investments (among other decisions) using the logic of real options. Although the general premise in both streams is that uncertainty in general is positively

related to option value (e.g., Bowman & Hurry, 1993; Kulatilaka & Perotti, 1998), the two streams provide different but complementary insights into the role of uncertainty.

In the first stream, researchers use formal models to study the theoretical benefits and cost of investing in different kinds of strategic real options, and to assess how flexibility can contribute to value creation. Many of these models focused on one or at most two different sources of uncertainty each. For instance, Bell (1995) and Huchzermeier and Cohen (1996) focused on exchange rate uncertainty. Bollen (1999) looked at demand uncertainty. Chi and McGuire (1996) and Chi (2000) examined how uncertainty about the market and about a collaborative partner can add to the value of collaborative ventures. Additionally, some scholars have emphasized that real options reasoning applies to uncertainty that is exogenous, that is, outside the control of the firm (e.g., Kulatilaka, 1995). Indeed, Miller and Folta (2002) argued that such exogenous uncertainty increases the value of a call option, unlike uncertainty that is under the control of the firm (e.g., responding to rivals' threat of pre-emption).

In the second stream, researchers examine empirically whether JV decisions are consistent with real options theory. Kogut (1991) found evidence of JVs being used as options to make subsequent acquisitions in the presence of market uncertainty. Folta and Miller (2002) looked at the timing of exercising options and found evidence of the influence of uncertainty, operationalized as the variability in stock-market subfield indices, on the timing of partner buyouts in equity partnerships in the biotechnology industry. Reuer and Tong (2005) found that the likelihood that a firm will have an explicit option to acquire equity in an IJV is a function of property rights uncertainty, political uncertainty and diversification-related uncertainty but not of cultural distance. However, other studies found results inconsistent with real options predictions. Reuer and Leiblein (2000) found that firms that enter into multiple JVs do not thereby reduce their downside risk; in fact, for two of three measures of downside risk, IJVs were associated with increased risk. Folta (1998) found that multiple forms of uncertainty were associated with the taking of real options positions in the form of minority equity investments (rather than acquisitions). However, only exogenous uncertainty associated with subfield-specific stock market volatility encouraged the formation of JVs as call options.

In summary, multiple sources and concepts of uncertainty have been advanced in real options research; however, very few studies have contrasted the effects of two or more sources of uncertainty. Furthermore, differences in concepts of uncertainty may explain some of the deviations from the general uncertainty–option value relationship that have been found in the empirical literature with respect to JVs. To address this, we seek to contrast multiple sources of uncertainty. In this respect, the gaps between theoretical and empirical literatures suggest that a critical distinction is whether or not uncertainty is exogenous to the firm's influence.

HYPOTHESES

The decision to invest in a call option to acquire will depend on the value of that option. This call option value will increase as uncertainty surrounding the value of the underlying asset increases. As the distribution of the possible values of the underlying asset at maturity widens, it becomes more probable that the option will be in-the-money at maturity, making the exercise of the call profitable. Conversely, the downside if the option is out-of-the-money does not increase – it is just the initial cost of the option. Once a firm acquires a real option on a future opportunity, it can strike the option and take the full opportunity if the uncertainty is resolved favorably over time, or just let the opportunity pass at no further cost if the uncertainty is resolved unfavorably.

Carrying over this insight from financial options to real options is what makes real options theory particularly appealing: it deals with one of firms' most important challenges by linking current strategic decisions with uncertainty about future outcomes. However, the carry-over is problematic if the conditions for the resolution of the uncertainty depart from the theory (Adner & Levinthal, 2004a). In this respect, two forms of uncertainty can be distinguished: exogenous uncertainty and endogenous uncertainty (Folta, 1998; Roberts & Weitzman, 1981).

Exogenous uncertainty is uncertainty of which the resolution is unaffected by the actions of the firm (Chi & Seth, 2001; Roberts & Weitzman, 1981). For example, uncertainty about currency exchange rates is exogenous since these rates are determined in atomistic markets that cannot be outguessed or manipulated (Campa, 1994). By contrast, endogenous uncertainty is resolved (at least in part) by the actions of the firm itself over time. More specifically, the degree, direction and pace of resolution of

endogenous uncertainty depend both on the effort of the firm to obtain more information and on the actions it undertakes accordingly to influence outcomes (Chi & Seth, 2001; Roberts & Weitzman, 1981). For instance, a firm may not know *a priori* how hierarchically structured the organizations in a given country may be, but that uncertainty can be resolved by making a systematic effort to learn about the issue and by adjusting the investor's own behavior and that of its business partners accordingly (Hofstede, 2001).

We argue that while real options theory should apply in the case of exogenous uncertainty resolution, it need not when uncertainty resolution is endogenous. The case of exogenous uncertainty corresponds to the case of financial options, where it is assumed that uncertainty is resolved independently of the investor's behavior. If this property carries over to investments that are non-financial in nature, the real options logic should hold (Adner & Levinthal, 2004a). Furthermore, Dixit and Pindyck (1994) argue that exogenous uncertainty increases the value of waiting for new information[3] and makes committing resources less attractive because investing will not influence how uncertainty is resolved. Hence options pricing models should be applicable.

Conversely, when uncertainty is resolved endogenously, three separate but related arguments can be made whereby real options logic will not hold any more. First, in the case of financial options, investors are assumed to be price-takers (Black & Scholes, 1973; Jarrow & Turnbull, 2000). This is reflected in the use of the Brownian (random) motion to model the price of the underlying asset. However, when investors can influence the resolution of uncertainty through their own actions, they are not pure price-takers any more; instead, they can affect the value of the underlying asset. This violates a fundamental assumption of (financial) option pricing models (Black & Scholes, 1973; Merton, 1973). The resulting arbitrage opportunities mean that existing models will fail to price options accurately (Jarrow & Turnbull, 2000).

Second, uncertainty that can be resolved endogenously influences the investment decision differently from uncertainty that is resolved exogenously. Endogenous uncertainty can be resolved by undertaking efforts to discover how to manipulate the outcome of interest and then by acting accordingly, that is, by proactive investment (Dixit & Pindyck, 1994; see also Kulatilaka & Perotti, 1998). In such a situation, the issue becomes one of figuring out the means and cost to resolve uncertainty, rather than of uncertainty about the payoffs of the project proper. According to Dixit and Pindyck (1994), only investing will reveal the relevant information and allow the corresponding solution to be implemented. Therefore there exists an incentive to invest and commit resources rather than wait. Hence the normal real options logic will not apply in the case of endogenous uncertainty. As Dixit and Pindyck (1994) noted, this does not exclude that investments surrounded by endogenous uncertainty occur sequentially, thereby superficially resembling real options investments when in fact their resolution depends on a different mechanism (the NPV component).

Third, Adner and Levinthal (2004a) argued that the validity of real options theory as a decision-making tool is likely to break down if uncertainty can be resolved endogenously and targets are flexible. Acting to reduce endogenous uncertainty will often lead to the discovery of new and unanticipated opportunities and paths. Thus actions will not only reduce the uncertainty surrounding the initially intended project, but also provide information about other possibilities and introduce new goals, even when the outcomes are negative from the perspective of the initial project and its goals. As a consequence of the open-ended nature of this discovery process, the discrete nature of real options investment is eroded, which creates serious organizational challenges to preserve the specific form of flexibility that made a real options investment attractive in the first place.

For these reasons, we expect that while real options predictions will accurately describe firms' responses to exogenous uncertainty, they will not accurately describe their responses to endogenous uncertainty. To explicate this difference further, we derive six hypotheses, of which three deal with sources of uncertainty that are resolved exogenously and three deal with sources of uncertainty that are resolved endogenously.

Exogenously Resolved Uncertainty

Economic uncertainty. An important host-country factor that has an impact on the value of an investment is economic uncertainty (e.g., Anderson & Gatignon, 1986). This refers to uncertainty about the macroeconomic situation in a host country, and encompasses all the unknowns about the level of economic activity and prices (Oxelheim &

Wihlborg, 1987). More economic uncertainty results in higher variability in both the foreign investor's cash flows and the value of the investment (Anderson & Gatignon, 1986). As a result, the value of a call option will increase as economic uncertainty increases.[4]

Key macroeconomic variables such as inflation, prices and aggregate demand are determined in a complex system consisting of markets and sovereign governments (Oxelheim & Wihlborg, 1991). Thus for individual firms it is extremely difficult, if not outright impossible in larger economies, to influence the macroeconomic conditions of the host country. Therefore economic uncertainty will be resolved exogenously. Accordingly, we expect real options logic to hold:

Hypothesis 1: *Ceteris paribus*, a foreign partner entering into a JV in an environment with higher economic uncertainty will have a higher propensity to make a call option investment. Therefore the foreign partner will take a smaller share in the JV.

Local institutional uncertainty. The institutional environment includes legal, regulatory and social factors that shape business activity (Davis, North, & Smorodin, 1971). These institutions can cause uncertainty for investors in various ways. For instance, in an underdeveloped judicial system, laws tend to be unclear or inadequate, and their enforcement unreliable. Investors are thus uncertain about current and future tax obligations, labor laws and the neutrality of courts. Generally, an unstable (local) institutional framework increases ongoing uncertainty for business owners (Davis et al., 1971). Such uncertainty is bound to affect foreign investors, including JVs (Shan, 1991).

Furthermore, institutional uncertainty is resolved exogenously, especially in larger and more complex national systems, because a firm is unlikely to be able to affect the multiple layers of government and institutions that make such policies, even if it manages to understand them (e.g., Chi & Seth, 2001). Accordingly, we hypothesize:

Hypothesis 2: *Ceteris paribus*, a foreign partner entering into a JV located in an area with higher institutional uncertainty within a country will have a higher propensity to make a call option investment. Therefore the foreign partner will take a smaller share in the JV.

Exchange rate uncertainty. Expanding abroad usually also commonly means that a firm has to deal with a currency other than its home country's currency. Changes in the exchange rate will in turn influence the value of the foreign investment. This source of uncertainty is inherent in international business, regardless of whether the exchange rate is fixed (and thus subject to unpredictable adjustment) or floating (Katz, 1972; Miller, 1992).

It has been well established that the private prediction of future exchange rates, is costly and unreliable – that is, investors cannot reliably predict the direction of exchange rates, beyond information provided in currency markets. Furthermore, individual firms are price-takers on the foreign exchange markets. Foreign exchange markets are too large in volume and too liquid for individual non-financial companies to influence exchange rates (Campa, 1994; Eiteman, Stonehill, & Moffett, 1998). Hence exchange rate uncertainty is resolved exogenously. Accordingly, we hypothesize:

Hypothesis 3: *Ceteris paribus*, a foreign partner entering into a JV in an environment with higher exchange rate uncertainty will have a higher propensity to make a call option investment. Therefore the foreign partner will take a smaller share in the JV.

Endogenously Resolved Uncertainty

Cultural uncertainty. When an organization expands abroad it will be confronted with an environment that is culturally different from that in its home country. The success of the foreign venture will depend on the cooperation and communication with local parties who tend to have different values, beliefs and customs (Hofstede, 2001). A lack of knowledge of the local culture can have serious negative effects on the investment (Barkema, Bell, & Pennings, 1996). The more distance there is between the culture of the foreign investor and the culture of the host country, the more uncertainty there will be in this respect. The foreign partner will be unsure of how well it communicates with local employees, suppliers and customers as is necessary to succeed in its new environment. The more distant the cultures, the less certain it becomes that the essential skills and knowledge can be effectively acquired. Thus initial uncertainty also exists about the conditions for operating successfully across cultural boundaries in the new environment.

Furthermore, as cultural distance increases, it becomes more uncertain how the parties (owners) to a JV will interact with each other. With increased cultural distance the partners face increased communication problems among themselves, are more likely to have different goals, are more likely to have a more negative attitude towards each other, and experience more stress (Weber, Shenkar, & Raveh, 1996). Uncertainty about the JV's performance increases accordingly.

While such cultural differences indeed represent a severe source of uncertainty for the firm initiating expansion abroad, this uncertainty can be resolved by the actions of the firm itself. With local experience, a foreign investor can much better assess cultural predilections in the host country. It can then assess better how its own personnel and organization should interface with local parties, and adjust its behavior to conform to local culture as relevant (Black, Mendenhall, & Oddou, 1991). The foreign investor can also use this information to bargain with the JV partner(s), local employees, suppliers and customers, etc. – parties whose behavior it may effectively influence, unlike macro-institutions. Such informed adjustments to the behavior of the foreign firm, and plausibly its business partners, will influence the outcome of the JV and thereby the value of the asset underlying the option. Furthermore, the firm can decide how to invest in learning about the local culture and values, and how to act proactively based on this (Black & Mendenhall, 1990). Thus, unlike the exogenous uncertainty described in our first three hypotheses, cultural uncertainty can be resolved endogenously. This entails a departure from the assumptions underlying real options logic. Therefore we do not expect cultural uncertainty to determine the value of a call option. Hence we hypothesize:

Hypothesis 4: *Ceteris paribus*, a foreign partner originating from a more culturally distant country will not have a higher propensity to make a call option investment when entering into a JV. Therefore the foreign partner will not take a smaller share in the JV.

Uncertainty about development capabilities. In the case of JVs an important source of uncertainty pertains to corporate capabilities (Chi & Seth, 2001). First, there is uncertainty about the standalone capabilities of the other party, because of information asymmetry. Second, there is uncertainty about the potential benefits of combining the assets contributed by each partner. This uncertainty is especially important when it comes to intangible assets and knowledge-based activities (Martin & Salomon, 2003; Seth & Kim, 2001).

Such uncertainty about capabilities is most prevalent in collaborations that involve product and/or process development activities. Development projects generally require a substantial amount of specific know-how and proprietary information (Chan, Kensinger, Keown, & Martin, 1997). Furthermore, in JVs that encompass development activities, this specific know-how and information must be shared in order to enable joint discovery, to search for new solutions, and to accomplish product or process development goals. This entails higher uncertainty than in JVs that limit themselves to the use of existing know-how (Pisano, 1989). Therefore we expect uncertainty about partner capabilities to be higher in JVs with development activities.

However, over time the foreign partner will become better able to assess the development contributions of the local partner (Chi & Seth, 2001). Information asymmetry about the standalone capabilities of the partner will be reduced too (Balakrishnan & Koza, 1993). This will start to reduce the uncertainty about the benefits of combining assets (Seth & Kim, 2001). Furthermore, the pace and extent to which this uncertainty is resolved will depend on how much effort the foreign investor allocates to acquiring and implementing knowledge in the development process (e.g., Cohen & Levinthal, 1990; Mowery, Oxley, & Silverman, 1996). As a result, the foreign partner will be able to take a number of actions to increase the likelihood that the development activities are successful. Hence resolution of this kind of uncertainty is endogenous to the foreign partner's actions (Chi, 2000; Chi & Seth, 2001; Dixit & Pindyck, 1994; Mowery et al., 1996). Therefore we do not expect the normal real options effect to hold. Rather, we predict:

Hypothesis 5: *Ceteris paribus*, a foreign partner entering into a JV with a product or process development purpose will not have a higher propensity to make a call option investment. Therefore the foreign partner will not take a smaller share in the JV.

Scope-related uncertainty. JVs differ in their scope, that is, the extent to which their partners combine

functions and activities within the JV (Oxley & Sampson, 2004). For example, JVs can perform manufacturing, marketing, R&D, service activities, or any combinations of these. An increase in the scope of a JV increases the interdependence, complexity and uncertainty of collaborating (Oxley & Sampson, 2004; Reuer, Zollo, & Singh, 2002). Thus we expect uncertainty to be higher in JVs with a broader scope.

However, the JV partners can choose to increase the level of communication and coordination to deal with the increased uncertainty resulting from a broader scope (e.g., Kogut, 1988). Furthermore, they can learn about each other's skills, procedures and capabilities and create idiosyncratic skills to collaborate, which enable them to deal more successfully with unanticipated contingencies (Nakamura, Shaver, & Yeung, 1996; Pisano, 1989). As a consequence, the uncertainty resulting from a broader scope can be addressed by the actions of the partners in the JV. Therefore scope-related uncertainty is endogenous and we do not expect a real options effect. Accordingly, we hypothesize:

Hypothesis 6: *Ceteris paribus*, a foreign partner entering into a JV with a wider scope of activities will not have a higher propensity to make a call option investment. Therefore the foreign partner will not take a smaller share in the JV.

RESEARCH DESIGN

Sample

We collected data on equity JVs (JVs) formed in China between 1979 and 1996 and involving a foreign partner. The main source of data is the *Almanac of Foreign Economic Relations and Trade of China*, which is published by the Chinese Ministry of Foreign Trade and Economic Cooperation (MOFTEC).[5] The data source listed 8077 Sino-foreign JVs. However, the number of observations was reduced to 6472, originating from 41 countries, once we excluded tripartite JVs for which each party's equity investment could not be broken down, and countries for which Hofstede's (2001) cultural scores were not available. These JVs are newly established legal entities in which both partners contribute resources, including equity. Moreover, the JVs in our sample are active in 59 different industries and cover China's entire geographical area.

The data have been shown to be reliable and consistent with FDI data from independent non-Chinese sources, and parts of the data have been used in several published studies (e.g., Chadee and Qiu, 2001; Chadee, Qiu, & Rose, 2003; Pan, 1996, 2002).[6] Furthermore, our sample is comparable to those used in other published studies of JVs in China that used other sources, such as from the *China Business Review* (e.g., Gaba, Pan, & Ungson, 2002; Tse, Pan, & Au, 1997). Hence we feel our sample is consistent with those used in other studies, and is representative of all JVs established in China between 1979 and 1996.

China and our JV data are particularly suited to test our hypotheses, for several reasons. First, China was the world's second largest recipient of FDI after the US as of 1994 – indeed it surpassed the US in 2003 (UNCTAD, 2003). This provides a large number of observations originating from a wide range of countries. Second, China is a complex environment for foreign investors, where each of the sources of uncertainty described in our hypotheses is substantial (Boisot & Child, 1999). Third, almost all foreign investment in China during the study period was through JVs. China's government actively sought to promote equity-based JVs while preventing other modes of investment.[7] This makes the data all the more complete.

The question arises, naturally, whether these JVs are indeed real options. Theoretically, numerous scholars have argued that JVs are real options (e.g., Chi, 2000; Chi & McGuire, 1996; Kogut, 1991; Miller & Folta, 2002; Reuer & Tong, 2005). Furthermore, there is strong and corroborating empirical evidence supporting JVs as real options. More specifically, there is evidence pertaining to the presence of explicit options in JVs (Reuer & Tong, 2005), the formation of JVs (Folta, 1998), the stability of JVs (Folta & Miller, 2002; Kogut, 1991; Vassolo, Anand, & Folta, 2004), and the performance implications of making JV investments (Kumar, 2005; Tong, Reuer, & Peng, 2008), which are all consistent with real options predictions.

In the specific case of China there are four additional reasons to think these JVs contain real options. First, Reuer and Tong (2005) argued that JVs are even more likely to be real options under high levels of uncertainty.

Second, we conducted a number of interviews with managers of multinational firms that are active in China. These interviews consistently revealed that firms take a real options approach when they enter China. For example, one manager in charge of a large electronics firm's JVs stated that: "We use a real options approach to structure our investments when we enter China because it is such

an unpredictable market". Other managers gave similar responses.

Third, by Chinese law, the articles of association of Sino-foreign JVs must include a pricing mechanism to determine the value of the JV at dissolution or for other changes of ownership. Furthermore, the contractual duration of a JV has to be specified *ex ante* in the JV's articles of association. Therefore JVs in China correspond at least with what Seth and Chi (2002) classify as an option with a restrictive termination clause and a pre-specified mechanism to value the JV. This kind of JV specification is a stronger and more explicit type of real option than purely implicit options, and it comes close to the strongest form of real options in which the strike price is exactly specified *ex ante*. Furthermore, we can say with confidence that the foreign parties in Sino-foreign JVs will hold only a call option, and no put option. That is because China's legislation and the policy of the ruling Chinese Communist Party (CCP) hampered foreigners from exiting by selling their equity to their venture partner. Likewise, the Chinese JV partner did not hold a call option but a put option. In addition, the secondary market for JVs stakes among foreign investors in China was highly regulated, and almost non-existent in practice.[8]

Fourth, to confirm this we conducted a quantitative analysis of all the stock-listed companies in our sample, which showed that most of the JVs remained stable over their *ex ante* specified life. This is consistent with real options predictions in that options are usually held until maturity because of the time value of the option. Furthermore, when we saw changes in the ownership distribution of JVs, they consisted of the foreign partner buying out some or all of the Chinese party's equity. This again is consistent with the JVs being real options where the foreign partner holds a call option. Moreover, there is anecdotal evidence that foreign partners use the *ex ante* specified pricing mechanism in the JV contract of association to value the venture when they decide to strike the call. For example, the Fortis banking group acquired an additional stake in one of its Chinese JVs without having to pay a premium over the price determined by the pre-specified pricing mechanism (*Financial Times*, 2005). This indicates that the Chinese party was not able to renegotiate and drive up the strike price.

All this does not preclude the foreign partner specifying an explicit strike price when the JV is formed, making for an even stronger form of real options. Indeed, we observed a number of firms entering into a JV in China with such an explicit option. Among these foreign firms are the British bank HSBC, US IT company 3COM, Australian telecommunication firm Telstra, and French car manufacturer PSA Peugeot Citroën. Overall, we found convincing evidence that the JVs in our sample indeed contain real options.

Dependent Variable

Foreign share. Our dependent variable is the percentage of foreign ownership in Sino-foreign JVs. As discussed earlier, a foreign investor who wants to capture the static NPV part will be more likely to take a large share, whereas an investor who makes a call option investment will take a smaller share (Chi & McGuire, 1996; Reuer, 2002). Under Chinese law the percentage of foreign ownership could range from 25 to 99.9%.

Independent Variables

Economic uncertainty (Hypothesis 1). The degree of economic uncertainty is measured using the *Euromoney* country risk index. This often-used index measures the economic uncertainty of a country at a particular time on a scale from 0 to 100 based on credit (e.g., payment records), analytical (e.g., economic performance forecasts) and market indicators (e.g., selldown performance). The index comprises a mix of market perception and objective measures.[9]

Local institutional uncertainty (Hypothesis 2). The Chinese government established a number of special areas over time to attract foreign investment. These areas are characterized by a lower level of uncertainty for foreign investors, as a result of a higher degree of liberalization, a more developed institutional and regulatory framework, less bureaucratic red tape, and less government involvement (Shan, 1991). Two types of special areas exist, which differ in location, but are otherwise similar: the Special Economic Zones (SEZ) and open coastal cities. Five Special Economic Zones[10] were declared in 1980, and a number of coastal cities[11] were opened in 1984. We include a dummy variable that equals 0 if the JV was located in either an SEZ or an open coastal city, indicating lower uncertainty, and 1 when the JV is located in any other region.[12] The same or similar variables have been used in other studies (e.g., Pan, 1996; Shan, 1991).

Exchange rate uncertainty (Hypothesis 3). In a fixed exchange rate regime such as China's, exchange rate uncertainty comes not from continuous daily market changes in the exchange rate but from discrete changes (i.e., devaluations or revaluations) made by the government at unpredictable intervals. However, a black market or so-called "parallel exchange rate market" has developed in many countries with a fixed exchange rate regime (Reinhart & Rogoff, 2004). On this parallel market the exchange rate changes continuously, subject to market forces. Therefore there will often be a difference between the fixed official exchange rate and the floating parallel market rate. These differences are an indication of the level of exchange rate uncertainty for foreign investors. The official rate will correspond to the real (economic) exchange rate when the fixed official exchange rate equals the floating parallel market rate. Thus it will be extremely unlikely that a discrete change of the official exchange rate will take place. However, there will be increasing exchange rate uncertainty when the gap between the fixed official exchange rate and the floating parallel market rate grows. This bigger difference indicates more strain on the official exchange rate. Uncertainty increases because it is unclear how much the official rate will change or when it will change. Accordingly, following Reinhart and Rogoff (2004), we measure exchange rate uncertainty as the absolute value of the parallel market premium (or discount), measured over the previous 12 months as is common in the literature:[13]

$$\text{Parallel Market Premium} = \frac{|\text{Average Annual Official Rate} - \text{Average Annual Parallel Rate}|}{\text{Average Annual Official}} \quad (1)$$

Thus a higher parallel market premium (or discount) indicates more exchange rate uncertainty.[14]

Cultural uncertainty (Hypothesis 4). We measure cultural uncertainty by using Kogut and Singh's (1988) cultural distance index. This often-used index is based on the difference between each country and a focal country (here, the investor's home country vs China) along each of Hofstede's (2001) four initial cultural dimensions. A higher score on Kogut and Singh's (1988) cultural distance index implies a higher level of cultural uncertainty.

Uncertainty about development capabilities (Hypothesis 5). Based on the textual description of the activities of the JVs, we identify those projects that were engaged in any substantive development activities. We construct a variable that takes a value of 1 if a JV undertakes development activities, and 0 otherwise. In almost all cases, these activities pertained to product (rather than process) adaptation. While pioneering technological research may represent exogenous uncertainty when it is subject to uncontrollable external conditions – a point to which we return in the discussion – upon careful verification we found no instance of such projects in our sample during this early period of foreign investment in China. A minute number of records (about 1 in 1000) indicated some form of "research" activity, but these were not necessarily the type subject to exogenous uncertainty, and there were too few cases for a separate analysis. Our results are robust to excluding these cases altogether or including them as development cases.

Scope-related uncertainty (Hypothesis 6). Similar to several other studies (e.g., Reuer et al., 2002), we measure the degree of scope-related uncertainty by using a count measure that captures the number of activities performed in the JV. This count measure increases with each of the following activities that are conducted in the JV: manufacturing, marketing, services and development.

Control variables. We control for a number of additional factors that may influence the ownership structure of a JV. First, we control for the *duration* of the JV, using the logarithm of the *ex ante* specified contractual duration of the JV. Foreign investors entering in an equity JV in China are required to determine the duration of the project *ex ante* (Beamish, 1993; Shan, 1991). The duration of an option determines its value insofar as longer time horizons provide more opportunities for the option to become in-the-money (Jarrow & Turnbull, 2000). Second, we control for the *total size* of the JV using the logarithm of the dollar amount invested by both partners. We also control for the experience of the foreign investor in China, measured as the logarithm of the number of years since the foreign investor formed its first JV in China. Furthermore, we create period fixed-effects for the different 5-year plans[15] of the CCP. These capture general differences in the business environment across periods. Finally, we control for *industry* differences. There is evidence of

inter-industry differences in the patterns of ownership of foreign subsidiaries (Kobrin, 1987). Furthermore, the CCP preferred to keep control over strategically and symbolically important industries, which might also influence the ownership distribution in certain industries. Therefore we classified all JVs by two-digit SIC code based on the description of their activities and business scope. Subsequently, we created industry fixed effects for every two-digit SIC code.

Estimation

We consider two important characteristics of our data in choosing the appropriate method to test our hypotheses. First, our dependent variable is censored because the Chinese government only allows foreign ownership to range from a minimum of 25% to a maximum of 99.9%. Foreign investors might actually prefer an ownership share outside this range but end up taking a share somewhere between 25 and 99.9%, choosing the value closest to their true preference. Indeed, a substantial number of observations have either boundary value. Not controlling for the censored dependent variable is likely to lead to biased results (Greene, 2003). Second, our data are hierarchically structured, with units at two different but nested levels. The lower level consists of the individual JVs, which we label with the subscript *i*. The higher level, which we will label with subscript *j*, represents the different countries of origin of the foreign investors. Failing to take into account the multilevel structure of the data would possibly result in underestimated standard errors (Hox, 1995).

Given these considerations, we use a multilevel tobit model to test our hypotheses. More specifically, we use a random-intercept multilevel tobit model with double censoring.[16] The general formulation of such a model, given in terms of an index function, is (Greene, 2003; Hox, 1995)[17]

$$y_{ij}^{*} = \beta X_{ij} + e_{ij} + u_j$$
$$y_{ij} = \begin{cases} y_{ij}^{*} \text{ if } 25 < y_{ij}^{*} < 99.9 \\ 0 \text{ otherwise} \end{cases} \qquad (2)$$

Testing Null Hypotheses

In the social sciences, and especially in management and international business, testing that two variables have no effect on each other has been done using a technique called *statistical power analysis* (e.g., Brock, 2003; Cashen and Geiger, 2004; Cohen, 1977, 1990; Lane, Cannella, & Lubatkin, 1998). Advocates of this approach argued that *ex post* power calculations could be used to interpret non-statistical results. Despite its popularity, the use of *post hoc* power analysis to test null hypotheses has been severely criticized. Among others, Hoenig and Heisey (2001) criticized the *post hoc* use of power analysis in general, and the use of the "observed power" and "detectable effect size" approaches in particular, for being misleading and meaningless, owing to the fact that for any test the *observed power* is a one-to-one function of the observed p-value and therefore does not add to the interpretation of the results.[18] Therefore we used a series of more robust alternative approaches to *post hoc* power analysis to test our null hypotheses. We will discuss these in detail below.

Despite the reservations about *post hoc* power analysis, some power applications are still considered to be appropriate and useful. These include the use of power analysis in meta-analyses, and the *ex ante* determination of the minimum sample size for designing studies (e.g., Colegrave & Ruxton, 2003; Hoenig & Heisey, 2001). The latter power application is proper and relevant for our purpose. That is, we use an *ex ante* approach to determine the minimum sample size that is needed to be able to pick up any existing relationships between our independent and dependent variables. More specifically, we implement Cohen's (1977: 440) multiple regression table conservatively by calculating the minimum sample size, given that the effect size is assumed to be extremely small (R^2=0.015), no more than 50 independent variables are used (including fixed effects not reported in our tables of results), and the power of the test ($1-\beta$) as desired *ex ante* is 0.99 (i.e., $\beta=\alpha=0.01$).[19] This reveals that the minimum sample size we need to be able to observe even an extremely small effect size is 4373, which is well below our sample of 6472 observations. Hence we can exclude the possibility that we fail to find any effects due to an insufficiently large sample size.

To then test whether an effect is indeed null, several scholars have suggested examining the practical magnitudes of the effects and analyzing the range of possible effect sizes that are (not) supported by the data (e.g., Colegrave & Ruxton, 2003). The practical magnitudes of the effects can simply be examined by taking the partial derivatives of the coefficients and evaluating the effect of a one-standard-deviation (for continuous variables) or one-unit (for binary variables) change in the variables. However, this only informs us about the

mean of all possible values the true effect can take. Therefore Hoenig and Heisey (2001) and Colegrave and Ruxton (2003) recommended that researchers investigate the range of effect sizes rather than just their mean value. To do so, we follow an approach similar to the one suggested by Johnson (2005) and Colegrave and Ruxton (2005) to interpret non-significant results and test null hypotheses. This approach considers simultaneously the range and the position (relative to zero) of the distribution that the true effect size can have, and thus allows us to calculate the probability that the real effect size is larger or smaller than a trivial value. This probability can be written as

$$F(\beta > d) \text{ or } F(\beta < d) \quad (3)$$

where β is the true coefficient, F=normal(β, SE_β), SE_β is the standard error of β, and d is a trivial effect.

For this test it is important to specify what is to be considered a trivial effect size. Several methods to determine d have been suggested in the literature (e.g., Murphy & Myors, 2004). One is a deductive method based on well-established theory. We do not deem this method appropriate in this study because it presumes that there is a wealth of previous research to draw on. Alternatively, an inductive method might be used. This is appropriate when there are sufficient relevant data, derived for instance from meta-analyses. However, such data are again not available in our case. Although neither of these approaches is helpful in our particular case, we can use a third method to identify values that are meaningful vs trivial: we use as starting points the minimum effect size we observe for the exogenously resolved sources of uncertainty and the maximum effect size we observe for the endogenously resolved sources of uncertainty. This also allows us to contrast both forms of uncertainty.

We ascertained the reliability of our measures of endogenous uncertainty (and others) in two ways. First, we used measures that have often been used in the literature, and particularly in studies that focused on the same empirical setting as ours and resulted in significant findings (e.g., Luo, 2005; Oxley & Sampson, 2004; Pan, 1996; Reuer et al., 2002). This indicates that sufficiently established and noise-free measures are on hand. Second, we conducted nomological validity testing – a method that is commonly used to test the validity of psychological constructs (Cronbach & Meehl, 1955). Using the same sample, we found that our independent variables are significantly related to various dependent variables (such as indicators of investment size and timing) in a manner consistent with extant theory.

RESULTS

Descriptive statistics and pairwise correlation can be found in Table 1. The negative correlations between our measures of economic uncertainty, local institutional uncertainty and exchange rate uncertainty, respectively, and the foreign share in the JV are consistent with our Hypotheses 1, 2 and 3. Conversely, the correlations between the measures of the three sources of uncertainty that are resolved endogenously – that is, cultural, development (capabilities) and scope-related uncertainty – and the foreign share in the JV are positive. Additionally, the correlations do not suggest that collinearity might be a problem.

Table 1 Descriptive statistics and correlations

	Variable	*Mean*	*Std dev.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	Foreign share	47.869	20.080	1.000									
2	ln(Duration)	2.829	0.528	0.435	1.000								
3	ln(Size)	8.300	1.489	0.310	0.588	1.000							
4	ln(Experience)	0.103	0.392	0.012	0.110	0.078	1.000						
5	Economic uncertainty	72.295	8.178	−0.080	−0.166	−0.254	−0.068	1.000					
6	Local institutional uncertainty	0.676	0.468	−0.041	−0.036	0.073	−0.047	−0.055	1.000				
7	Exchange rate uncertainty	0.599	0.639	−0.197	−0.157	−0.173	0.016	−0.519	0.002	1.000			
8	Cultural uncertainty	1.067	1.290	0.117	0.157	0.103	0.053	−0.021	−0.030	0.015	1.000		
9	Development uncertainty	0.016	0.124	0.034	0.024	−0.009	−0.019	0.027	0.008	−0.020	0.044	1.000	
10	Scope-related uncertainty	1.078	0.285	0.072	0.069	0.055	−0.009	0.086	0.020	−0.161	0.039	0.218	1.000

Number of observations=6472. Absolute correlations above 0.032 are significant at $p < 0.01$.

Examination of the distribution of equity shares shows that the values are broadly dispersed over the allowed range of 25–99.9%, and that no more than 20% of cases are censored (either to the right or to the left). This falls well below the threshold whereby an extreme proportion of censored cases may bias tobit estimates. The multilevel tobit results, obtained from Stata 10, are reported in Table 2. Model 1 represents a baseline model including all control variables except for the industry fixed effects, whereas Model 2 includes the industry fixed effects. In Model 3 measures of the sources of uncertainty that are resolved exogenously (only) are added. Model 4 includes our measures of the three endogenous forms of uncertainty (only). Finally, Model 5 includes measure of all sources of uncertainty simultaneously. The model likelihood chi-squares show that every model is significant ($p<0.001$) relative to an intercept-only model.[20]

We also conduct likelihood ratio tests to determine the joint significance of, respectively, the exogenous and endogenous forms of uncertainty. The likelihood ratio can be useful to evaluate our null hypotheses, as it allows us to evaluate the strength of evidence for one hypothesis vs another (Johnson, 2005; Royall, 1997). The likelihood ratio test shows that adding the three sources of uncertainty that

Table 2 Results of the multilevel tobit models of the foreign partner's equity share in a JV

		Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
	Constant	11.796***	11.223***	36.393***	10.919**	37.252**
		(3.094)	(3.364)	(4.866)	(3.936)	(5.272)
	ln(Duration)	15.643***	15.479***	14.854***	15.435***	14.828***
		(0.659)	(0.654)	(0.652)	(0.654)	(0.653)
	ln(Size)	−0.441	−0.244	−0.228	−0.239	−0.226
		(0.290)	(0.295)	(0.294)	(0.295)	(0.294)
	ln(Experience)	−2.457***	−2.179**	−2.482***	−2.158**	−2.462***
		(0.702)	(0.689)	(0.683)	(0.689)	(0.683)
H1	Economic uncertainty			−0.278***		−0.279***
				(0.043)		(0.043)
H2	Local institutional uncertainty			−1.819**		−1.853***
				(0.582)		(0.583)
H3	Exchange rate uncertainty			−6.671***		−6.560***
				(0.680)		(0.685)
H4	Cultural uncertainty				−0.816	−0.858
					(0.841)	(0.826)
H5	Development uncertainty				−0.075	0.395
					(2.264)	(2.246)
H6	Scope-related uncertainty				2.125*	1.170
					(0.978)	(0.982)
	Period fixed effects	Included	Included	Included	Included	Included
	Industry fixed effects	Excluded	Included	Included	Included	Included
	σ_u	4.429***	4.316***	4.214***	4.241***	4.138***
		(0.946)	(0.928)	(0.918)	(0.909)	(0.895)
	σ_e	21.305***	20.841***	20.653***	20.832***	20.650***
		(0.221)	(0.216)	(0.214)	(0.216)	(0.214)
	ρ	0.041	0.041	0.040	0.040	0.039
		(0.017)	(0.017)	(0.017)	(0.016)	(0.016)
	Log-likelihood	−24,559.68***	−24,430.10***	−24,373.89***	−24,427.22***	−24,372.58***
	LL ratio relative to Model 2			112.42 (3)***	5.76 (3)	
	LL ratio relative to Model 3					2.62 (3)
	No. of observations	6472	6472	6472	6472	6472
	Uncensored	5173	5173	5173	5173	5173
	Left-censored	1085	1085	1085	1085	1085
	Right-censored	214	214	214	214	214

Standard errors are in parentheses.
All tests are two-tailed: †$p<0.10$; *$p<0.05$; **$p<0.01$; ***$p<0.001$.

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are resolved exogenously to Model 2 as we did in Model 3, significantly increases the fit of the model (χ^2=112.42 for three variables; $p<0.001$). By contrast, the addition of the three sources of uncertainty that are resolved endogenously to Model 2, as we did in Model 4, does not improve model fit (χ^2=5.76 for three variables). Finally, in Model 5 we add the three sources of endogenous uncertainty to the model that includes all the sources of exogenous uncertainty (Model 3). This also reveals that the endogenous sources of uncertainty do not contribute significantly to model fit (χ^2=2.62 for three variables). Overall, the joint significance of the exogenous forms of uncertainty and the lack of joint explanatory power of the three endogenous forms of uncertainty are in line with our hypotheses.

The results of Models 1 and 2 show that, among the control variables, only JV duration has a significant (positive) effect. This is consistent with the existence of an NPV component in real options investments (Dixit & Pindyck, 1994). Likewise, the foreign partner's experience has a significant (negative) effect. Inclusion of industry effects does not substantially change the interpretation of the results.

Exogenously Resolved Uncertainty

In Model 3, we find a negative and significant relationship ($p<0.001$) between foreign share and our measure of economic uncertainty. This is consistent with Hypothesis 1. Similarly, we find a negative and significant relationship ($p<0.01$) between foreign share and our measure of local institutional uncertainty, supporting Hypothesis 2. Finally, we find that foreign investors will take a smaller share when our measure of exchange rate uncertainty increases. Thus Hypothesis 3 is strongly supported ($p<0.001$). When we add to Model 3 the effects for endogenously resolved uncertainty, as in Model 5, we find almost identical results, with Hypotheses 1, 2 and 3 supported; indeed, the significance of local institutional uncertainty (Hypothesis 2) improves to $p<0.001$. Thus our findings strongly support our first three hypotheses. The results for the exogenously resolved sources of uncertainty are, as expected, in line with real options logic.

Endogenously Resolved Uncertainty

Model 4 adds the effects of endogenously resolved uncertainty. In line with Hypothesis 4 (and contrary to what might be expected if real options logic were misapplied), we find no relationship between foreign share and our measure of cultural uncertainty. Similarly, in line with Hypothesis 5, we find no relationship between foreign share and the presence of development activities indicating uncertainty about partner capabilities. In Model 4, we do not find a negative relationship between foreign share and our measure of scope-related uncertainty in the JV; indeed the coefficient is significant and positive in Model 4, but becomes insignificant in the more completely specified Model 5. Either way, this is in line with Hypothesis 6. The coefficients of the other two sources of endogenously resolved uncertainty remain insignificant in Model 5. Thus the overall results are in line with Hypotheses 4, 5 and 6. As expected, real options predictions do not hold when uncertainty can be resolved endogenously, and thereby the source of uncertainty departs from the assumptions underlying option logic.

Effect Magnitudes

Examination of the practical magnitudes of the hypothesized effects confirms the statistically significant results. Based on the partial derivatives of the coefficients in Model 5, the marginal effect of a one-standard-deviation increase in economic uncertainty lowers the foreign partner's equity stake by 2.2%. Likewise, the dependent variable is approximately 1.8% lower when the investment is in a Special Economic Zone or coastal city with lower local institutional uncertainty. A one-standard-deviation increase in exchange rate uncertainty, meanwhile, lowers the dependent variable by over 4.1%. Besides being statistically nonsignificant, the practical magnitudes associated with endogenous sources of uncertainty are only a fraction of those of the exogenous variables. The marginal effect of a one-standard-deviation change in cultural uncertainty lowers the foreign partner's equity stake by just 1%. The dependent variable is about 0.4% higher in JVs that encompass development activities. Likewise, a one-standard-deviation change in the scope-related uncertainty increases the dependent variable by 0.3%. Comparing continuous variables, the magnitudes of the exogenously resolved variables are over twice as large as (and up to 13 times larger than) those of endogenously resolved variables. Likewise, comparing binary variables, the endogenously resolved variable has a magnitude 4.5 times greater than the exogenously resolved variable. Overall, the average of the absolute values of the practical magnitudes of the exogenous sources of uncertainty is more

than 4.5 times greater than that of the endogenous sources of uncertainty. This analysis is again consistent with our predictions, and we hope that this also illustrates the value of paying more attention to the substantive magnitude of observed effects in international business research as well as in related fields, whether or not authors are interested in null hypotheses (Shaver, 2008).

Analyzing the Range of the Effect Magnitudes

Analyzing the practical magnitudes of the effects revealed strong differences between exogenously and endogenously resolved sources of uncertainty. This provides essential information about the mean of all possible values that the true effect can take, but not about the range of values that the true effect can take (and therefore confidence in the mean). Therefore we investigated the entire range of effect sizes, which also allows us to calculate the probability that the true effect of each hypothesized coefficient is larger than a trivial value. As it is difficult to specify what is a trivial effect size, we consider several plausible and empirically informed cutoff values for trivial effects.

First, we considered a 1% change in the dependent variable as cutoff for a trivial effect. Of all the endogenous sources of uncertainty, a one-standard-deviation change in cultural uncertainty has, with an impact of 1%, the largest effect on the dependent variable. Furthermore, a 1% change in ownership is the smallest change we can observe in our data; given rounding, any observed 1% change may in fact be much smaller yet. Hence this is a meaningful cutoff. The probabilities that a 1% decrease in the foreign partner's ownership of the JV results from a one-standard-deviation increase in economic uncertainty ($p=0.999$), a unit increase in institutional uncertainty ($p=0.924$), and a one-standard-deviation increase in exchange rate uncertainty ($p>0.999$), respectively, are all very high. By contrast, the probabilities that a 1% decrease in the dependent variable results from respectively a one-standard-deviation increase in cultural uncertainty ($p=0.500$, by definition), a one-unit increase in development uncertainty ($p=0.265$), and a one-standard-deviation increase in scope-related uncertainty ($p<0.001$) are considerably lower.

Second, we considered a 1.8% change in the foreign partner's ownership stake as a cutoff for a trivial effect. A 1.8% change is meaningful in that the effect of a one-unit change in institutional uncertainty equals 1.8%, which is the lowest effect of all three sources of exogenous uncertainty. We find that the probabilities that a 1% decrease in the dependent variable results from, respectively, a one-standard-deviation increase in economic uncertainty ($p=0.900$), a one-unit increase in institutional uncertainty ($p=0.500$, by definition) and a one-standard-deviation shift in exchange rate uncertainty ($p>0.999$) are again considerable. Conversely, the corresponding probabilities for the endogenously resolved forms of uncertainty are less than half of those values: cultural uncertainty ($p=0.248$), development uncertainty ($p=0.161$) and scope-related uncertainty ($p<0.001$).

Finally, we replicate the analysis using 2.5% as a cutoff value. This is motivated by the fact that a 2.5% change in ownership corresponds, on average, to a $100,000 increase in the equity investment made by the foreign partner in our data. The tests reveal a similar pattern: the probabilities that an increase in each of the exogenous sources of uncertainty result in a decrease in the dependent variable that is larger than 2.5% are still considerable, while those of the endogenous sources are small ($p<0.100$).

Overall, across a range of different cutoff values for a trivial effect, we find high probabilities that the true effect of the exogenous sources on the dependent variable is non-trivial. In contrast, the probabilities that the true effects of the endogenously resolved sources of uncertainty are non-trivial are considerably smaller. These consistent differences between the exogenous and endogenous resolved sources of uncertainty provide strong support for our hypotheses.

Hoenig and Heisey (2001) also argued that Bayesian methods provide an alternative approach to evaluate null hypotheses. To further test the robustness of our results, we generated the posterior distributions of our coefficients using a Bayesian tobit model.[21] Analyzing the posterior distributions of the coefficients of the exogenously resolved sources of uncertainty revealed that all three are negative and distinctly different from zero. By contrast, the posterior distributions of the coefficients of the endogenously resolved sources of uncertainty are centered around zero. Further details of our Bayesian analysis are available from the authors upon request.

In summary, by every method proposed by Hoenig and Heisey (2001), Colegrave and Ruxton (2005), and Johnson (2005), among others, we find consistent support for the predictions whereby exogenous uncertainty leads to a real-options-consistent choice of equity shares, and conversely

consistent support for the predictions whereby endogenous uncertainty does *not* lead to such outcomes.[22]

DISCUSSION

The results advance our understanding of the boundary conditions for real options theory. In real options theory, one of the main predictions is that higher levels of uncertainty will increase option value, which will in turn increase the likelihood of the occurrence of a real options investment. In JVs this will result in a smaller ownership share for the call option holder. However, we also argued that this logic would not hold when uncertainty is resolved endogenously rather than exogenously. When uncertainty is resolved exogenously, we indeed find a negative relationship between economic uncertainty (Hypothesis 1), local institutional uncertainty (Hypothesis 2) and exchange rate uncertainty (Hypothesis 3), respectively, and the foreign share in a JV. These results confirm the power of real options logic when it comes to exogenous uncertainty. We also examined the relationship between cultural uncertainty (Hypothesis 4), uncertainty about development capabilities (Hypothesis 5) and scope-related uncertainty (Hypothesis 6), respectively, and the foreign share in a JV. Using appropriate techniques meant to test null hypotheses, we find no support for the statistical relationship that would follow from a real options model. Thus, as we argued, conventional real options logic is applicable when uncertainty is resolved exogenously, but not when it is resolved endogenously.

This study has implications for both scholars and practitioners. First, our framework makes it possible to identify the conditions under which an investment can truly be expected to represent a real option. A wide range of investments has been classified as real options investments, and previous empirical results have shown inconsistent support for real options theory. We argue that this may be because real options logic might inadequately characterize investments that are subject to endogenously resolved uncertainty. Our research also confirms that real options theory has strong predictive power in the presence of exogenous uncertainty. While we did not examine the performance implications of JV stakes, the results are consistent with arguments whereby real options can be an effective means of dealing with uncertainty when undertaking strategic investments – provided the uncertainty is exogenous.

Second, as appealing as using real options metaphorically may be, this should be done only while keeping carefully in mind what sources of uncertainty the option is meant to hedge, and whether the uncertainty is resolved endogenously. Third, researchers and practitioners should be aware of the boundaries of the theory when they use it to examine potential investments. Using real options logic to value projects when it is not suitable is likely to lead to suboptimal decision-making. Adner and Levinthal (2004a, b) argued that practitioners might be able to make use of real options logic when uncertainty is resolved endogenously, but only if they compensate for endogeneity by putting control systems into place and by changing the design of the organization. However, this is likely to require a costly trade-off, as such mechanisms may impede progress, and the organizational costs may outstrip the quasi-option value thus obtained.

Similarly, researchers might be able to make use of real options logic when uncertainty is resolved endogenously – but only if their formal models, and equally importantly their empirical analyses, incorporate the unique characteristics and consequences of endogenously resolved uncertainty. Sophisticated decision-theoretic models with endogenous uncertainty have been developed in the operations research and economics literatures (Koussis, Martzoukos, & Trigeorgis, 2007; Pawlina & Kort, 2006), and have started to find their way into international business and strategy research, such as Chi and Seth's (2009) work on MNE entry mode choices. However, these modeling developments have so far been accompanied by a relative dearth of empirical evidence about the actual feasibility and impact of such strategies. From this standpoint, our study does not imply that it is necessary to "shut down" research on real options when uncertainty is endogenous. However, it implies that such research should duly and explicitly incorporate the endogeneity of uncertainty. Furthermore, it must also develop and build upon compelling, generalizable empirical evidence about whether the strategies for real options with endogenous uncertainty are feasible and cost-effective in practice, notwithstanding the computational and organizational costs that they add.

The implications for JV research are substantive too. While numerous scholars have looked at the conditions under which JVs are more or less appropriate (e.g., Contractor & Lorange, 2002; Hennart, 1988), the determinants of the ownership

distribution of JVs have received far less attention in the JV literature (Cuypers & Martin, 2007), and studies have produced comparatively disappointing empirical results (e.g., Gatignon & Anderson, 1988). Our results confirm that a real options perspective can be useful in modeling equity share decisions in JVs, although we show that this is true only when uncertainty is resolved exogenously.

Furthermore, our model describes determinants of the optimal level of ownership for a foreign investor. This is especially relevant in dealing with highly (exogenously) uncertain markets, which is a basic reason to consider JVs in the first place. Our findings thus point to the importance of carefully specifying the relationship between various sources of uncertainty and a firm's expansion strategy, as a firm's strategy should be in line with the nature of the uncertainties it faces. This highlights the need for and the rewards from a more precise conceptualization of uncertainty in the international business and strategy literatures.

Limitations and Suggestions for Further Research

This study is not without its limitations, and several suggestions for further research can be made. First, we study the applicability of real options theory in one particular country. While China has become a favorite destination of foreign investment, future studies could verify our results in other national settings, provided local conditions are consistent with the use of JVs as real options. Second, we look only at one particular type of real options investment, namely the JV. However, our theoretical arguments hold regardless of the type of real options investments. Thus it would be interesting to look at other types of real options investments, such as in patenting and new business contexts. Third, we look at six different sources of uncertainty. Future research could examine yet other sources of uncertainty to further evaluate where real options logic holds in practice.

Relatedly, a debate has arisen about the extent to which research activities should be thought of as real options. As mentioned above, our sample did not include pioneering technological research activities – as opposed to plain development activities, which are more akin to technical tasks (Kotabe, Martin, & Domoto, 2003). Nevertheless, our framework offers a way to think about research activities too. By our logic, research aimed at pioneering new technology may represent a real options investment – but only if the resolution of the associated uncertainty is outside the control of the firm and therefore exogenous. Oriani and Sobrero (2008) likewise point to the relevance of the distinction between industry-wide patterns of design upheaval, whose resolution may depend on the uncoordinated efforts of multiple actors from various industries, and discrete projects within a dominant design. The former may represent (nearly) exogenous uncertainty that can occur at some stages of an industry's evolution, whereas the latter is normally endogenous. This distinction thus maps onto our discussion of exogenous vs endogenous uncertainty, and future research encompassing this distinction may generate insights into specific conditions under which R&D can be effectively modeled as a matter of real options.

We examined the roles of different types of uncertainty on the ownership distribution of JVs from a real options perspective. However, our findings also have implications for alternative theoretical perspectives. For example, in transaction cost economics (TCE) behavioral uncertainty figures as an endogenous factor that can be addressed via governance decisions (Williamson, 1985). More specifically, a premise of TCE is that firms will opt for a governance structure that provides a higher level of control, in order to reduce the increased hazards of opportunistic behavior by the other party, when behavioral uncertainty is high. However, few TCE studies have looked at the equity distribution of JVs, and these studies yielded mixed results. Gatignon and Anderson (1988) were able to explain the choice between full ownership and shared ownership, but they were generally unsuccessful in explaining the ownership distribution when a JV was chosen. Similarly, Delios and Beamish (1999) and Chen, Hu, and Hu (2002) found ambiguous or no effects of factors causing behavioral uncertainty on the ownership distribution of JVs.

Given these mixed results in the TCE literature on JVs, our non-significant findings are not surprising. However, we must note that the variables we use to capture the level of endogenous uncertainty differ from the typical variables used in TCE studies, where measures typically focus on asset specificity and marketing intensity. Unfortunately we lack such data for the JVs in our sample, although our JV-level control variables and industry fixed effects go some way towards accounting for such unobservables. Furthermore, although our empirical setting is all the more suitable to test real options predictions, it is far less suitable to explain the ownership distribution from a TCE perspective or

from an agency perspective. That is, because of China's unique JV legislation during the period of our sample, the correspondence between decision rights and control, respectively, and the level of ownership in JVs was not as close as in other contexts. In our setting, it may be more appropriate for TCE research to examine the allocation of key (managerial) positions instead (Chi & Roehl, 1997). Nevertheless, research exploring the implications of our findings for various alternative theoretical perspectives would be well warranted.

Finally, we use a dichotomous classification to distinguish between endogenously and exogenously resolved uncertainty. However, some sources of uncertainty may be more strictly endogenous (exogenous) than others. Therefore a more continuous classification of how uncertainty is resolved could lead to additional insights, provided proper scales can be developed. On this basis, it would also be worthwhile to extend the range of sources of uncertainty considered, including especially demand uncertainty (Delacroix & Swaminathan, 1991; Wholey & Brittain, 1989). Furthermore, an interesting avenue for future research would be to refine our conceptualization of uncertainty by identifying different types of uncertainty within the exogenous–endogenous classification, and to explore their implications. In particular, some forms of endogenous uncertainty may precipitate all-or-nothing investments (for instance, to shape industry structure) while others need not.[23]

CONCLUSION

Our study shows that the use of real options can be made more powerful, both academically and in practice, by paying extra attention to the sources and resolution of the uncertainty that the options are meant to exploit. In the context of IJVs, we show that normal real options predictions are ineffective when uncertainty is resolved endogenously, but all the more powerful when the firm faces exogenous uncertainty. Given the prevalence of uncertainty in international operations, and of IJVs as a mode of entry, further research in this area is all the more justified.

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NOTES

[1]The approaches that have been used in the few existing studies investigating the distribution of JV ownership among partners are transaction cost economics (Chen et al., 2002; Delios & Beamish, 1999; Gatignon & Anderson, 1988), agency theory (Chi & Roehl, 1997; Nakamura & Yeung, 1994) and the bargaining perspective (Blodgett, 1991; Fagre and Wells, 1982). However, these studies have yielded mixed results regarding the role of (behavioral) uncertainty in the equity distribution of JVs. For a detailed review of this literature, see Cuypers and Martin (2007).

[2]The concept of uncertainty used in option theory is actually one of risk in the sense of Knight (1921), in that options pricing models assume that it is possible to specify the probability distribution of future asset values. Nevertheless, we follow the extant use of terminology in referring to this as "uncertainty".

[3]In the case of exogenous uncertainty the firm will wait for information about how the exogenous source of uncertainty has evolved and subsequently take action, that is, decide whether to strike, hold onto or abandon the option. In a broad sense this can also be seen as learning. However, contrary to learning in the case of endogenously resolved uncertainty, the firm cannot determine the pace of information revelation, nor can it influence its outcomes. "Learning" amidst exogenous uncertainty thus simply represents the passive receipt of updated information. It does not represent the systematic, forward-looking accumulation of experience or the proactive development of causal insight that is normally associated with organizational learning (Fiol & Lyles, 1985).

[4]For simplicity of exposition, we treat the foreign partner as the call option holder. This is consistent with the existing literature (e.g., Reuer & Tong, 2005). We will discuss why this assumption is all the more valid in our empirical setting, that is, China, when we describe our sample below. In some other empirical settings it may be less clear who is the call option holder.

[5]MOFTEC was formerly known as the Ministry of Foreign Economic Relations and Trade (MOFERT), and is currently known as the Ministry of Commerce of the People's Republic of China (MOFCOM).

[6]Pan (2002) also looks at JVs established between 1979 and 1996. Other studies use a subset of our sample. Pan's (1996) sample covers the 1979–1992 period; Chadee and Qiu (2001) look at 1992–1995; and Chadee et al. (2003) study JVs established between 1984 and 1996.

[7]Deng Xiaoping's reforms were summed up in the "Four Modernizations" of agriculture, industry, science and technology and the military. The focus was on knowledge transfer from the West. The CCP's initial view was that this could best be achieved by setting up joint ventures with foreign partners. Therefore all alternative investment modes were prohibited except for a few exceptions (*Almanac of Foreign Economic Relations and Trade of China*, various issues).

[8]Whatever the letter of the law, contracts may be imperfectly enforceable in the presence of weak institutions. For instance, in the context of the Brazilian telecommunication industry, Perkins, Morck, and Yeung (2008) found that local partners may use pyramidal ownership schemes, and used local institutions to take advantage of foreign partners. Our fieldwork does not suggest that this is as much of an issue in China. This may partly explain why China has been so successful at attracting foreign direct investment, including Sino-foreign JVs. As Fan, Morck, Xu, and Yeung (2007: 25) put it: "Ultimately, China may well provide a better institutional environment for FDI operations than for domestic operations – large or small, state controlled or privately run. If China, more than other countries, favors FDI in this way, it might well receive an elevated FDI inflow".

[9]The *Euromoney* index is available in its current format only from 1982 onwards. An alternative format, albeit with similar interpretation, was reported for the earlier years in our study period. We transformed the index for the earlier of our sample years to get consistent scores that go back to 1979. Excluding the observations from 1979 to 1981 or using alternative methods to extrapolate does not materially change our results. We opted to keep these observations to have a more complete and representative sample.

[10]Shenzhen, Zhuhai and Shantou in Guangdong Province, Xiamen in Fujian Province, and all of Hainan province.

[11]Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Beihai.

[12]As an alternative measure of institutional uncertainty, we used the component of the Economic Freedom of the World index that captures the level of uncertainty resulting from a country's institutional framework. This measure is published annually by the Fraser Institute, and varies over time rather than between different geographical areas within China. Our results remain robust. However, using this alternative measure resulted in moderate levels of collinearity, which is especially undesirable when testing multiple hypotheses. Therefore we used the location-based variable described above instead.

[13]Exchange rate data are from various annual issues of the World Currency Yearbook, Pick's Currency Yearbook and the IMF's *Annual Report on Exchange Rate Arrangements and Exchange Restrictions.*

[14]To test the robustness of our results, we used the 18-month volatility of the parallel rate (again the common time frame) as an alternative measure of exchange rate uncertainty. The results were consistent with those reported below.

[15]Our sample covers (parts of) the fifth (1976–1980), sixth (1981–1985), seventh (1986–1990) and eighth (1991–1996) plans. The period effects are lagged by one year because these plans were usually announced at the end of the year. Thus fixed effects represent the periods 1979–1981, 1982–1986 and so on.

[16]Our model comprises two levels: JV and home country. Such a model is also referred to as a tobit model with double censoring and random effects. Here, the random effects are for home countries.

[17]Several scholars have argued that JVs in which one partner has a very dominant controlling stake can be better considered as wholly owned subsidiaries (e.g., Hennart, 1991). Therefore, to test the robustness of our results, we also specified several models with different limit values of ownership – such as upper limits of 90% (e.g., Hennart, 1991) and 95% (e.g., Hennart & Larimo, 1998; Lu, 2002) ownership. Our results were robust to these alternative tobit specifications.

[18]We are grateful to an anonymous reviewer and the Associate Editor for pointing out this issue and putting us on the path towards using the alternatives below.

[19]In the language of power analysis, α is the significance criterion, that is, the "level of significance" as commonly used to evaluate (non-null) hypotheses. β is the probability of rejecting the null hypothesis when it is in fact false, that is, of making a type II error. The value we set for these parameters is more conservative than those used by Lane et al. (1998), for example. Note that β as referred to in this

paragraph is a parameter for the power calculations, not to be confused with the β coefficient estimates from regression analyses as discussed elsewhere in the paper.

[20]A stepwise approach adding each hypothesized variable separately does not substantively change the results.

[21]We generated the posterior distributions using uninformative priors and the Gibbs sampler. This involves sampling sequentially from all relevant conditional distributions over a large number of iterations. We made 100,000 draws from a single continuous Gibbs chain, of which the first 20,000 draws are used as a "burn in" period and subsequently discarded. Unfortunately, existing Bayesian software is limited in that it does not allow for random effects and cannot incorporate left-censoring and right-censoring simultaneously. The replication is therefore imperfect. Nevertheless, our results are very similar to those obtained using the conventional (non-Bayesian) tobit model.

[22]In addition, we replicated the commonly used if statistically problematic use of *post hoc* power analysis to test the null Hypotheses 4–6. The results, available from the authors, again show that the effects of the endogenously resolved variables do not differ from zero.

[23]We are grateful to an anonymous reviewer and the Associate Editor for pointing out these research opportunities.

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