Real Options and the Theory of the Firm

Ellen Roemer

University of Bradford
School of Management, Marketing Group
Emm Lane, Bradford West Yorkshire BD9 4JL, UK
E-mail address: e.roemer@bradford.ac.uk
Phone: +44 (0)1274 – 23 44 64
Fax: + 44 (0)1274 – 54 68 66

Real Options and the Theory of the Firm

Abstract

From the real options perspective the firm is conceived as a portfolio of real options. However, the theory of the firm traditionally argues into a similar direction by viewing the firm as either a set of institutions, as set of property rights or as a set of contracts. Due to this similarity, the question arises how far real options analysis can contribute to the theory of the firm and to an understanding of the organizational question 'Why do firms exist?'. Therefore, this paper investigates the issue how real options should be best managed according to different types of uncertainty: within the firm, outside the firm or by intermediate forms of organizations such as joint ventures. In this light, real options analysis appears as a further, promising approach within the theory of the firm.

Real Options and the Theory of the Firm

I. Introduction

Real options analysis is a research field that spreads across different academic and research disciplines such as finance, economics, operations research, engineering, supply chain management, strategic management, marketing, etc. However, the real options approach is still a young field of research and thus at an early stage of development. Therefore, from the perspective of theory development, it seems interesting to challenge the approach and to confront it with new fields of application.

In recent times, it can be observed that real options analysis is gradually advancing into the domain of strategic management and economic organization since the real options approach is increasingly applied in relation to strategic management questions. In this respect, a growing number of papers have been published dealing with real options analysis in combination with matters of economic organization. Papers focus for example on 'Real Options Pricing and Organizations' (Kogut and Kulatilaka 2004), 'Joint Ventures and the Option to Expand and Acquire' (Kogut 1991), 'A Real Options Logic for Initiating Technology Positioning Investments' (McGrath 1997) and 'Capabilities as Real Options' (Kogut and Kulatilaka 2001).

Traditionally, the issues of economic organization are discussed within the theory of the firm. The theory of the firm is highly diverse since it gathers different approaches under the label 'theory of the firm'. One of the first who asked the question 'why do firms exist' and 'why are not all transactions coordinated by markets' – as orthodox neoclassical theory proposes – was Ronald Coase (1937). Since his seminal article 'The Nature of the Firm', several approaches have been developed in order to contribute to an understanding of the 'firm' as a form of coordination. Each of them uses a different way of conceiving the firm. To provide an impression on the diversity of the 'theories' of the firm, consider the following approaches. Transaction cost economics views firms as a set of institutions[1] (e.g. Hodgson 1988; Richter and Furubotn 1997). Property rights theory conceives the firm as a

---

[1] In this context, institutions are understood as "the rules of the game in a society or, more formally, humanly devised constraints that shape human interaction" (North 1990, 3).

nexus of property rights (Grossman and Hart 1986; Holmström and Tirole 1989). Contract theory interprets the firm as a nexus of contracts (Alchian and Demsetz 1972; Jensen and Meckling 1976). Moreover, the resource based view understands the firm as a set of resources and capabilities (e.g. Hamel and Prahalad 1994). All of these approaches have in common that they deal with the question how to organize transactions. Different ways of organizing transactions are usually discussed: Transactions can be aligned within the firm, outside the firm or by intermediate forms of coordination such as joint ventures. When it is beneficial to organize particular transactions within a firm, the question 'why do firms exist' is sufficiently answered.

From the real options perspective, the firm can be viewed as a portfolio of real options instead of a conceiving the firm as a set of institutions, property rights or contracts as the traditional approaches propose. In connection with economic organization the question emerges how to manage this portfolio of real options in order to maximize the value of the firm.

The aim of this paper is to explore the question how far real options analysis can contribute to an understanding of the firm. More precisely, I investigate the organizational decision how real options should be best aligned: by market coordination, by hierarchical coordination or by intermediate forms of coordination when there are different types of uncertainty. The criteria determining how real options are coordinated refer to different efficiency criteria having an impact on the value of the firm.

To answer the research question, I use the transaction cost economic approach (Williamson 1985, Williamson 1991) as a reference point of the theory of the firm since it is one of most famous approaches within the theory of the firm and since it has been successfully submitted to rigorous empirical testing (e.g. Walker and Weber 1984, Heide and John 1990). Nevertheless, this paper does not pretend to provide a comprehensive theory of the firm based on real options; rather, it serves to highlight some potential paths how real options analysis can be used to make organizational decisions.

The paper is organized into three sections in addition to this introduction. In Section II, I sketch the foundations of real options analysis and I briefly summarize transaction cost economics as one approach to explain the boundaries and the existence of firms. Moreover, I compare the real options approach with the transaction cost economic approach in order to demonstrate parallels and divergences as a basis for a discussion of real options and

economic organization. One result of this comparison is that both approaches deal with similar problems which makes the investigation of real options analysis as a theory of the firm a promising research area. Since both approaches are concerned with different types of uncertainty, Section III provides a discussion of different types of uncertainty and different types of options. I point out how different types of real options should be organized in the presence of uncertainty to maximize the value of the firm. I support my argumentation by a number of practical examples. A summary of the main results is provided at the end of the section. The final section offers critical remarks and ideas for future research.

II. Real Options, Transaction Cost Economics, and Economic Organization

Both real options analysis and transaction cost economics deal with similar issues while there exist some differences between the two streams of research especially with respect to uncertainty. This will be explored in the following discussion.

The *real options approach* is a concept of explicitly valuing the flexibility of investment projects. Its basic unit of analysis is the real option. The real options approach is based on several assumptions. First of all, it assumes a strong form of rationality. Due to this form of rationality, individuals choose among known sets of alternatives and maximize their expected values. They are rational decision-makers, i.e. they can foresee a set of future states of the world including related probability distributions although they do not know which state of the world will eventually prevail. Real options uncertainty refers to Knightian risk because an uncertain realization of future environmental states can be derived from an ex-ante specified probability distribution. Uncertainty can thus be translated into rational calculus. Furthermore, it is traditionally assumed that capital markets are perfect and complete and that actors are risk-averse.

Real options analysis accounts for the irreversibility of investments. According to Dixit and Pindyck (1994, 8) "[i]nvestment expenditures are sunk costs when they are firm or industry specific … and cannot be recovered". Principally, the options to defer the investment, to expand or contract a project, to abandon it or to switch the modes of production are considered when real option values are assessed.

Real options analysis incorporates different types of environmental uncertainty such as price uncertainty, demand uncertainty or technological uncertainty. Real options allow

firms to add value, to amplify good fortune or to mitigate loss (Brealey and Myers 2000) thereby maximizing the value of real options. Under conditions of environmental uncertainty, firms choose only positive alternatives as soon as new information becomes available. Real options analysis posits that the value of an option rises with increasing uncertainty in the underlying asset. The maximum of option values indicates which strategy should be chosen by the company. Real options analysis applies to sequential decision-making under uncertainty.

Under the umbrella of the 'theory of the firm', *transaction cost economics* (TCE) aims at detecting the most transaction cost efficient form of coordination such as markets, hierarchies or hybrid forms of coordination according to the characteristics of the transactions between sellers and buyers (Williamson 1985, 1991). The basic unit of analysis is the transaction. TCE moves away from the strong form of rationality and assumes bounded rationality. According to Herbert Simon (1961, xxiv; emphasis in original) human behavior is "*intendedly* rational, but only *limitedly* so". Cognitive constraints limit human behavior. However, individuals try to do the best they can within their cognitive constraints. Moreover, TCE assumes that agents act opportunistically. Opportunism is the strongest form of self interest extended by the use of guile. Unlike simple self interest seeking behavior which implies a maximization of utility according to given rules, opportunism explicitly considers achieving higher utility by the use of guile, to the disadvantage of others (Williamson 1985). Finally, actors are risk-neutral.

In the past, researchers widely agreed that the principal attribute of transactions determining transaction costs are specific assets caused by specific investments (e.g. Joskow, 1988; Williamson 1991). More precisely, given the attribute of asset specificity, TCE analyzes which form of coordination is most appropriate to minimize transaction costs. TCE presumes that specific investments entail specific assets which cannot be redeployed without valuable sacrifice if relationships are prematurely terminated (Williamson 1985). The dimension of asset specificity is most important for an understanding of efficient governance structures.[2]

To measure the specificity of assets, Marshall's quasi-rent concept is used. Klein, Crawford, and Alchian (1978, 298) forward a basic definition of quasi-rents: "The quasi-rent value of the asset is the excess of its value over its salvage value, that is, its value in its

next best use to another renter". The degree of specificity varies to the extent of the existence and the level of salvage value. If the salvage value of the specific asset is close to zero, specificity is high. Conversely, if the salvage value is rising, the degree of specificity decreases.

When specific investments are made and quasi-rents are created, the possibility of opportunistic behavior arises as a form of behavioral uncertainty (Klein, Crawford, and Alchian, 1978). A fraction or even the whole quasi-rent can be exploited and appropriated by the partner. Thus, the risk of hold-up occurs, i.e. the risk that the non-owner seeks possibilities for expropriation of the invested values. Having committed specific resources to a partner, the investor finds himself/herself 'locked in' in a relationship (Klein, Crawford, and Alchian 1978; Williamson 1985). To quit the relationship would result in the loss of a portion or even the whole quasi-rent for the party having specifically invested, since specific investments cannot or only partly be redeployed.

To protect against hold-up and to minimize transaction costs, Williamson (1985) proposes different governance structures to cope with the safeguarding problem according to the level of asset specificity (Figure 1).

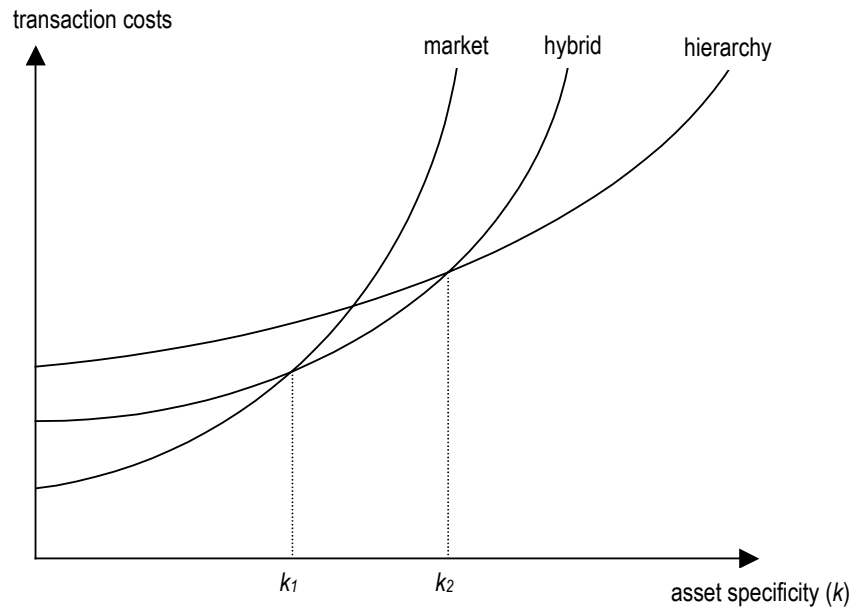[2] Roughly speaking, governance structures are forms of coordination.

Figure 1: Choice of Coordination Form according to Asset Specificity[3]

When asset specificity is low ($k < k_1$), market coordination will be the most transaction cost efficient governance mechanism. The risk of hold-up is literally non-existent because of other valuable alternatives of using a resource. Neither party must fear a loss of quasi-rent, so that hierarchical governance would incur added bureaucratic costs while it yields no additional benefits, i.e. protection against hold-up. As the degree of specificity rises ($k_1 < k < k_2$), the exit option becomes costly for the party having specifically invested, so that hybrid forms of coordination become more efficient to safeguard against hold-up. Hybrid forms of coordination are located in between the extreme polar forms market and hierarchy. Usually the use of long-term contracts, explicit and normative contracts, take-or-pay procurement clauses, pledges, hostages, offsetting investments, franchising, joint-ventures, strategic alliances are discussed as intermediate or hybrid forms of coordination. Under conditions of high specificity ($k > k_2$), the risk of hold-up is obstructive because a potential loss of quasi-rents is high. Then, transactions are managed most efficiently by hierarchical structures (Klein, Crawford, and Alchian 1978, Williamson 1985). To sum up, as asset specificity increases, market coordination gives way to hybrid governance, which is in turn

---

[3] According to Williamson (1991, p. 281).

replaced by hierarchy (Williamson 1985). According to TCE, the transaction cost minimizing governance structures should be chosen to protect the partners against behavioral uncertainty. TCE applies to sequential decision-making under uncertainty.

A comparison of real options analysis with TCE reveals some parallels as well as some differences between the two approaches. On the one hand, both approaches resemble each other to a high degree. Both address the same issue, i.e. sequential decision making under uncertainty (Trigeorgis and Mason 1987; Williamson 1985). Second, Williamson (1991) stresses that asset specificity has a strong relation to the notion of sunk costs and the irreversibility problem discussed in real options approaches.

On the other hand, real options analysis and TCE differ in their assumptions on rationality entailing a shift in the meaning of uncertainty. In contrast to the assumption of bounded rationality underlying the TCE framework, real options analysis uses an unbounded rationality perspective. In this perspective, contingent 'market' contracts can be concluded. There is no necessity to organize the transaction within the firm. Moreover, both approaches focus on different origins of uncertainty: While TCE concentrates on the safeguarding aspect of governance structures to reduce behavioral uncertainty, the real options approach mainly treats environmental types of uncertainty. Table 1 provides an overview of the discussion.

Topic	Real Options Analysis	Transaction Cost Economics
Unit of Analysis	Real Option	Transaction
Assumptions	Rationality, Perfect and Complete Capital Markets, Risk Averseness	Bounded Rationality, Opportunism, Risk Neutrality
Nature of Investments	Irreversible Investments	Specific Investments
Source of Uncertainty	Environmental Uncertainty	Behavioral Uncertainty
Optimization Criterion	Maximization of Option Values	Minimization of Transaction Costs
Decision Problem	Choice of Option Strategy	Choice of Governance Structure
Basic Statement	The higher environmental uncertainty, the more valuable an option becomes to the firm.	The higher the specificity of assets, the more efficient is an internal organization of transactions.
Application	Sequential Decision Making under Uncertainty	Sequential Decision Making under Uncertainty

Table 1: A Comparison of Real Options Analysis and Transaction Cost Economics

Although based on different and more restrictive assumptions than TCE, I propose that the real options approach can contribute to the choice of governance structures and to an understanding of the firm due to its similarities to the transaction cost economic approach. Since both approaches deal with different types of uncertainty affecting economic organization, I investigate how different organizational forms can deal with different types of uncertainty, i.e. with behavioral and environmental uncertainty. According to the type of uncertainty affecting the firm, I discuss whether real options should be organized inside the firm, outside the firm or by intermediate forms of governance.

III. The Alignment of Real Options as a Contribution of Real Options Analysis to the Theory of the Firm

Since real options analysis and transaction cost economics deal with the same issue, i.e. sequential decision-making under uncertainty, I will now investigate how real options should be organized in order to maximize the firm's value. In this way, real options analysis contributes to an understanding hy firms exist. Real options analysis traditionally deals with the value of flexibility in the presence of *environmental types of uncertainty* as price uncertainty, demand uncertainty, technological uncertainty, etc. These types of uncertainty have an impact on the value of the underlying asset in terms of volatility (σ) of the underlying asset. However, different real options need different governance in the presence of different types of uncertainty. First, I will discuss the management of real options in the presence of different forms of environmental uncertainty which is in the tradition of real options analysis. Second, I will additionally investigate behavioral types of uncertainty which are traditionally discussed in transaction cost economic literature.

Price uncertainty, i.e. fluctuation in market prices of the underlying assets are traditionally analyzed by real options analysis. For example, prices of raw materials such as crude oil or iron ore are highly volatile. The volatility of these prices can be observed on capital markets. Since the investments in the oil industry or in the raw material industry, in general, are mostly irreversible and the produced good (raw material) is affected by frequent price changes, the options to expand production or contract production are often discussed in the literature (e.g. Trigeorgis 1996). The option to expand production should

be exercised when raw material prices rise. In contrast, the option to contract production should be exercised when raw material decrease. Even more radical would be the options to shut down and to start up operations according to raw material prices. However, additional costs of shutting down and restarting operations have to be considered when these options are to be exercised.

To decide whether and when to exercise an option to expand or contract, shut down or restart operations, a company has to be alert and able to respond quickly to market changes as soon as prices rise or fall. Otherwise, the value of these options could be reduced because the management cannot implement its decisions (to exercise an option) fast enough. The company has to be independent and able to decide autonomously whether and when to expand or to contract. Haggling and disputing with relationship partners who can equally influence the exercise decision can cost time and money, since the option's value can be reduced when options are not converted in time. Therefore, options to expand or to contract as well as option to shut down and restart operations should be managed by hierarchical structures due to the efficiency and timeliness of implementing the exercise decision within the firm when there are price uncertainties as in the raw materials industry. In this way, legal disputes with relationship partners can be avoided. Consequently, I propose:

Proposition 1: Higher price uncertainty favors the organization of the options to expand and contract or to shut down and restart operations within firms (governance form of hierarchy).

The real options literature has forwarded a number of real world examples from the raw materials industry where the option to expand/contract or to shut down/restart operations have been carried out by one single decision-maker, i.e. single raw material companies[4] (e.g. Brennan and Schwartz 1985, Trigeorgis 1996).

Demand uncertainty can have an influence on the volatility of the underlying asset. For example, the demand for a product can be highly volatile in certain markets. In these market types, a flexible firm has to be able to quickly respond to changing customer

demand. When demand increases, the flexible firm has an option to expand production, increase sales and thus to increase returns and the value of the firm on the one hand. On the other hand, a flexible company has to be able to reduce production when customer demand declines. Then, the firm can exercise an option to contract the business. A flexible firm is able to reduce workloads at low cost or even sell parts of the production.

The options to expand and to contract a business in the presence of demand uncertainty need to be exercised quickly and at low cost as soon as new information on customer demand becomes available. The firm has to promptly respond to the changing market data. Therefore, it has to be able to autonomously decide on the exercise of an option to expand or to contract. Haggling and negotiating with a relationship partner in intermediate organization forms, such as long-term relationships where both partners have to agree on an expansion or contraction of the business, will become inefficient due to delays in exercising a real option to expand or to contract. Therefore, it is more efficient to arrange the real options to expand and to contract inside the firm, i.e. by hierarchical coordination, when there is high demand uncertainty. In contrast, when demand uncertainty is low, the value of the options to expand and to contract the business is reduced, so that the specific real options can be organized by loose coupling in relationships where other parties have to agree on the exercise of the option or by market coordination where the firm's influence on the exercise of an option is even smaller.

In the presence of demand uncertainty, it is the timeliness and the efficiency of the firm's response to market changes that favors the organization of real options within the firm when demand changes quickly in an industry and when volatility of the underlying asset (e.g. a product) is high. Therefore, I forward the following proposition:

Proposition 2: Higher demand uncertainty favors the organization of the options to expand and contract within firms (governance form of hierarchy).

This line of argumentation can be supported by empirical TCE research. The positive relationship between demand uncertainty and the degree of vertical integration (hierarchy) has been corroborated e.g. by Walker and Weber (1984) and Heide and John (1990).

---

[4] Of course, there may be disputes about the exercise of an option within companies, e.g. between different managers. However, I suspect that it will be easier to come to an agreement within a company than between

Examples of industries with high fluctuations in demand are e.g. the automobile industry or the tourism industry. Automobile suppliers, for example, traditionally have to make specific, irreversible investments into production facilities and/or specific production tools or specific production sites. Since automobile suppliers are assembling increasingly complex modules for the car manufacturers, they have even started to buy out the manufacturer's production sites. A recent example is that *Siemens VDO* purchased an automotive electronics production site from *Chrysler* in Huntsville, USA. Similarly, the pistons producer *Mahle* acquired a camshaft production site from BMW in Berlin. These investments can hardly be resold on a secondary markets or it is improbable that there other users or uses the investment can be dedicated to. Therefore, there will be a value of the option to expand and/or to contract when there is demand uncertainty and the firm can react quickly to market changes.

Another type of environmental uncertainty is *technological uncertainty*. When a firm intends to invest into a new technology, it will be uncertain whether the technology will be successful or not. Technological uncertainty is usually modeled by jump (or alternatively Poisson) processes where the mean arrival rate (λ) and the size of the jump (u) can be predetermined by the researcher. Technological uncertainty affects the success of an investment into a new technology. Therefore, it can have an impact on the level of future revenues. The option to invest into a new technology can be interpreted as an option to expand into a new business area while it is uncertain whether the technology will be successful or not. The real options literature has proposed to organize such real options by intermediate forms of coordination, e.g. by joint ventures. Kogut (1991, 19) argues that investments into joint ventures can provide a 'window for future opportunities'.

Two arguments can be forwarded why options to expand should be managed by hybrid governance forms such as joint ventures, and not by vertical integration (hierarchy), in the presence of high technological uncertainty (Kogut 1991):

(1)   Joint ventures can distributes the risk of failure between two or more partners. This is the risk-sharing argument;

(2)   Because parties can combine different capabilities they can reduce the total investment expenditures.

different relationship partners, i.e. between different companies.

TCE adds another argument. When investments into new technologies fail, it becomes difficult and expensive to dissolve a real option that has been acquired earlier. There are high transaction costs of disinvesting integrated real options which means that the put option becomes extremely costly. On account of the high transaction costs of dissolving a hierarchical structure in case of failure of the new technology on the one hand, and because a firm intends to receive a share of the potential returns from the investment if the new technology is successful on the other hand, real options in new technologies should be governed by intermediate forms of transactions (e.g. by joint ventures) when technological uncertainty is high. In contrast, when technological uncertainty is low, real options can be integrated into the firm in order to earn the profits from the new technology. Then, risk needs no distribution among partners. For the relationship between technological uncertainty and the alignment of the option to expand, I propose:

Proposition 3: Higher technological uncertainty favors the organization of the option to expand in hybrid forms of governance.

These findings can be equally backed by empirical TCE investigations. For example, Balakhrishnan and Wernerfelt (1986) found out that with increasing technological uncertainty, the degree of vertical integration declines. Equally, Heide and John (1990) found empirical evidence that technological unpredictability uncertainty is managed more efficiently by loose coupling in relationships than by higher continuity in hierarchical structures.

Examples of industries which are affected by high technological uncertainty are the biotechnology industry, the pharmaceutical industry, or the micro-electronics industry. Usually technological uncertainty is high when small and medium sized biotech companies develop innovative products. As soon as a the product's success is assessable and technological uncertainty is reduced they are usually vertically integrated (governance form of hierarchy) by incumbent pharmaceutical companies. A recent example is the takeover of *Esperion* by *Pfizer*. *Esperion* has developed a medicinal product ETC-216 that reduces already existing concretions in arteries. Now that the product's medical success has been proven in several clinical studies and technological uncertainty has been reduced, *Esperion* is vertically integrated by Pfizer.

Second, behavioral types of uncertainty, exerted by other players in markets, are less frequently discussed in real options analysis. Real options analysis thus has to be complemented by other approaches in order to account for these types of uncertainty.

The *risk of preemption* has been discussed in combination with game-theoretic analysis. The value of options to delay an investment can be eroded when there is the risk that competitors preempt (e.g. Weeds 1992). The option to expand can be 'killed' by another competitor's first move. Game-theoretic analysis together with real options analysis thus proposes to safeguard those real options that risk preemption by competitors by patents, legal contracts or legally enforceable property rights. This result is analogous to TCE reasoning which posits that behavioral uncertainty (here competitor uncertainty) should be reduced by vertical integration in order to safeguard options from preemption and thus secure future cash flows. In order to preserve the value of a real option to delay investment and to expand into a new business, the real option should be integrated into the firm to protect the value from preemption. Consequently, the higher the risk that a real option will be exploited by competitors, the higher will be the need to safeguard the option against preemption and the more likely the real option will be vertically integrated. Based on these considerations, I advance the following proposition:

Proposition 4: Higher risk of preemption favors the vertical integration of option in order to protect them against preemption by competitors.

The risk of preemption prevails in the pharmaceutical industry and high-tech industry where innovative products such as drugs or computer processors are developed and granted. The development of these product are usually carried out in different stages. Frequently, there are races between two or more competitors to release the newly developed product to the market before anybody else does. A patent for a developed product, as the above mentioned drug by *Esperion* preventing and reducing concretion in arteries, can then guarantee monopoly rents to the drug developing company. To safeguard against preemption by vertical integration is even a stronger safeguard than just patenting a product. By vertical integration, the stream of monopoly rents e.g. to *Esperion* will be guaranteed to the overtaking company *Pfizer*.

A further behavioral type of uncertainty is the *risk of hold-up*. When a partner dedicates specific and irreversible investments into a relationships, the resulting quasi-rents can be exposed to the partner's expropriation. Hold-up affects a company's stream of future cash flows from the partner in the sense that future cash flows can be expropriated by the other party. Perceiving the partner as a real option to expand, option values can be eroded when there is a lack of safeguarding mechanisms. In the case of hold-up, future quasi-rents and future cash flows converge towards 0 (Roemer 2003). This type of uncertainty is usually neglected in real options analysis.

The risk of hold-up is traditionally discussed in transaction cost economics. Transaction cost economics recommends higher degrees of safeguarding when the level of asset specificity is high. The higher the specificity of assets, the higher and the more consequential becomes the risk of hold-up, and in turn the higher should be the degree of vertical integration (hierarchy) to appropriately prevent from hold-up. Consequently, real options to expand into a new relationship should be integrated into the firm when the risk of hold-up is high in order to protect the value from the real option to expand from expropriation. When the risk of hold-up is low, real options can be organized by intermediate or by market coordination. Based on this discussion, I forward the following proposition:

Proposition 5: Higher risk of hold-up favors the vertical integration (hierarchy) of real options to expand into new business relationships.

Several empirical TCE studies have analyzed the relationship between asset specificity (risk of hold-up) and the degree of vertical integration. Among some of the most famous studies are the ones carried out by Walker and Weber (1984), Balakhrisnan and Wernerfelt (1986), Heide and John (1990), or Suttcliffe and Zaheer (1998).

The risk of hold-up prevails whenever a company has to dedicate specific relationship investments as for example franchisees have to make specific investments when they start up a relationship with a special franchiser. As an example of hold-up, consider the relationship between Taco Bell and its franchisees (Besanko, Dranove, and Shanley, 2000). Franchisees had to make considerable specific investments to establish and maintain the relationship with Taco Bell. In the late 1980's, Taco Bell decided to increase market shares

by introducing small concession stands that offered only a limited menu: 'Taco Bell Express'. While Taco Bell itself was in the position to choose alternative trading partners, the franchisees tied their hands because they lacked alternative users of their specific assets. Taco Bell used higher competition between franchisees to squeeze the franchisees' profit margins and to redistribute profits in the relationship in favor of Taco Bell itself (hold-up). Taco Bell's strategy to open new outlets reduced the franchisees' value of the relationship partner. This example demonstrates that Taco Bell's expropriation can be value destroying for the franchisees. Safeguards are needed to reduce the risk of hold-up caused by Taco Bell's, to secure the franchisees quasi-rents, and to stabilize the relationship.

The discussion of how to align real options has alluded to many different aspects. An overview of the discussion may sum up the main points (Table 2).

Type of Uncertainty	Type of Option	Governance of Real Option	Area of Application (Examples)
Price Uncertainty	Option to Expand / Contract, Option to Shut Down and Restart Operations	Hierarchy	Petroleum Industry, Raw Material Production
Demand Uncertainty	Option to Expand / Contract	Hierarchy	Automobile Industry, Tourism Industry
Technological Uncertainty	Option to Expand	Hybrid Forms	Biotechnology, Pharmaceutical Industry, Microelectronic Industry
Risk of Preemption	Option to Delay, Option to Expand	Hierarchy	Biotechnology, Pharmaceutical Industry, Microelectronic Industry
Risk of Hold-up	Option to Expand	Hierarchy	Automobile Industry, Aircraft Industry

Table 2: Different Types of Uncertainty and the Governance of Real Options

As a result, most types of uncertainty favor the arrangement of real options within organizations (hierarchy) except for technological uncertainty. The main arguments are the quick and efficient response to market changes in the face of environmental uncertainty. Furthermore, vertical integration of real options as a safeguarding mechanism against pre-

emption and hold-up as behavioral types of uncertainty is the most efficient governance mechanism.

However, in the real world there are frequently situations where more than one type of uncertainty prevails. In these cases, trade-offs may appear giving contradictory implications on how to manage real options. If, for example, technological uncertainty prevails and if there is the risk of hold-up because the investments which have to be dedicated are highly specific, trade-offs will appear regarding the management of these options. Technological uncertainty promotes less vertical integration, while the risk of hold-up claims for higher degrees of vertical integration. In these situations, formal real options analysis can help resolving these trade-offs and finding optimal management implications (Roemer 2004).

IV. Conclusions

This paper proposes an innovative approach towards the theory of the firm. It explores how real options analysis can be used to explain the existence of firms in addition to the well-known approaches under the umbrella 'theory of the firm'. By investigating the question how should real options be organized in the presence of different types of uncertainty, there are several reasons why real options should be aligned within the firm (or, in TCE terms, why the governance structure of hierarchy should be chosen). In this paper I have elaborated several aspects why some real options should be managed within in firms. The arguments are the quick response to environmental market changes such as changes in prices and changes in demand and low transaction costs. Furthermore, the inner organizational management of real options protects against preemption by competitors as well as against expropriation by a business partner. Based on these arguments, the existence of firms can be explained. However, in the presence of technological uncertainty, the integration of options into the firm appears less favorable. In this case, intermediate forms of coordination should be chosen to distribute the risk of failure among the parties, to share different capabilities, and to secure a share of potential future profits.

Nevertheless, there are some constraints regarding the analysis. The discussion on how to organize real options has been based solely on theoretical reasoning. Future research will have to submit hypotheses to empirical testing. Empirical evidence could stem either from large quantitative analysis using multivariate methods to test hypotheses or from case study

methods. Moreover, there are probably a number of further types of environmental and behavioral uncertainty that have not been discussed in this paper and that need further investigation.

Another interesting avenue for future research is the incorporation of bounded rationality and other forms of behavioral uncertainty into real options analysis. First steps have already been made to include asymmetric information into the formal analysis of real options which relates to the problem of bounded rationality. This would make the analysis more appropriate for real world applications since the assumptions of perfect decision-makers as proposed by real options thinking do not necessarily prevail in reality.

Again, with this I did not pretend to provide a comprehensive theory of the firm based on real options; rather, my intention was to highlight some potential paths of how real options analysis can be used to make organizational decisions and to explore a new application for real options analysis.

References

Alchian, Armen A. and Demsetz, Harold (1972) Production, Information Costs, and Economic Organization, in: The American Economic Review, 62, 5, 777-795.

Balakrishnan, Srinivasan and Wernerfelt, Birger (1986) Technical Change, Competition and Vertical Integration, in: Strategic Management Journal, 7, 347-359.

Besanko, David, David Dranove and Mark Shanley (2000) Economics of Strategy. New York: Wiley.

Brealey, Richard A. and Myers, Stewart C. (2000) Principles of Corporate Finance. 6th Edition, New York: McGraw-Hill.

Brennan, Michael J. and Schwartz, Eduardo S. (1985) Evaluating Natural Resource Investments, Journal of Business, 58, 2, 135-155.

Coase, Ronald H. (1937) The Nature of the Firm, in: Economica, 4, November, 386-405.

Dixit, Avinash K. and Pindyck, Robert S. (1994) Investment under Uncertainty. Princeton, NJ: Princeton University Press.

Grossman, Sanford and Hart, Oliver (1986) The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, in: Journal of Political Economy, 94, 4, 691-719.

Hamel, Gary and Prahalad, C. K. (1994) Competing for the Future: Breakthrough Strategies. Boston, MA: Harvard Business School Press.

Heide, Jan B. and John, George, (1990) Alliances in Industrial Purchasing, The Determinants of Joint Action in Buyer-Seller Relationships, in: Journal of Marketing Research, 27, 24-36.

Hodgson, Geoffrey M. (1988) Economics and Institutions: A Manifesto for a Modern Institutional Economics, Cambridge.

Holmström, Bengt and Tirole, Jean (1989) The Theory of the Firm, in: Schmalensee, Richard and Willig, Robert (Eds.): The Handbook of Industrial Organization, Amsterdam: Elsevier Science, 61-133.

Jensen, Michael C. and Meckling, William H. (1976) Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure, in: Journal of Financial Economics, 3, 4, 305-360.

Joskow, Paul L. (1988) Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence, in: The Journal of Law, Economics, and Organization, 4, April, 95-117.

Klein, Benjamin, Crawford, Robert G. and Alchian, Armen A. (1978) Vertical Integration, Appropriable Rents, and the Competitive Contracting Process, in: Journal of Law and Economics, 21, 297-326.

Kogut, Bruce (1991) Joint Ventures and the Option to Expand and Acquire, in: Management Science, 37, 19-33.

Kogut, Bruce and Kulatilaka, Nalin (2001) Capabilities as Real Options, in: Organization Science, 12, 6, 744-758.

Kogut, Bruce and Kulatilaka, Nalin (2004) Real Options Pricing and Organizations: The Contingent Risk of Extended Theoretical Domains, in: Academy of Management Review, 29, 1, 102-110.

McGrath, Rita G. (1997) A Real Options Logic for Initiating Technology Positioning Investments, in: Academy of Management Review, 22, 4, 974-996.

North, Douglass C. (1990) Institutions, Institutional Change and Economic Performance, Cambridge: Cambridge University Press.

Richter, Rudolf and Furubotn, Eirik (1997) Institutions and Economic Theory : The Contribution of the New Institutional Economics, 2nd Edition, Ann Arbor: University of Michigan Press.

Roemer, Ellen (2003) Asymmetric Buyer-Seller Relationships and Real Switching Options, in: Proceedings of the 7th Annual International Real Options Conference, Georgetown University, Washington DC.

Roemer, Ellen (2004) Flexibility in Buyer-Seller Relationships: A Transaction Cost Economics Extension by Real Options Analysis, Wiesbaden: Gabler (*forthcoming*).

Simon, Herbert A. (1961) Administrative Behaviour, 2nd edition, New York: Wiley.

Sutcliffe, Kathleen M. and Zaheer, Akbar (1998) Uncertainty in the Transaction Cost Environment, Strategic Management Journal, 19, 1, 1-23.

Trigeorgis, Lenos and Mason, Scott P. (1987) Valuing Managerial Flexibility, Midland Corporate Finance Journal, 5, 14-21.

Trigeorgis, Lenos (1996) Real Options, Managerial Flexibility and Strategy in Resource Allocation. Cambridge: MIT Press.

Walker, Gordon and Weber, David (1984) A Transaction Cost Approach to Make versus Buy Decisions, in: Academy of Management Journal, 30, 589-596.

Weeds, Helen (2002) Strategic Delay in a Real Options Model of R\&D Competition, in: Review of Economic Studies, 69, 3, 729-747.

Williamson, Oliver E. (1985) The Economic Institutions of Capitalism, New York: The Free Press.

Williamson, Oliver E. (1991) Comparative Economic Organization: The Analysis of Discrete Structural Alternatives, in: Administrative Science Quarterly, 36, 2, 269-296.