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Exploring the Link of Real Options Theory with Dynamic Capabilities Framework in Open Innovation-Type Merger and Acquisition Deals

Andrejs Čirjevskis

Business Department, RISEBA University of Applied Sciences, Meža Street 3, LV-1048 Riga, Latvia; andrejs.cirjevskis@riseba.lv

Abstract: Although it is well established that acquisition-based dynamic capabilities have important consequences for merger and acquisition (M&A) processes, direct evidence on how real option applications can measure a dynamic capability-based synergy in open innovation-type M&A deals has been scarce. This study draws from seminal research on real options theory to explore some of these benefits and limits to value a synergy in one recent highly strategic acquisition. To strengthen the identification of causal effects, the paper develops the proposition that justifies the role of dynamic capabilities as antecedents of the success of open innovation-type M&A deals in the ICT industry and demonstrates real options' application to measure M&A synergies. To test the internal and external validity of the proposition, the explorative case study on Samsung's acquisition of Harman International Industries was analyzed and interpreted. This study contributes important empirical evidence to bear on the literature on open innovation theory, dynamic capabilities framework, and real options theory.

Keywords: real option; dynamic capabilities; acquisition; synergy; open innovation

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1. Introduction

The open innovation (OI) literature has grown tremendously in recent years with a primary focus on external knowledge sourcing at the organizational level (Ferraris et al. 2020). Therefore, OI has become well established as a new imperative for organizing innovation (Bogers et al. 2019). However, there has been limited focus on the role of dynamic capabilities of those processes. This paper aims to explore the link of real options theory with dynamic capabilities framework and to understand the full benefits and possible limits of an application of real options theory to measure dynamic capabilities-based synergy in OI-type merger and acquisition (M&A) deals have been scarce in previous research.

Several authors viewed dynamic capabilities in terms of real options; however, they did not link capabilities and real options with the reciprocal synergies in M&A deals (Kyläheiko et al. 2002; Jahanshahi and Nawaser 2018). Recently, scholars employed real options valuation to obtain the expected value of synergies arising from M&A deals, but they did not consider synergies as consequences of the dynamic capabilities (Loukianova et al. 2017; Barbopoulos et al. 2019). In the current paper, the author integrates the influence of dynamic capabilities on reciprocal synergies in open innovation type M&A deals into real options valuation and reconciles what has previously been presumed to be independent.

Innovation is a cutting-edge objective for companies interested in expanding their business (Baierle et al. 2020). In current post-pandemic contexts, characterized by high technological and market obsolescence, innovation is a fundamental mechanism for companies to achieve competitive advantages (González-Sánchez et al. 2020). Whatever technology is needed to respond to emerging market demand, the firm can acquire one or invest in promising startups (Bogers et al. 2019). OI requires procedures for acquiring and obtaining knowledge that resides outside the firm (Ferraris et al. 2020). Therefore, corporations use open innovation through strategic alliances and/or M&A deals (Čirjevskis 2019).

In this vein, the role of dynamic capabilities in the OI-type M&A deal is difficult to overestimate in terms of the abilities of an acquirer to integrate two merging companies in search of strategic synergies. Dynamic capabilities are abilities to renew and regenerate internal and external core competencies in OI-type M&A deals. In turn, real options valuation provides a mathematical apparatus to measure such dynamic capabilities-based synergies (Čirjevskis 2021). In this study, the author regards the OI-type of M&A deal as innovative ambidextrous (explorative and exploitative) learning (Čirjevskis 2016) of acquirers' companies and examines how such type of acquisitions contribute to securing growth options by improving an acquirer's dynamic capabilities and consequently providing a synergy.

Real options have attracted considerable interest in recent decades, both academically and practically, according to Tong and Reuer (2007) as well as Ferreira et al. (2009). Recently, Driouchi et al. (2020) explored the role of national culture and ambiguity as antecedents of real option appraisal. The real options analysis was applied by Araya et al. (2021) in enabling investment decision-making under uncertainty in the Chilean mining industry. By taking insights from real options theory in strategic management literature, Noorizadeh et al. (2021) measured the buying firm's overall supply chain performance.

Both tangible assets, such as companies, buildings, machinery or human resources, and intangible assets—patents, copyrights, or even capabilities, may be evaluated through the lens of real options theory (Luehrman 1995; Rivoli and Eugene 1996; Mun 2002; Damodaran 2005). These corporate assets also include the successful outcomes of outlays in research and development (R&D), learning outcomes acquired via M&A deals (Trigeorgis and Tsekrekos 2018). Having applied a real options framework to explore the role of real option in the takeover premia in M&A deals, Barbopoulos et al. (2019) found that "an acquire with real option capacity is willing to pay higher takeover premia for an option embedded in the target firm" (Barbopoulos et al. 2019, p. 19). The multi-step binomial model option pricing model can be useful as a "road map" framework to determine the value of growth options embedded in the M&A deals. What is more, the managerial synergies acquiring from a merger also can be valued as a real option (Čirjevskis 2021).

The paper proceeds as follows. The introductory section outlines the main problem of the research and provides reasons for conducting the study. The literature review introduces the reader to the concept of open innovation, innovative ambidexterity, dynamic capabilities, and the real options theory, and justifies the importance of them in sustaining success (synergies) in open innovation type M&A deals. Next, the author explains and justifies the methodology of the paper. Having explored the case study of Samsung's acquisition of Harman, this paper contributes to the real options theory by illustrating, and empirically testing, whether an external dynamic capability of the target company may exert synergetic influences on distinct dynamic capabilities of the acquirer's company and how to measure such type of synergism by real option application. Finally, the paper discusses findings that promote understanding of the consequences (synergy) of important external factors (dynamic capabilities of a target's firm) that an acquirer's firm may get by pursuing an OI type M&A deal.

2. Key Literature Review

2.1. Understanding Open Innovations, Innovative Ambidexterity, and Dynamic Capabilities in M&A Deals

The basic idea of open innovation (OI) was that firms can use both external and internal knowledge to promote their innovations. Chesbrough and Bogers (2014) formulated OI as a distributed innovation process based on purposively managed knowledge flows beyond organizational boundaries. There are three main modes of OI: inbound (outside-in), outbound (inside-out), and coupled mode of OI, the last one is a combined form of inbound and outbound OI or the mode of co-creations (Bogers et al. 2018). Corporations cannot rely exclusively on their research and development (R&S) ideas, but can also include external knowledge to contribute to their innovativeness.

In a recent publication, Bogers et al. (2019) argued that companies should use OI through acquisitions. The companies can acquire technologies needed from the outside. Bogers et al. (2019) cited the statement of John Chambers, chairman emeritus of Cisco, who recognized that new knowledge could come from external sources and insightfully said, "Learn about tech M&As, or the future might happen without you" (Bogers et al. 2019, p. 83). Recently, to better understand co-innovation opportunities, Bogers et al. (2019) integrated the OI concept into the dynamic capabilities' framework.

Kyläheiko et al. (2002) argued that dynamic capabilities perspective is required to find prospective business partners and a target for an acquisition. Dynamic capabilities are the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments in which there is deep uncertainty (Teece et al. 1997). "Dynamic capabilities are undergirded by three sets of organizational processes: sensing, seizing, and transforming capabilities. These three clusters of dynamic capabilities can help companies effectively reap the full benefits of open innovation" (Bogers et al. 2019, p. 84). What is more, Bogers et al. (2019) argued that companies that benefit from OI strategies should demonstrate the organization's flexibility.

Organizational flexibility is achieved through organizational ambidexterity (Shield and Travis 2017). Ambidexterity was defined by March as the capabilities to explore and exploit knowledge simultaneously (March 1991). Tushman and O'Reilly argued that ambidextrous organizations have organizational flexibility to concurrently nurture these diverse innovation requirements (Tushman et al. 1997). Moreover, dynamic capabilities are the core organization's ability to be ambidextrous. "The essence of organizational ambidexterity is to be found in dynamic capabilities of organizations, in the ability of the organizations to leverage existing assets and core competencies from the mature markets of the company to gain and sustain competitive advantage in new emerging markets (Čirjevskis 2016, p. 222).

An ambidextrous innovation is a dynamic capability to realize high levels of both explorative and exploitative types of innovation that positively affect the performance and the sustainable advantage (Broersma et al. 2016). The ambidexterity in OI-type of M&A deals means simultaneously exploring technologies, knowledge, and dynamic capabilities of merging companies and exploiting them employing a couple of types of OI, getting strategic synergies by doing so, and, thus, adding value to an acquirer's shareholders. Having examined value creation mechanisms in M&A deals through the exploration and exploitation concept, Florian et al. (2018) found that ambidexterity in M&A enables a synergistic effect between a target and acquirer even in the pre-merger phase.

2.2. Exploring the Link of Real Options Theory with Dynamic Capabilities Framework in an M&A Deal

According to the dynamic capability view of the firm's competitive advantage, the firm consists of already existing and routinely exploited human, physical, and financial resources, and its knowledge base, which is static and not yet fully developed. In turn, a firm can exploit dynamic capabilities, which can be produced externally through the open market or networks (Kyläheiko et al. 2002). Thereby, the management of dynamic capabilities is of utmost strategic importance for the firm competing in technologically advanced industries and experiencing a high level of market uncertainty.

According to Teece et al. (1997), dynamic capabilities (DC) enable firms to integrate, build, and reconfigure their resources and competencies in the face of changing business environments. In this vein, dynamic capabilities can be perceived as strategic growth options on renewing an existing set of core competencies (rights but not obligations) when a chance or necessity arises (Pavlou and El Sawy 2006). Therefore, the firm's decision about the employment of new dynamic capabilities by acquiring the target company can be interpreted in terms of the growth real option. From dynamic capabilities and a real-options perspective, "Management should not treat the trajectory and pattern of related outlays along a strategic path as a static scenario, but instead dynamically adjust it depending on uncertain developments in the business environment" (Smit and Trigeorgis 2004, p. 437).

The essence of the dynamic capabilities' idea assumes that they dynamically deal with innovative activities and are related and market uncertainty (Kyläheiko et al. 2002). Managerial uncertainty consists in not knowing which scenario of the state of the world is a true one (Arrow 1974, p. 33). However, such scenario-based uncertainty creates a set of real options (Teece et al. 2016). Thus, the uncertainty as a range of states dictates CEOs to manage dynamically a bundle of real options and to exercise options having a great probability to be in the money.

As we begin to think in options terms, each M&A deal can be viewed as a bundle of corporate growth options to acquire competencies (resources and capabilities) that extend over the long term (Smit and Trigeorgis 2004). Based on the real options theory, growth options can enhance competitiveness and bring sustainable competitive advantages to the firms in the future (Song et al. 2015). In this vein, recent research by Shen et al. (2020) justified that CEOs prefer to cater the capital market through high-risk and high-reward investments, such as M&As.

From a dynamic capabilities' perspective and a real-options tradition, where the firm is going in the future depends on the technological opportunities that lie ahead, and management's dynamic strategic plans (Smit and Trigeorgis 2004, p. 437). "If there is a synergistic effect with the acquired firm, it will improve the acquirer's long-term performance, especially when the industry competition is very fierce" (Shen et al. 2021, p. 2).

2.3. Measuring Synergies of M&A Deals by Real Options

The idea behind the following case study is to view an acquisition as an option on potential benefits. Assuming semi-efficient capital markets, the market capitalization reflects the market participants' view on the value of those benefits once the merger is announced. Therefore, the combined market value of both a target's and an acquirer's companies before the M&A deal is the share price of the option. The exercise/strike price is the expected future market value of both companies without the merger. (Dunis and Klein 2005, p. 6).

"The option on potential merger benefits to the shareholders is a European call option on the market value of the merged company with the expected future stand-alone market value defined as the exercise price" (Dunis and Klein 2005, p. 7). "The share price equivalent of the option is the cumulated market value of target and acquirer before the announcement of the deal terms" (Dunis and Klein 2005, p. 7). Thus, the share price (So) is proxied by the sum of the market capitalization of merging companies before the announcement of an M&A deal. The strike price (K) as the sum of the future value of Harman International Industries Inc. and the future value of Samsung was calculated using EV/EBITDA multiples.

The volatility (σ) of share price can be calculated using the observations of the standard deviation of the acquirer's stock price return that was started the week after the announcement (Dunis and Klein 2005). The author obtained Samsung Electronics Ltd. historical volatilities of the merged company within the first week after the merger announcement from the sources of the V-Lab APARCH Volatility Analysis (NYU Stern).

Dunis and Klein assumed one year is the time to maturity or the duration (T) of achieving synergy (Dunis and Klein 2005, p. 7). Moreover, previous scholars' studies on the period of getting synergies in M&A deals of stock-listed companies recommended using three years after acquisitions (Vergos 2003) or using even up to a ten-year period (Damodaran 2002). Therefore, three years of a real option maturity were assumed for the deal of Samsung's acquisition of Harman. $US dollars was chosen as the reference currency for this acquisition. Further, for Samsung Electronics Ltd., the domestic ten-year bond yield of the acquirer's country (South Korea) on the announcement day was used as the risk-free rate (Rf).

"This call option is in the money if the market value of the merged entity exceeds the expected future market value of the two separate companies." (Dunis and Klein 2005, p. 6). Finally, the real option value dynamic capabilities-based synergy's results were calculated employing Excel spreadsheets. Damodaran argues: "If, as is more common, acquiring a firm is one of many different ways of entering a competitive market, a discounted cash flow valuation is more than adequate for capturing expected synergies" (Damodaran 2005, p. 20).

But let us consider the case study example of the Samsung corporation buying Harman in an emerging market of connected and electric cars with immense growth potential. The acquiring corporation Samsung is buying a growth option to expand in the emerging connected cars market rather than a set of Harman's expected cash flows. Therefore,

Proposition 1. *Dynamic capabilities-based synergies provided by the OI-type of M&A deals can be measured with real options application.*

To test the internal and external validity of the proposition, an explorative case study on Samsung's acquisition of Harman International Industries was analyzed and interpreted.

3. Data and Methodology

This section explains the methodology of the paper. This research aims to explore the link of real options theory with dynamic capabilities framework and to apply real options theory to measure dynamic capabilities-based synergy in OI-type M&A deals. Teece argued that the research paradigm of dynamic capabilities is still relatively new, accordingly, illuminating case studies are likely to yield powerful insights (Teece 2012, p. 1400). It is a major advantage of case study research that the chosen sample can be explored in depth which would not be possible with a large case sample (Yin 2009).

3.1. Open Innovation-Type M&A Deals through the Option Lens

The method was based on case study research and followed a single-case study design (Yin 2009). The proposition is phenomenon-driven and according to Eisenhardt and Graebner, it is appropriate using a single case if a phenomenon-driven research question (or proposition) is subject to investigation (Eisenhardt and Graebner 2007). Ridder argued that in single case study research, the opportunity to open a black box arises by looking at deeper causes of the phenomenon and gaining a better understanding of "how" and "why" things happen (Fiss 2009; Ridder 2017). What is more, concerning one single case study research, Siggelkow argued that it "can be a very powerful example" (Siggelkow 2007). As objects of research, the author selected a very powerful example, i.e., the company that is especially active and successful in the global ICT industry and thus intriguing for research: Samsung Electronics, Co., Ltd., Suwon, South Korea.

Two steps were elaborated to provide empirical research of Samsung's acquisition of the Harman case. Firstly, to investigate the validity of the proposition, the author adopted Bogers et al.'s model of the interrelation of dynamic capabilities and open innovation (Bogers et al. 2019, p. 85). The model underpins the illustration of three clusters of dynamic capabilities that help Samsung Electronics Co., Ltd. effectively reap the full benefits of outside-in open innovation deal with Harman.

The Boger et al. framework helped also to unpack micro-foundations of their dynamic capabilities that support the acquisition's success. Using extensive archival data including Samsung and Harman financial statements, annual reports, and industry publications, the strategic steps of Samsung in open innovation-type of the acquisition of Harman and micro-foundations of dynamic capabilities to innovate the industry were identified.

Secondly, the paper presents the application of the Black–Scholes option pricing model (BSOPM) and binominal option pricing model (BOPM) to value real options and to quantify open innovation-based synergies in this strategic acquisition deal. Below, the author justifies his choice of real option valuation techniques to review the main methods for valuing real options: Black–Scholes, binomial tree, and Monto Carlo simulation.

3.2. Towards a Real Option Approach to Estimate an M&A Deal's Synergies

There are different methods to estimate option values using the same options' variables. The most popular methods include Black–Scholes, binomial model, and Monte Carlo simulation. Several scholars' studies demonstrated that both Monte Carlo and the binomial models converge to the Blacks–Scholes option value (Hon 2013). "Although the values of both Monte Carlo and binomial model should be the same, the binomial value converges more quickly" (Liu and Ronn 2020, p. 3). Having reviewed the above main methods for valuing real options, a least squares Monte Carlo simulation-based real options (Longstaff and Schwartz 2001) should be discussed in the comparison with Black–Scholes and binomial trees.

Longstaff and Schwartz (2001) presented a simple and powerful approach to approximating the value of American options by simulation. " ... By its nature, simulation is a promising alternative to traditional finite difference and binomial techniques and has many advantages as a framework for valuing, risk managing, and optimally exercising American option" (Longstaff and Schwartz 2001, p. 114). Gamba (2003) suggested that this approach is very intuitive and clear and is more suited to valuate complex investments with many interacting options.

This simulation method was recently applied by Dehghan-Eshratabad and Albadvi (2018) to value startups by venture capitalists in the first round of financing. Dehghan-Eshratabad and Albadvi (2018) used the numerical method of Monte Carlo least squares simulation to determine the percentage of the start-up's ownership of the entrepreneur and venture capitalist based on the results of the simulation. What is more, Zheng and Negenborn (2017) applied the simulation for a Chinese steel cargo terminal investment decision in a competitive setting with uncertainty. Zheng and Negenborn (2017) proposed a least squares Monte Carlo simulation algorithm to find the investing probabilities in the maritime terminal for future years.

On the one hand, Bashiri et al. argued that by employing the least squares Monte Carlo simulation to estimate the option value, the model's complexity increases substantially (Bashiri et al. 2018). The mathematical complexity might find a lack of top management supports because this requires too much sophistication (Lambrecht 2017). "Due to numerical nature, the least squares Monto Carlo model is not that useful for the development theory ... The use of complex statistical techniques may turn the valuation process into a black box" (Lambrecht 2017, p. 168)

On the other hand, it is important to clarify that simulation does not add complexity, instead, it was suggested as a method for valuing real options in complex real problems as they are in the real world. In fact, through simulation, it is possible to include more sources of uncertainty, also not price uncertainty, in the problem (De Neufville et al. 2006). Also, simulation can overcome some limitations that traditional financial methods for pricing real options have in the use of real options for problems of the real world (Lander and Pinches 1998). Several applications witnessed this in different fields, such as public projects, renewable energy, supply chain (Chiara et al. 2007; Martínez-Ceseña and Mutale 2011; Carbonara and Pellegrino 2018). Hence, this is a promising area for future research.

Below, the paper uses Black–Scholes, binomial, and Monte Carlo methodologies to justify the given proposition. The Black–Scholes option-pricing model's variables, binomial option pricing model's and Monte Carlo's parameters to measure dynamic capabilities-based synergies of Samsung and Harman's in OI type M&A deal are further discussed in the case study research.

4. The Explorative Case Study: Samsung's Acquisition of Harman International Industries

Samsung Electronics Co., Ltd. is a global leader in smartphones and high-tech electronics manufacturing. Harman International is a US-based global enterprise specializing in vehicle infotainment, telematics, connected car features, and vehicle automation software (Kim et al. 2019). Most acquisitions are carried out to acquire these target firm's capabilities; how was Samsun's acquisition of Harman International Industries in 2017 different? Harman's acquisition by Samsung (announced on 14 November 2016 for US$8 bn) involved combining open innovations and dynamic capabilities that would ultimately help to develop a new customer value proposition and to provide their users the 'ultimate professional experience' and, thus, deliver dynamic capabilities-based synergies.

One of the main enablers of the success of Harman's acquisition by Samsung was gouged by their strong complementarities that made the probability to exercise the real option and to generate dynamic capabilities-based synergies in the acquisition of Harman very high. "Harman perfectly complements Samsung in terms of technologies, products, and solutions, and joining forces is a natural extension of the automotive strategy we have been pursuing for some time," said Oh-Hyun Kwon, vice chairman, and chief executive officer of Samsung Electronics.

Harman provided Samsung the ability to bolster its software engineering capabilities. At the same time, Harman received the complementary technologies necessary to accelerate their growth and enhance Samsung's industry leadership. "Their unique synergies in audio and video products, hardware and software solutions, and their automotive and mobile expertise enabled Harman and Samsung to solidify their roles as the industry leaders in the areas in-which leadership has decided to focus" (Automotive World 2018, p. 1). In turn, that leads to the conclusion that the OIs of the corporations are transferable and provide a couple modes of OI. Table 1 demonstrates clusters of dynamic capabilities of Samsung, strategic steps in the acquisition of Harman, and micro-foundations of dynamic capabilities that underpinned the acquisition's success.

Table 1. Clusters of dynamic capabilities of Samsung and their micro-foundations in the process of the acquisition of Harman.

Clusters of Dynamic Capabilities of Samsung	Strategic Steps of Samsung in OI-Type of Acquisition of Harman	Micro-Foundations (Processes) of Dynamic Capabilities of Samsung
Sensing (identify new market and evaluate technologies needed)	Identify emergent customer needs and discover valuable external technological opportunities.	Samsung sensed a new customer demand and shaped a new key activity in the connected car industry. The dynamic capabilities of Harman and Samsung are excellent complements in terms of their dynamic technological capabilities, products' development capabilities, and valuable solutions for customers.
Seizing (put a process into place to monetize ideas)	Invest in OI-type M&A, mobilize external valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney 1991) to address customers' needs, and capture value from doing so.	Samsung acquired and mobilized strategically valuable resources of Harman. The acquisition of Harman gives Samsung a strong presence in the developing market of connected car technologies. Samsung becomes one of the leading players in the connected car industry, specifically, in automotive electronics. This acquisition is immediately won Samsung a position at the heart of the car-tech market.
Transforming (reorchestrate of internally developed and externally acquired technologies and knowledge)	Realign the merging companies to integrate external knowledge and technologies to reflect changing customers' needs and market opportunities.	The companies have continuously worked together to create and implement leading-edge technologies for various industries and customers. Having integrated knowledge and technologies of Harman corporation, Samsung has magnified substantial growth opportunities and deliver a greater customer value proposition.

Source: Adopted from Bogers et al. (2019) and Extended by the Author. Abbreviations: OI, open innovation; M&A, merger and acquisition.

The dynamic capabilities-based synergies provided by this OI-type of M&A deals can be measured by real option application. To value a dynamic capabilities-based synergy with a real options application and to justify the proposition, the author used the Black–Scholes option pricing model (BSOPM) and binominal option pricing model (BOPM). Option variables to value synergies of Samsung and Harman's M&A deal with BSOPM as well as with recombining binomial lattices (underline the value and real option value) parameters of BOPM are discussed in this paper further.

The Black–Scholes option pricing model (Black and Scholes 1973) was used to calculate the theoretical value of options (synergies). Parameters of the Black–Scholes option pricing model to value European call option and thereby to value an M&A deal's synergy are given in Tables 2 and 3.

Table 2. Black–Scholes option-pricing model variables and their parameters to measure dynamic capabilities-based synergies of Samsung and Harman in an OI type M&A deal. Source: Developed by the author.

Option Variables	Sources	Data
S(t)	The price of the underlying assets from the BSIC portal (BSIC 2016)	Samsung Electronics Co. Ltd. (005930: KSE)—market cap as of 18 November 2016: $188.98 bn (KRW 223.117 tn). Harman International Industries Inc. (HAR: NYSE)—market cap as of 18 November 2016: $7.622 bn Therefore, the price of the underlying assets: *S*(*t*) was $196.6 bn
K	The future value of Harman International Industries Inc. was calculated with EV/EBITDA multiple in 2016—a year following the DISCOVERCI report (DISCOUVERCI 2020), and the future value of Samsung using EV/EBITDA multiples was done in 2016, published by KPMG (KPMG 2017)	Samsung's EBITDA was $39.96 bn in 2016 (The Wall Street Journal 2020). For Samsung, median EV/EBITDA multiple in 2016 for the next twelve months (NTM) was 5.3. The hypothetical future market value of Samsung equaled $211.8 bn. The hypothetical future market value of Harman equaled $8.6 bn. Thus, the strike price (K) was $220.4 bn
Rf	The annualized risk-free interest rate in 2016 was South Korea Government Bond 10Y T-bonds yield.	For Samsung Electronics Ltd., the domestic ten-years bond yield of the acquirer's country on the announcement day was 2.16% in December 2016 (Trading Economics 2020).
T	Duration (*t*) getting dynamic capabilities-based synergy of the merger or acquisition	According to Young Sohn, Samsung Electronics Limited president and chief strategy officer, the expected time getting synergies for Samsung Electronic from the deal was about a few years (US SEC 2016). The assumption on duration getting synergy was 3 years.
σ	Samsung Electronics Ltd. historical volatilities of the merged company within the first week after the merger	Thus, expected volatility (σ) equaled σ = 28.84% (V-Lab 2020)

Table 3. Parameters of the Black–Scholes option pricing model and the value of synergies: European call option value (Samsung's acquisition of Harman, in US$ bn).

Option Variables	Data	Option Variables	Data
T=	3.0000	d_1=	0.1508
S_0/K=	0.8921	$N(d_1)$=	0.5599
$\ln(S_0/K)$=	−0.1142	d_2=	−0.3487
variance/2=	0.0416	$N(d_2)$=	0.3637
[risk-free rate + variance/2] × T=	0.1896	−rT=	−0.0648
the square root of variance=	0.2884	e^{-rT}=	0.9373
the square root of T=	1.7321	$S_0 \times N(d_1)$=	$110.09
(square root of variance) × (square root of T)=	0.4995	$K \times e^{-rT} \times N(d_2)$=	$75.12
		Real option value: the value of reciprocal synergies, C=	$34.97

Source: Developed by the author.

Based on the valuation results, Samsung would add market value through the acquisition of Harman of around US$ 35.0 billion, as shown in Table 3.

Afterward, to value a dynamic capabilities-based synergy with a real options application and to justify the proposition, the author applied the BOPM. In the context of option pricing, lattices (trees) are discrete-time models that show different paths that option value may follow till its maturity (Hull 2005, p. 243; Nembhard and Mehmet 2009, p. 24). Conversely, recombining binomial lattices are one of the most flexible methods to value options due to their (relative) simplicity of calculus and illustrative appeal. This has led to enduring and wide-spread acceptance of the recombining binomial approach.

If a given variable is risk-neutral, it is "stripped of its risks" Mun (2002, p. 163) and characterizes by risk-adjusting probabilities that determine the underline value at different periods. The risk neutral probabilities (RNP) approach (Brandao et al. 2005) is used in this paper. In risk-neutral valuation, the probabilities are risk neutralized. Thus, underlined values can be discounted at a risk-free rate, not a risk-adjusted one. This allows for ease of valuation and avoids double counting the risk (Mun 2002, p. 163). The results from either method must be equal, thus the RNP approach is applicable in the "real world" as well, as noted by Hull (2005, p. 247).

Subsequently, the time frame between each time step in the lattice must be derived—this is known as stepping time or time step size (δt, ΔT, or Δt) (Bailey et al. 2003; Nembhard and Mehmet 2009, p. 24). Stepping time essentially represents the length of each time step or how much time passes between sequential nodes and is computed as follows (Mun 2002, p. 144). At each node of the lattice, the value of the underlying increases by the up factor (u) and decreases by the down factor (d). Those up (u) and down (d) factors provide a value of the changes of the underlying asset within a one-time step and depend on implied volatility (Mun 2002, p. 145). The recombining binomial lattices parameters are given in Table 4.

Table 4. Recombining binomial lattice parameters (Samsung's acquisition of Harman).

Parameters of the Binominal Option Pricing Model	
time increment (years)	$\delta t = \frac{t}{N}$ = 0.60
up factor (u)	$u = e^{\sigma\sqrt{\Delta T}} = \frac{1}{d}$ = 1.250
down factor (d)	$\frac{1}{u}$ = 0.800
risk neutral probability (p)	$p = \frac{e^{r\Delta T} - d}{u - d}$ =0.473

Source: Developed by the author.

At least two lattices are needed in the RNP approach. Firstly, the lattice of the underlying (event tree) must be constructed. It was calculated beginning with the starting node and proceeding left to right till real options expiration. Secondly, real option valuation lattice is developed and calculated in the opposite direction, back to the starting node. This approach is both a "road map" and a valuation tool. For descriptive appeal, both may be also merged into one lattice (Mauboussin 1999; Copeland et al. 2000, pp. 407–13).

A lattice of the underlying illustrates the evolution of the underlying asset (S) over the duration of the real option. However, before the lattice of the underlying can be developed, it is necessary to determine for how many discrete periods it is to be built—the number of time steps (N). The number of time steps is arbitrarily assigned, depending on the problem on hand. However, a shorter stepping time will result in higher granularity (more nodes) of the lattice. Lattices with higher granularity will provide more precise results, continually getting closer to the results of a closed-form model, if applicable (Kodukula and Papudesu 2006, p. 74). Five steps were taken in the current research, therefore each step was six months. The lattice of the underline values of Samsung Electronics after the acquisition (in $ bn) is shown in Table 5.

Table 5. Binominal option pricing model: a lattice of the underline values of Samsung Electronics after the acquisition (in $ bn).

Stepping Time: δt 0	δt 1	δt 2	δt 3	δt 4	δt 5
					600.73
				480.47	
			384.28		384.28
		307.34		307.34	
Underline value:	245.81		245.81		245.81
196.60		196.60		196.60	
	157.24		157.24		157.24
		125.76		125.76	
			100.58		100.58
				80.45	
					64.34

Source: Developed by the author.

Mun (2002, pp. 153–54) earlier noted that in the binomial lattice approach, some precision in determining real options valuation is inevitably lost; thus, with a small number of time steps, the main disadvantage of the binomial lattice approach becomes apparent. While Hull (2005, p. 355) indicated that for a financial option about thirty-time steps yield good results, Kodukula and Papudesu (2006, p. 96) indicated that in real options valuation, about four-to-six-time steps are normally sufficient for good approximations. The five times steps were used within a three-year period of getting synergies, as shown in Tables 5 and 6.

Table 6. Binominal option pricing model. Real options lattice: a value of Samsung Electronics synergies of the acquisition (in $ bn).

Stepping Time: δt 0	δt 1	δt 2	δt 3	δt 4	δt 5
					380.33
				262.91	
			169.52		163.88
		10.23		89.78	
Real option's value (value of synergies):	61.89		48.12		25.42
35.78		25.37		11.88	
	13.20		5.55		0.00
		2.59		0.00	
			0.00		0.00
				0.00	
					0.00

Source: Developed by the author.

After lattice of the underlying was developed, a second lattice is constructed—that of real option's valuation or decision tree (Copeland et al. 2000, p. 410). Using the backward induction process, the real option valuation lattice was calculated back to the first node (wherein S0 initially was input). The value of this node represented the expanded NPV or expected value eNPV. This was considered as the "correct value" by real options valuation's adherents (Mun 2002, p. 320; Suto et al. 2008; Nembhard and Mehmet 2009, p. 26). Afterward, as Borison (2005) points out, the lattice was back-calculated (informally—"rolled back") to the starting node to determine the value of the embedded real option(s) or dynamic capabilities synergies of OI tyle M&A in this research, as given in Table 6.

Finally, the synergetic result was generated by using a Monte Carlo simulation, where Excel forecasted the call option value for Samsung's acquisition of the Harman case based on the variables discussed above. The option life was divided into the same five-time steps and the number of simulations was 100,000 times. The higher the number of time steps and the higher the number of simulations, the more accurate the results (Kodukula and Papudesu 2006). The simulation results from a custom-made spreadsheet showed an average real option value of $35.1 million, as given in Table 7.

Table 7. Parameters of the Monto Carlo simulations and the value of synergies: European call option value (Samsung's acquisition of Harman, in US$ bn).

The price of the underlying assets (S(t))	196.6
The strike price (K)	220.4
Time to maturity (T)	3
Volatility (σ)	28.84%
Risk-free rate (Rf)	2.16%
Number of steps	5
Number of simulations	100,000
Call option price as reciprocal synergies	35.08

Source: Developed by the author.

Now, the result of the Monte Carlo simulation can be compared to the results from a Black–Scholes option pricing model and binomial option pricing model. The call option is in the money if the market value of the merged entity exceeds the expected future market value of the two separate companies (Dunis and Klein 2005, p. 6). According to BS-OPM, BOPM, and Monte Carlo results, Samsung would have added an increased market value of about $34.97–35.78 billion. Therefore, the expected market value (eNPV) of merging Samsung Electronics was the cumulated future market value of target and acquirer after the announcement (K) of $189 bn plus dynamic capabilities-based synergies of $35 bn equals the future market value of $224 bn in three years. As of December 2019, the market capitalization of Samsung Electronics Ltd. was $229.5 bn (GuruFocus 2020), which is $5.9 bn more than the paper predicted. The estimated value of synergies shows evidence that Samsung Electronics Ltd. had fully realized their forecasted dynamic capabilities-based synergies (real options value as a market value-added) thus far.

5. Discussion and Contributions

5.1. The Theoretical Contribution

Bogers et al. argued that future research and practice should focus on the attributes that are related to leveraging and enhancing internal capabilities and enhancing competitiveness through outside-in open innovation (Bogers et al. 2019). This paper contributes to this request, provides a better understanding of the benefits of OI-type M&A deals, and thereby provides a better grasp of how to strategically manage this innovation imperative. The major theoretical and managerial contributions of the paper are summarized in Figure 1.

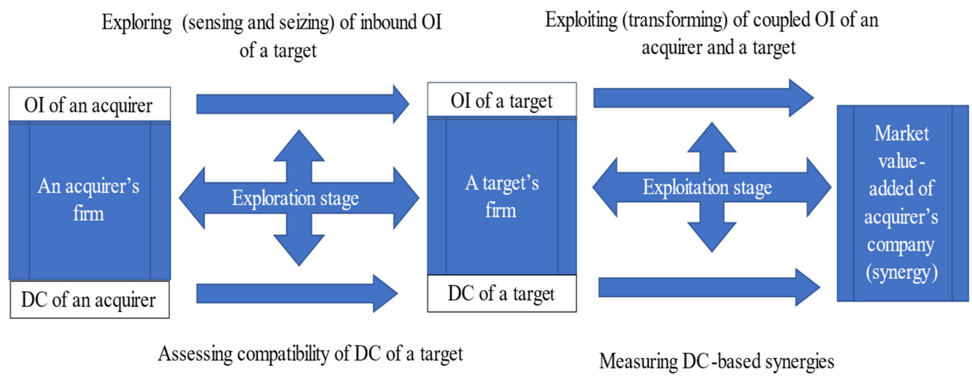

Figure 1. Conceptual illustration of the relationship among discussed research variables. Source: Developed by the author. Abbreviation: DC, dynamic capabilities.

The set of dynamic capabilities needed to enhance inbound OI include sensing external technological opportunities to acquire valuable knowledge and the "purchase" of real options" to achieve a competitive advantage over competitors (Teece et al. 2016). In this approach, the dynamic capabilities framework is to be focused on compatibilities of dynamic capabilities of various partners and on learning processes that enable an acquirer's and target's firms to benefit couple mode of OI and to sustain the competitive advantage obtained. Kyläheiko et al. (2002) argued that the real options approach can contribute to managerial practice twofold: a real option is future-oriented, and it gives quantified valuation onto the strategic management decisions. The paper contributes to this scientific conversation by adding a fresh look at the cutting-edge managerial practice of OI-type M&A deals with the application of real options valuation.

When it comes to innovative ambidexterity, the M&A deal is one among other different modes of exploration and exploitation such as internal R&D and alliances. Open innovation methodologies assist innovative ambidexterity (exploration and exploitation) by enriching and speeding up new product development to meet nascent market opportunities. In this vein, this paper contributes to the scientific discussion on innovative ambidexterity in general and M&A-based ambidexterity in particular. M&A ambidexterity enables simultaneously exploring DC and OI of a target and exploiting them by pursuing couple type of OI and getting a dynamic capabilities-based synergy, which can be measured by real option application.

5.2. The Managerial Implication

"Although the academic literature on real option has grown enormously over past three decades, the adoption of formal real option valuation models by practitioners appears to be lagging" (Lambrecht 2017, p. 166). Usually, the challenge with strategic decisions is that they are in many cases based on strong intuition and qualitative information only (Kyläheiko et al. 2002). With relevant quantitative information about merging companies and real option variables, it becomes possible to get more transparency to the strategic decisions and making outcomes of dynamic capabilities measurable at least in high-tech-based M&A deals. Therefore, this paper contributes not only to real options theory and dynamic capabilities framework development by bridging them onto a new theoretic level, but also underpins theoretical advancements with the practical managerial illustration.

The author used the real option application Monte Carlo simulation with BSPOM, BOPM, and Monte Carlo, which can be easily understood by managers. What is more, the BOPM model is both a valuation tool and a "road map". Thereby, the valuation of managerial synergies by using real options in M&A with an application of binomial option pricing lattices gives practitioners a clearer strategic observation of the reciprocal synergism of an M&A deal (Čirjevskis 2020). This is a major managerial implication of the current paper.

When it comes to limitations, " … real options valuation due to its complexity is not a particularly flexible valuation framework as managers cannot in advance identify the firm's real options, but have to discover and exercise them as uncertainty unfolds (Lambrecht 2017, p. 168). What is more, Liu and Ronn argued that "when the number of simulation paths is small … and when the number of exercise opportunities is large, the Monte Carlo simulation will have poor performance" (Liu and Ronn 2020, p. 3). The BOPM model provides a more favorable condition to be applied in projects where the execution time could be at any time (Guo and Zhang 2020).

6. Conclusions, Limitations, and Future Work

Many established firms attempt to carry out explorative and exploitative learning to overcome the limitations of internal R&D (March 1991; Nelson and Winter 1982) through different strategies, including technological alliances, joint ventures, and M&A deals (Schildt et al. 2005). Open innovation is especially powerful when the sources of innovation are widely dispersed, organizationally, and geographically (Teece et al. 2016). Thus, firms can employ outside-in OI processes to utilize the knowledge of external parties and further develop technologies outside the originating firms.

The 'real option' perspective is not new in financial management literature. However, Lambrecht argued that existing studies on real options focus on only a few industries (Lambrecht 2017). "Hopefully future studies will cover a wider variety of industries and investment decisions" (Lambrecht 2017, p. 170). In this vein, this paper contributes to this conversation, bridges a real options approach with a dynamic capabilities' framework, and demonstrates that OI-type M&A deals create strategic growth options that enable an acquirer to rapidly address various technological and environmental changes and to maximize market value-added. When it comes to computational limitations, the connection of the theoretical value with market actual value largely depends on the timing of the prices taken and is entirely difficult to justify it precisely in such kinds of studies.

Kyläheiko et al. (2002) argued that "In the future particularly the management of dynamic capabilities—like the ability to choose the right R&D portfolio, to generate Schumpeterian new combinations or to find fruitful partnerships or acquisition opportunities—will be major success determinants. Hence, the genuinely dynamic perspective is necessarily required" (Kyläheiko et al. 2002, p. 65). Having extended those arguments, this paper adds that dynamic perspective in the conjunction with real options application is necessarily required.

Real options theory helps improve strategic decision-making by bridging the discipline of corporate finance with qualitative strategic planning tools. However, the author must discuss the limitation of the selected model for valuing real options in the real world, where we have not only price uncertainty, but also other sources of uncertainty. Any valuation analysis aims to assess the true value of an asset. Unfortunately, true intrinsic value is unobservable (Bruner 2004). Virtually every number in valuation is measured with error because of uncertainty about the future (Bruner 2004, p. 252). Moreover, the current COVID-19 pandemic is associated with a huge increase in uncertainty about the future. It combines economic uncertainty, non-economic uncertainty, and policy uncertainty (McMahon 2020). Therefore, the entire process of valuation analysis in the post-pandemic period should be structured as triangulation from several vantage points.

In this vein, the author is looking forward to addressing future perspective research on measuring dynamic synergism of cross-border mergers with real options applications, therefore, to contribute to the current conversation on the interaction between global context, M&A strategies, global dynamic managerial capabilities, and real options theory that are in the course of the interests of international academic society and practitioners. After all, real option valuation, which combines corporate finance and corporate strategy, is not only a science but an art (Lambrecht 2017). Therefore, future research papers could discuss and contribute to related issues on the influencing mechanisms of the synergetic effects of deals and real option application perspectives.

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