ECONOMIES OF SCOPE AND OPTIMAL DUE DILIGENCE IN CORPORATE ACQUISITIONS

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Abstract

This study develops a theory of due diligence in corporate acquisitions. Using a formal model, the study situates due diligence in the context of prospective economies of scope, which are often sought by corporate acquirers but about which acquirers are incompletely informed. Relatedness, the key determinant of economies of scope, and ambiguity, the key determinant of incomplete information, are used to formally derive the optimal due diligence effort and the returns to acquirers that result from that effort. The derived theoretical predictions revisit the conventional wisdom that corporate acquirers cannot be too diligent or implicit assumption that such efforts are exogenous to the transaction. The predictions can be tested in future empirical research on corporate acquisitions, and they may also guide corporate acquirers on the optimal allocation of their research effort in acquisition deals.

Keywords: corporate acquisition, due diligence, economies of scope, synergy, resource redeployment

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INTRODUCTION

Economic gains expected from corporate acquisitions have always been under close scrutiny by executives and academics alike. Often termed *economies of scope* (Teece, 1980), such gains serve as one of the most common justifications for acquisitions (DePamphilis, 2010; Seth, 1990; Singh and Montgomery, 1987) and represent value that can be added only when an acquirer and a target merge into a single company. According to the study conducted by Deloitte LLP, more than 60 percent of the surveyed Chief Financial Officers of corporate acquirers named the pursuit of such economies a key purpose of acquisitions in 2016 (Sirower, Engelbrecht, and Joiner, 2017). Economies of scope can occur in an acquisition when resources are either redeployed between the target and the acquirer (Capron, Dussauge, and Mitchell, 1998; Capron, Mitchell, and Swaminathan, 2001) or are contemporaneously shared between the acquirer's and the target's businesses (Brush, 1996; Li and Greenwood, 2004). Although academic researchers have explored such economies in part because acquisitions often fail to realize gains expected from them (Porter, 1987; Sirower, 1997), this study focuses on the effort that an acquirer should put in assessing those economies before completing an acquisition deal. Many guides for practitioners of corporate acquisitions (Cullinan, Le Roux, and Weddigen, 2004; Deloitte, 2016; DePamphilis, 2010; KPMG, 2018; Howson, 2003) recognize the scrutiny of economies of scope as a critical part of *due diligence*, investment an acquiring firm makes in scrutinizing the records, risks and potential liabilities, facilities, and other resources of an acquired firm (DePamphilis, 2010).[1]

How much due diligence with respect to economies of scope should acquirers undertake? Conventional wisdom expressed by consultants, business press, and educators suggests that, with

[1] Besides the review of economies of scope, due diligence involves the examination of 'intrinsic' (Eccles, Lanes, and Wilson, 1999) or 'stand-alone' (Cullinan *et al*., 2004) value of the target that reflects the value of the target if it continues to be independent rather than is combined with the acquirer. This study does not focus on due diligence with respect to intrinsic value.

numerous and consequential risks that acquisitions present, acquirers cannot be too diligent. As Moeller and Brady (2014) maintain, "the 'knowledge is power' mantra could not be more appropriate than in describing the value of genuine due diligence." In line with this 'mantra,' on the one hand, consultants position the pre-deal evaluation of economies of scope as 'the prime hard key to deal success, one which can enhance chance of success to 28 percent above average' (KPMG, 1999). On the other hand, consultants warn that 88 percent of senior executives with experience in corporate acquisitions consider insufficient due diligence the most common reason for the deal failure (The Storytellers and Mergermarket, 2013). Accordingly, business press advises that acquirers be very skeptical about the target's asking price (Eccles *et al*., 1999) and prepare to refrain from the deal if that price exceeds the value diagnosed by due diligence (Cullinan *et al*., 2004). Likewise, the virtue of extensive due diligence is emphasized in business cases that introduce students to best deal-making practices. For example, Cisco Systems Inc. is often held out as an exemplar for undertaking far-reaching due diligence that involves large cross-functional teams from human resources, manufacturing, engineering, and marketing to discern the value of targets (Singh, Chaudhuri, and Shelton, 2009).

Academic research also advocated extensive due diligence of economies of scope:

> Acquiring firm decision makers must have a clear vision of how synergy will be created in the combined firm… Such a vision is worked out through careful due diligence on the part of acquiring firm executives before a decision is made to proceed with the acquisition. Effective visions do not result from transactions that are completed quickly and without careful analyses. (Hitt, Ireland, and Harrison, 2005: 386)

More broadly, the conventional wisdom that acquirers cannot be too diligent is reflected in the frequency with which management research appeals to the importance of due diligence. In the 1985-2018 time period, due diligence has been mentioned in over two hundred articles in leading management journals (*i.e*., 83 in *Strategic Management Journal*, 42 in *Organization Science*, 49 in *Management Science*, 58 in *Academy of Management Journal*, 16 in *Academy of Management*

Review, and 21 in *Administrative Science Quarterly*). Although empirical evidence on costs of due diligence in 'in-house acquisitions' (Servaes and Zenner, 1996) where acquirers conduct due diligence by themselves is yet to develop, multiple studies in finance reported that acquirers pay very substantial advisory fees when due diligence (including economies of scope) is conducted by investment banks (Chahine and Ismail, 2009; Chuang, 2017; Golubov, Petmezas, and Travlos, 2012; Thomas, 1995).[2] Much of that research concluded that the more acquirers pay for such outsourced due diligence, the greater the acquirers' returns (Benou and Madura, 2005; Chuang, 2017; Golubov *et al*., 2012). Despite that prevailing evidence, some research found that the use of the expensive investment bank advisory does not improve acquirer returns (Hunter and Jagtiani, 2003; Servaes and Zenner, 1996). Moreover, research in accounting, economics, and law on the contractual provisions that acquirers use to address adverse selection risks in acquisitions (*e.g*., material adverse change provisions, earnouts, *etc*.) also suggests there are inherent limitations in the efficacy and efficiency of acquisition due diligence (*e.g*., Datar *et al.*, 2001; Gilson and Schwartz, 2005; Cain *et al.*, 2011). Most commonly in empirical M&A research, however, studies treat selection processes as exogenous and targets as givens (*cf*. Schildt and Lamaanen, 2006), yet the deals that materialize and the characteristics of these transactions are likely to be the consequence of firms' heterogeneous due diligence efforts.

[2] One very rare clue for the cost of in-hose due diligence is the post by Peter Lehrman, the Chief Executive Officer of Axial: "A lot of due diligence can be done yourself these days by leveraging expert networks who can connect you with experts very quickly on the topics that [are] related to the transaction. As a rule of thumb, all of your transaction-related expenses shouldn't be more that 5% of the purchase price" (Quora, 2014). According to Kosnik and Shapiro (1997), the prevailing structure for external advisory fees was based on the Lehman Formula that applies a decreasing sliding scale against the deal value. The scale starts at 5% for the first $1 million of the deal value, 4% for the second $1 million, and declines to 1% for all values over $4 million. Chahine and Ismail (2009) reported that, in 2005, acquisition advisors generated over $31 billion in fees on the overall volume of deals of over US $2.7 trillion, thus capturing 1.15% of the deal value. Chuang (2017) analyzed 5,271 corporate acquirers from the Asia-Pacific region in 1995-2011 and found that 4,200 of those bidders conducted due diligence without assistance from investment banks. Golubov *et al*. (2012) reported that, in 2007, investment banks advised on over 85% of acquisition deals by transaction value and received advisory fees of $39.7 billion from the overall value of transactions of $4.2 trillion. Thomas (1995) analyzed a sample of 627 corporate acquirers in 1988-1990, of whom 70% undertook in-house due diligence.

The present study therefore aims to develop a more nuanced view of due diligence with regard to economies of scope and to offer a theory of this important aspect of acquisition deal-making activities. Although it is natural for an acquirer to want the most accurate assessment of a target's value that would protect the acquirer from the adverse selection or 'lemons' (Akerlof, 1970) problem, due diligence is an expensive process that poses considerable demands on the time and attention of the acquirer's management (DePamphilis, 2010; Howson, 2003). Hence, this study places due diligence in the specific context of the economies that are inherent in the value creation logic of an acquisition but also may be compromised by incomplete information about them. With that combination of economies of scope inherent in a particular deal and of the costs of due diligence of those economies, this study inquires into the extent of due diligence that is optimal for a specific context of economies of scope, while holding conditions (specific to the target, to the acquirer, and to the deal) other than those economies constant. That inquiry should identify rules of thumb that executives may use in their acquisition strategies. Such a perspective draws broad support from the focus of Makadok and Barney (2001) on strategic factor market intelligence that, while not considering economies of scope in corporate acquisitions, developed normative implications of strategizing over the acquisition of information more generally.

Following precedents in the literature on economies of scope (Helfat and Eisenhardt, 2004; Sakhartov and Folta, 2014; 2015; Sakhartov, 2017; 2018), this study uses a formal model to build a theory of acquisition due diligence. The model examines both determinants of acquirers' optimal due diligence efforts and the net returns enjoyed by acquirers, and separate focus is given to resource redeployment and resource sharing as sources of scope economies in acquisitions. Besides specific results that are reported after analyses, the model delivers four key insights that involve the most popular determinant of economies of scope (*i.e.*, relatedness between the merged businesses) and the key determinant of incomplete information in acquisitions (*i.e.*, ambiguity about economies of scope targeted in the acquisition). First, when economies of scope are based on resource redeployment from the target to the acquirer, optimal due diligence effort has inverse U-shaped relationships with relatedness between the merged businesses and with ambiguity about such economies. These and other findings we present below indicate that the more due diligence is not always better. Second, when acquisition economies stem from resource sharing between the merged businesses, optimal due diligence effort has a positive relationship with ambiguity about such economies but does not have a significant relationship with relatedness between the merged businesses. Third, when acquisition economies are linked to resource redeployment, the net return to the acquirer has inverse U-shaped relationships with relatedness between the merged businesses and with ambiguity about such economies. Finally, when acquisition economies stem from resource sharing, the net return to the acquirer has an inverse U-shaped relationship with ambiguity about such economies and is enhanced by relatedness.

Each of these specific relationships that emerge from the model is discussed at length, but together they have three broad contributions and implications for the acquisitions literature. The first implication is that the study develops a theory of due diligence in corporate acquisitions. In particular, the study rigorously derives the optimal amount of the due diligence effort as a function of observable determinants of economies of scope and of incomplete information that were emphasized in previous research. The analyses suggest that an acquirer should not seek to apply the highest possible, or any other uniform, level of scrutiny to all considered deals. Furthermore, the derived function is too complex to be uncovered without a formal model. For instance, as noted above, some relationships between the optimal due diligence and the determinants of economies of scope and of incomplete information are curvilinear and counterintuitive, even though they are robust and can be explained using the developed model. One such relationship involves relatedness present with resource redeployment, another complex relationship involves ambiguity. As a second illustration, although relatedness determines the efficiency of both resource redeployment and resource sharing, how it affects the optimal due diligence differs between the two types of economies of scope. The developed theoretical predictions about the optimal extent of due diligence can be incorporated in future empirical research that predicts strategic choices that are made by acquirers in corporate acquisitions. The predictions may also be used to guide corporate managers on the efficient allocation of their research effort in acquisition deals.

The second broad implication of the developed theory of due diligence is that it builds upon and extends the existing insights with respect to how the known determinants of economies of scope, specifically resource relatedness, determine economies realized in corporate acquisitions. That elaboration is implemented by bringing information economics to the context of economies of scope that were often treated as occurring where information is either complete or easy to access. In fact, the presence of ambiguity about economies of scope between the acquirer and the target substantially revises some of the well-known relationships documented in previous research. For example, relatedness was often argued conceptually (Penrose, 1959; Sakhartov and Folta, 2014; 2015) and shown empirically (Anand and Singh, 1997; Montgomery and Wernerfelt, 1988; Wu, 2013) to enhance value realized in redeploying resources between businesses in a multi-business firm. Thus, the widely shared view was that the highest value is realized when firms redeploy their resources between the closest related businesses. However, when due diligence is recognized as an expensive process that places considerable demands on time and attention of the acquirer's management, an intermediate level of relatedness between the acquirer's and the target's businesses leads to the highest net return that the acquirer attains from redeploying resources between those businesses.

The third broad implication of the offered theory relates to the strategic use of incomplete information in M&A deals, where the extent of incompleteness of information about the target is managed by the acquirer rather than is taken as given. On the one hand, avoidance of incomplete information (Balakrishnan and Koza, 1993) or of underlying ambiguity (Drechsler, 2013) by market players implies a negative relationship between the extent of ambiguity about the target and the acquirer's proclivity to implement the deal. On the other hand, ambiguity increases arbitrage opportunities for acquirers (Sakhartov, 2018), thus suggesting a positive relationship between ambiguity and the acquirer's willingness to complete the deal. In contrast to those two opposing predictions, each of which treats incomplete information as given, this study explores situations where buyers seek to improve information available and thus might get an advantage over other suitors for the target who do not commit due diligence or who undertake inadequate scrutiny. The model therefore demonstrates that it is not always best for the acquirer to buy the target presenting the lowest level of ambiguity. Notably, when the acquirer aims to redeploy the target's resources to the acquirer's own business, an intermediate rather than the lowest or the highest level of ambiguity about the efficiency of redeployment leads to the highest net return to the acquirer. Parameters used to formally derive the results that underlie these three implications are first introduced qualitatively in the review of the relevant literature immediately below.

THEORETICAL BACKGROUND

Economies of scope

'Economies of scope' were originally defined as the reduction in average costs for a firm that combines multiple businesses relative to the costs that would be incurred by those businesses when operated as stand-alone firms (Panzar and Willig, 1981; Teece, 1980). Such a reduction often occurs when a combined firm shares knowledge developed in one of its businesses with another business in the firm, thus avoiding the costly duplication in the knowledge development (Bryce and Winter, 2009; Teece *et al*., 1994). That definition was later extended to include 'demand-side synergy' (Ye, Priem, and Alshwer, 2012), for example when a firm that shares distribution activities across its businesses not only cuts costs but also increases revenues by adding convenience of one-stop shopping and thus increasing consumer willingness-to-pay. Helfat and Eisenhardt (2004) have recently contrasted such 'intra-temporal economies of scope' on the cost or revenue side with 'inter-temporal economies of scope'— or the value that is added when a combined firm withdraws some resources from one of its businesses and redeploys them to another of its businesses. The use of inter-temporal economies of scope in multi-business firms was exemplified with redeployment of resources from the declining explosives businesses of E.I. du Pont de Nemours & Co. to other units in the firm (Chandler, 1962; Penrose, 1960) and has been assessed empirically in multiple studies (Anand and Singh, 1997; Lieberman, Lee, and Folta, 2017; O'Brien and Folta, 2009; Wu, 2013). Economies of scope in the form of synergy (Chatterjee, 1986) or resource redeployment (Capron *et al*., 1998) have also been applied directly to the contexts of mergers and acquisitions where the value of a merged company is expected to exceed the sum of the values of an acquirer and a target.[3]

'Relatedness,' the similarity between businesses Rumelt (1974), has been considered to be the key determinant of economies of scope (Hill, Hitt, and Hoskisson, 1992). With intra-temporal economies, relatedness enables the contemporaneous sharing of resources. Because knowledge is intangible and thus is not limited in physical capacity, a combined firm can apply technological or marketing knowledge created in one business (*e.g.*, a target) to another business (*e.g.*, an acquirer), thus avoiding the costly duplication in knowledge creation (Porter, 1987; Teece, 1980). The more related the two combined businesses, the more similar are their knowledge requirements and the easier is the knowledge sharing between them (Bryce and Winter, 2009). Relatedness between the combined businesses in terms of served consumers can also enable a firm to share the distribution system across its businesses and to sell multiple products to the same consumers at a premium, thus also enhancing 'demand-side synergy' (Ye *et al*., 2012). With inter-temporal economies, relatedness also makes resource requirements between businesses more similar, thus reducing costs of redeployment of a firm's resources from its one business to its another business (Montgomery and Wernerfelt, 1988; Sakhartov and Folta, 2014, 2015). While not being able to separate intra-temporal and inter-temporal economies of

[3] Before the concept of inter-temporal economies of scope was introduced by Helfat and Eisenhardt (2004) and its unique applicability to non-scale free resources was clarified in Levinthal and Wu (2010), the notion of synergy had subsumed the notion of economies of scope. In particular, the earlier mentions of economies of scope in corporate acquisitions in Seth (1990) and Singh and Montgomery (1987) included the sharing of non-scale free resources (*e.g.*, facilities and human resources). Indeed, when a firm withdraws part of non-scale free resources from one business and redeploys them to another business, the realized inter-temporal economies from that partial redeployment may appear synergy, or intra-temporal economies, because the firm starts the sharing of those resources between the two businesses. However, unless the sharing *per se* adds value, the resource withdrawal is what now allows researchers to confidently classify those economies uniquely as inter-temporal economies stemming from the redeployment. Besides, the notion of synergy in corporate acquisitions is used to be and continues to be broader than intra-temporal economies from the sharing of resources between related but distinct businesses. Specifically, according to Cullinan *et al*. (2004) and Eccles *et al*. (1999), synergy is also realized in consolidating acquisitions where the acquirer and the target operate in the same industry and thus can either reduce costs by eliminating duplicate resources or increase profits by exercising market power. To clarify, except for the quote from Hitt *et al*. (2005) that conflates intra-temporal and inter-temporal economies, all mentions of synergy in the present paper (like in Helfat and Eisenhardt, 2004) are equivalent to mentions of intra-temporal economies of scope.

scope, many empirical studies have confirmed the positive relationship between relatedness and performance of multi-business firms (Ahuja and Novelli, 2017). With the view that the more due diligence the better, there has been little clarity about how relatedness alters the demand for due diligence by an acquirer, however.[4]

Incomplete information

The concept of economies of scope in acquisitions has also been often linked to the challenges that incomplete information presents to acquirers. Like a buyer of a used car with an uncertain quality in the classical example of the adverse selection problem (Akerlof, 1970), an acquirer in a corporate acquisition bears the risk of buying a 'lemon,' a target that is worth less than what the acquirer pays for it. Indeed, economies that are counted on and factored into the deal price by acquirers often turn out illusive and lead acquirers into a 'synergy trap' (Sirower, 1997). Scholars noted that external evaluators, including acquirers, are unlikely to know the value of synergy between the merged businesses (Sirower, 1997). Thus, intra-temporal economies of scope, or synergy, from shared knowledge, distribution, or other functions are notoriously hard to estimate (Cullinan *et al*., 2004; Eccles *et al*., 1999). Likewise, inter-temporal economies of scope from resource redeployment are difficult to evaluate (Maritan and Florence, 2008; Sakhartov, 2018).

Information challenges associated with synergy and resource redeployment have been attributed to ambiguity, or the 'subjective experience of missing information relevant to a prediction' (Frisch and Baron, 1988). Evaluators face ambiguity 'where the sample for studying the event is small' (Einhorn and Hogarth, 1985). According to Bernstein (1996), 'when events are unique ambiguity takes over.' Uniqueness pertains to synergy and resource redeployment.

[4] An exception to the observation that there was little clarity about how relatedness alters the demand for due diligence is the idea that relatedness between a target and an acquirer mitigates information asymmetry faced by the acquirer and reduces demand for due diligence. Studies that embraced that idea (Balakrishnan and Koza, 1993; Coff, 2002) implied avoidance of deals that require extensive due diligence; while this study focuses on the optimal amount of due diligence in any deal, even if that amount is large.

Researchers have raised a paradox or tension that arises when such economies can add value but are also hard to evaluate adequately. Litov, Moreton, and Zenger (2012) studied the 'uniqueness paradox': unique synergies among a firm's businesses reduce costs or increase revenues for that firm and are potentially a source of competitive advantage as a result, but they are also ambiguous and can elevate financing costs since outside investors cannot appreciate the unique synergies. Sakhartov (2018) proposed a 'redeployability paradox': redeployment of resources between two businesses is a valuable option that is similarly ambiguous to evaluators. The extent of uniqueness determines the degree of ambiguity, which in turn affects the difficulty of evaluation of scope economies. When a certain opportunity for synergy or resource redeployment has not been previously pursued, then evaluators (including the acquirer) have no data points to estimate the economies. Conversely, when such economies of scope are prevalent, evaluators are better equipped with data to assess them. Despite the general intuition that greater ambiguity makes evaluation of a target more difficult to an acquirer, how much that acquirer should invest in the reduction of ambiguity has not been specified. Therefore, the next section builds a formal model that identifies the amount of due diligence as a function of relatedness and of ambiguity, and predicts the return to the acquirer from those parameters.

MODEL

The model of acquisition due diligence focusses on two firms, the acquirer and the target. At the initial time $t = 0$, the acquirer operates in business j and considers buying the target that runs business i. Each of the following three conditions is necessary for making the deal happen.

The first necessary condition is that the acquisition deal should add value that would not be realized if the two firms stayed separate. Following Sakhartov and Folta (2014), the model specifies two types of economies of scope that can justify the deal. First, the acquirer can attain synergy when it continues the target's business i and shares the distribution (Ye *et al*., 2012) or technological knowledge between that business and its own business j (Bryce and Winter, 2009). Second, if the target's business i underperforms and its resources can be used more efficiently in the acquirer's business j, then at any time before the end of the useful life of the resources $t = T$, the acquirer can withdraw the target's resources from the target's business i and redeploy them to the acquirer's own business j (Capron *et al*., 1998).

The second condition is that the price paid by the acquirer for the target must be at least as high as the next best bid for the target. If the bid by the acquirer were below a competitive bid, the acquirer could not win the bid in the market. Although the value of the next best bid depends on the equilibrium among alternative strategic buyers of the target and capital investors in the market where the target's equity is traded, this model does not derive that equilibrium explicitly. Rather, the model follows the approach established in existing research (Chen and Epstein, 2002; Epstein and Wang, 1994; Sakhartov, 2018) and implies the existence of the equilibrium in the market where participants have incomplete information about the target.

The third necessary condition is that, by committing some due diligence effort, the acquirer arrives at the estimate of the target's value that is at least as high as the deal price; but the difference between the acquirer's improved estimate of the target's value and the deal price should not be offset by the due diligence effort. Otherwise, that difference would not compensate the acquirer for the costly due diligence. The three necessary conditions are built into the model as described in the three respective sections below.

Economies of scope in the acquisition deal

Economies of scope from merging businesses i and j are modeled based on Sakhartov and Folta (2014). That specification starts with defining the evolution of uncertain returns in i and j when those businesses are run as stand-alone firms. In particular, the margin C_{it} in the target's business and the margin C_{jt} in the acquirer's business follow geometric Brownian motions:

$$C_{it} = C_{i0} e^{\left[\left(\mu_i - \frac{\sigma_i^2}{2}\right)t + \sigma_i W_{it}\right]} \quad (1)$$

$$C_{jt} = C_{j0} e^{\left[\left(\mu_j - \frac{\sigma_j^2}{2}\right)t + \sigma_j W_{jt}\right]} \quad (2)$$

$$dW_{it} dW_{jt} = \rho dt . \quad (3)$$

In Equations 1–3, C_{i0} and C_{j0} are margins in businesses i and j, respectively, at the initial time $t = 0$; μ_i and μ_j are drifts for the two corresponding margins; σ_i and σ_j are volatilities of those margins; and W_{it} and W_{jt} are Brownian motions with the correlation coefficient ρ. Thus, the original specification taken from Sakhartov and Folta (2014) is two-dimensional: it involves two random variables C_{it} and C_{jt}, also known as state variables or primitives. Because the model that is developed below is more complex and more expensive computationally, the dimensionality of the problem is reduced in deriving the main results by setting $\sigma_i = 0$, thus making the margin in the target's business certain.[5] Formally,

$$C_{it} = C_{i0} e^{\mu_i t} . \quad (4)$$

[5] That simplification is relaxed in the additional analyses. The results reported here for the streamlined model do not qualitatively differ from the results checked selectively with the full model. Those robustness tests are available from the authors upon request.

After the acquisition, the combined firm can use synergy from sharing of distribution or knowledge between businesses i and j. The firm can also derive extra value from redeploying resources from business i to business j. Following Sakhartov and Folta (2014), the two types of economies of scope are reflected in the net return attained by the combined firm at time t:

$$F_t^{xy} = \left[\omega_{it}^{xy} C_{it}^x + \left(1-\omega_{it}^{xy}\right) C_{jt}^y\right] - S\left(\omega_{it-1} - \omega_{it}^{xy}\right) C_{jt}^y + \frac{\omega_{it}^{xy}}{\omega_{i0}^{xy}} \beta \left[\omega_{it}^{xy} C_{it}^x + \left(1-\omega_{it}^{xy}\right) C_{jt}^y\right]. \quad (5)$$

In Equation 5, superscripts x and y denote the realizations of the two random variables C_{it} and C_{jt} with the probability distribution that is specified with Equations 1–3.[6] Parameter ω_{it}^{xy} is the proportion of resources of the combined firm that is kept in the target's business i at time t. That proportion can take values of either zero (when all resources of the target have been redeployed to the acquirer's business) or ω_{i0} (when all resources of the target are being kept in the target's business). Accordingly, $\left(1-\omega_{it}^{xy}\right)$ is the proportion of resources of the combined firm that is deployed in the acquirer's business j at time t; whereas $\left(\omega_{it-1} - \omega_{it}^{xy}\right)$ is the proportion of resources of the combined firm that is redeployed from the target's business i to the acquirer's business j at time t, which can be either zero or ω_{i0}. The ratio $\frac{\omega_{it}^{xy}}{\omega_{i0}^{xy}}$ is added to Equation 5 to discriminate the case where the target's resources are kept in the target's business $\left(\frac{\omega_{it}^{xy}}{\omega_{i0}^{xy}} = 1\right)$ and the combined firm generates some synergy, from the case where the target's resources have been redeployed to the acquirer's business $\left(\frac{\omega_{it}^{xy}}{\omega_{i0}^{xy}} = 0\right)$ and no synergy occurs.

[6] With the mentioned reduction in the dimensionality wherein $\sigma_i = 0$, x becomes redundant.

The following two parameters in Equation 5 capture relatedness between i and j, the similarity of resource requirements between them (Rumelt, 1974). First, relatedness increases redeployability of resources between i and j by reducing the marginal redeployment cost $S \geq 0$. When the firm redeploys resources to j, the net margin earned with the resources that are redeployed from i is lower than the regular margin C_{jt} in j by the marginal redeployment cost S. That parameter captures a loss in efficiency that occurs due to the needed adjustment of resources, which were previously used in one business, for use in another business; the stronger the relatedness, the less adjustment is needed (Montgomery and Wernerfelt, 1988). Thus, the full cost of redeployment is a product of the marginal redeployment cost S of a unit of resources, the amount $\left(\omega_{it-1} - \omega_{it}^{xy}\right)$ of resources redeployed to j, and the current realization C_{jt}^{y} of the margin C_{jt}. Second, relatedness enables sharing of resources between i and j by raising the sharing factor β. When the merged firm continues to operates both businesses $\left(\frac{\omega_{it}^{xy}}{\omega_{i0}^{xy}} = 1\right)$ and shares the distribution or knowledge between those businesses, the net margin that is earned by the firm in each business is higher than it would be if the firm discontinued the target's business by the multiplier $(1+\beta)$, where $\beta \geq 0$ is the sharing factor. The stronger the relatedness, the more similar are the customers and the knowledge requirements between the businesses and the easier the firm can share resources between those businesses (Sakhartov and Folta, 2014).

Because relatedness decreases S and raises β, a strong negative relationship between S and β might occur, thus potentially making the operationalizations redundant. The present study takes into account this issue in two ways. The first way is to eliminate the separate specification of S and make it perfectly negatively determined by β so that the highest value of β coincides with the lowest value of S and *vice versa*. The second way is to consider many possible combinations of S and β. Because the existing theory has not proven that synergy and redeployability are perfectly codetermined and because the tentative empirical evidence shows the lack of such strong codetermination (Sakhartov and Folta, 2014; Sakhartov, 2017); by not imposing a specific structure on the relationship between S and β, the current model avoids making any assumption that some combinations of S and β are more likely than other combinations.

Deal price for the target

The price for the target is modeled as occurring in the capital market where the two economies of scope, synergy and redeployability, are incompletely understood by market players. In particular, following Sakhartov (2018), that incompleteness of information is enabled by letting the sharing factor β and the marginal cost of redeployment S be ambiguous to market participants. Such ambiguity represents the experience of missing information about the rare events (Bernstein, 1996; Frisch and Baron, 1988) concerning resource sharing and redeployment. In that case, each market participant has multiple priors for S and for β but does not know the relative likelihoods of those priors. Because the rarity of redeployment and of sharing of resources between businesses i and j that leads to ambiguity is a matter of degree, ambiguity about the two ramifications of relatedness, S and β, is parametrized with σ_M, like in Sakhartov (2018):

$$S_t^M = S_0^M e^{\left[\left(\mu_S - \frac{\sigma_M^2}{2}\right)t + \sigma_M W_{Mt}\right]} \qquad (6)$$

$$\beta_t^M = \beta_0^M e^{\left[\left(\mu_\beta - \frac{\sigma_M^2}{2}\right)t + \sigma_M W_{Mt}\right]}. \qquad (7)$$

In Equations 6 and 7, S_t^M and β_t^M summarize multiple priors that are maintained by market players at time t for S and β, respectively. The Brownian motion W_{Mt} is set uncorrelated with either W_{it} or W_{jt}.[7] Initial values S_0^M and β_0^M for S_t^M and β_t^M are set equal to the respective true values S and β; and μ_S and μ_β are drifts for the evolution of priors for S and for β.[8]

Because relatedness was argued to increase the intensity of both redeployment (Anand, 2004) and sharing (Bryce and Winter, 2009) of resources between businesses, a strong negative relationship between relatedness and ambiguity might occur, thus potentially making one of those considerations redundant. The present study responds to that possibility by eliminating separate independent specification of S and σ_M in some of the analyses. In those analyses, each of S and σ_M is made perfectly negatively determined by β so that the highest value of β coincides with the lowest value of S and with the lowest value of σ_M; alternatively, the lowest value of β coincides with the highest value of S and with the highest value of σ_M.

The model assumes that the acquirer competes for the target with all other players in the specified incomplete market.[9] The target's market valuation V_0^M, which the acquirer has to match to win the bid, should reflect the net present value of return that is accumulated over time by a representative buyer of that target including economies of scope for that buyer.[10] In the

[7] That assumption is not consequential for the solution and simply avoids unnecessary parameters for the two correlations.
[8] Setting the initial values for S and β reflects the authors' preference to avoid the consideration of biases in the priors.
[9] Although that modeling approach does not explicitly consider the simultaneous game between two suitors (including the focal acquirer) who submit their bids at the exact same time, the model does not disallow the more realistic situation wherein an alternative suitor had made its bid a bit earlier that the focal acquirer. In that case, the alternative bid above the immediate previous market price for the target would communicate some news to the capital market and represent a new equilibrium that corresponds to the new (lower) level of ambiguity with respect to the efficiency gains in the acquisition.
[10] Because the focal acquirer can buy the target at the price equal to the net present value of return that is accumulated by a representative buyer including the efficiency gains anticipated by such buyer, the deal price for the focal acquirer that knows the target at least as well as a representative buyer in the market is always less than or equal to the sum of the target's stand-alone value and the efficiency gains as accepted by the focal acquirer itself, thus relaxing the participation constraint for the acquirer.

specified incomplete market, V_0^M cannot be computed by market players as an expectation because they do not know the probability distributions for S_t^M and for β_t^M. The target's market valuation V_0^M is assessed based on the 'maxmin' principle of Gilboa and Schmeidler (1989):

$$V_0^M = \max_{\boldsymbol{\Omega}} \int_{t=0}^{t=T} \left[e^{-rt} \int_y \int_x \min_{z \in Q_{xyz}^M} \left\{ F_t^{xyz} \right\} dxdy \right] dt - V_0^B = \max_{\boldsymbol{\Omega}} \int_{t=0}^{t=T} \left[e^{-rt} \int_y \int_x F_t^{xy\underline{Q}_{xyz}^M} dxdy \right] dt - V_0^B . \tag{8}$$

Like F_t^{xy} in Equation 5, F_t^{xyz} is the net return that the merged firm generates at time t when C_{it} and C_{jt} have respective realizations x and y from the probability distribution described in Equations 1–3. The additional superscript z in F_t^{xyz} reflects ambiguity with regard to S and β. The 'min' operator captures the ambiguity aversion, with which market participants count on the worst-case scenario $\underline{Q}_{xyz}^M$ from all possible scenarios Q_{xyz}^M for the ambiguous parameters S_t^M and β_t^M characterized with Equations 6 and 7: the highest possible marginal redeployment cost $\bar{S}_t^M$ and the lowest possible sharing factor $\underline{\beta}_t^M$ at time t. The main economic implication of that minimization is that economies of scope are undervalued in the incomplete market, thus enabling an arbitrage opportunity for the diligent acquirer.[11] Matrix $\boldsymbol{\Omega}$ summarizes choices ω_{it}^{xy} with regard to how a representative buyer of the target should optimally use the target's resources with all possible realizations x and y for C_{it} and C_{jt} and at any time $t \in [0, T]$. Finally, V_0^B is the stand-alone value of a representative buyer of the target. Because resource redeployability is an American-type option that can be exercised by a representative buyer at any time $t \in [0, T]$

[11] The minimization implies that the capital market is dominated by players with very strong aversion to ambiguity. That approach is justified for the following three reasons. First, strong ambiguity aversion was diagnosed in laboratory experiments as a robust pattern of human behavior (Ellsberg, 1961). Second, formal models with the strongest ambiguity aversion have been repeatedly used to derive market prices (Chen and Epstein, 2002; Epstein and Wang, 1994). Finally, Drechsler (2013) provided empirical evidence that real market participants respond to ambiguity by pricing assets based on the worst case scenario.

and that can be further complicated by non-trivial redeployment cost $S_t^M > 0$, Equation 8 cannot be solved analytically. Therefore, V_0^M is estimated numerically, as described in Appendix S1.

Value of the target to the acquirer with due diligence

Without due diligence, the acquirer would not have an information advantage over other buyers. The acquirer would not anticipate any return to such a deal because the deal price in the competitive market would fully incorporate the economies of scope envisioned equally (but not accurately) by the acquirer and by a representative buyer. If due diligence were effortless, the acquirer would always conduct the most thorough due diligence to fully eliminate ambiguity regarding the efficiency gains and would fully appropriate the undervaluation of the target in the incomplete market. In a more realistic setting, due diligence is neither absent nor effortless. The eventual utility of that due diligence to the acquirer is determined by the balance between the extent of the undervaluation of the target by a representative buyer that is uncovered with due diligence and the cost of the due diligence effort that is borne in uncovering that undervaluation. Those two sides of the balance are modeled as described in turn below.

Because in the general case the acquirer undertakes the extent of due diligence that eliminates some (from none to all) ambiguity, the acquirer sees the target's value as follows:

$$V_0^D = \max_{\boldsymbol{\Psi}} \int_{t=0}^{t=T} \left[e^{-rt} \int_y \int_x \min_{z \in Q_{xyz}^D} \left\{ F_t^{xyz} \right\} dxdy \right] dt - V_0^A = \max_{\boldsymbol{\Psi}} \int_{t=0}^{t=T} \left[e^{-rt} \int_y \int_x F_t^{xyQ_{xyz}^D} dxdy \right] dt - V_0^A . \qquad (9)$$

Like Equation 8, Equation 9 cannot be solved analytically. Therefore, V_0^D is also estimated numerically, as described in Appendix S1. Equation 9 differs from Equation 8 in the following three ways. The first distinction is that the representation Q_{xyz}^M of priors that are maintained for S and β by a representative buyer changes to Q_{xyz}^D that is held by the acquirer. That change occurs because the acquirer exerts due diligence effort $\theta \geq 1$ that makes S and β less ambiguous than perceived by the market. Formally,

$$\sigma_D = \frac{\sigma_M}{(1+\theta)} \tag{10}$$

$$S_t^D = S_0^D e^{\left[\left(\mu_S - \frac{\sigma_D^2}{2}\right)t + \sigma_D W_{Dt}\right]} \tag{11}$$

$$\beta_t^D = \beta_0^D e^{\left[\left(\mu_\beta - \frac{\sigma_D^2}{2}\right)t + \sigma_D W_{Dt}\right]}. \tag{12}$$

In Equations 10–12, σ_D represents the residual ambiguity ($0 < \sigma_D \leq \sigma_M$) that is faced by the acquirer regarding S and β after it exerted due diligence effort θ. An intuitive interpretation of that operationalization is that there is information asymmetry between a representative buyer and the acquirer: the bands for possible values of S and β as seen by the acquirer are narrower that the bands for those values as considered by the market.[12] With that operationalization, S_t^D and β_t^D summarize the multiplicity of priors for S and β that is still experienced by the acquirer.[13] The 'min' operator continues to model the ambiguity aversion, with which the acquirer counts on the worst-case scenario $\underline{Q}_{xyz}^D$ from all possible scenarios Q_{xyz}^D for the ambiguous parameters S_t^D and β_t^D: the highest possible marginal redeployment cost $\overline{S}_t^D$ and the lowest possible sharing factor $\underline{\beta}_t^D$ at time t. The second distinction of Equation 9 is that choices $\boldsymbol{\Psi}$ with regard to how the acquirer should use the target's resources can differ from choices $\boldsymbol{\Omega}$ by a representative buyer due to the information asymmetry between those players. The third difference of Equation

[12] The present model assumes that there is no spillover of the information learned by the acquirer in the course of due diligence to the rest of the market, that is σ_M does not depend on due diligence.

[13] The Brownian motion W_{Dt} is set uncorrelated with W_{it}, W_{jt}, or W_{Mt}. Initial values S_0^D and β_0^D are equal to S and β.

9 from Equation 8 is that the acquirer's stand-alone value V_0^A is subtracted instead of the stand-alone value of a representative buyer V_0^B. Because the only way in that the model differentiates the acquirer from a representative buyer is by enabling the due diligence effort, $V_0^A = V_0^B$.

The disutility of the due diligence effort to the acquirer is modeled to capture diminishing returns to the research effort that is committed by the acquirer to better discern efficiency gains inherent in the acquisition. That ramification is operationalized similar to Makadok and Barney (2001: 1626) by setting the problem of choosing the optimal due diligence level as follows:

$$\theta^* = \arg\max_\theta \left\{ \frac{\left(V_0^D(\theta) - V_0^M \right)}{(1+\theta)} \right\} \qquad (13)$$

$$\Delta = \max_\theta \left\{ \frac{\left(V_0^D(\theta) - V_0^M \right)}{(1+\theta)} \right\}, \qquad (14)$$

where Δ is the acquirer's net return in the acquisition deal.[14]

RESULTS

As was described in the previous section, the three key parameters of the model (S, β, and σ_M) that characterize the contexts of the acquisition *might* be strongly codetermined. Because the extent of that codetermination is an empirical issue that is yet to be explicated, the analyses of the optimal due diligence considers the following three scenarios. In the first (main) scenario, S and β are ramifications of relatedness that may or may not be strongly related to each other; whereas σ_M is ambiguity that may or may not be strongly codetermined with either S or β.

[14] Of course, knowing the target's value including economies of scope is not the same as realizing that target's value in the course of integrating the target in the merged firm. The present study estimates the net return to the acquirer under the assumption that the acquirer acts optimally based on what the acquirer learned about economies of scope That assumption involves what the acquirer learned about different integration challenges and is built in Equation 9.

That first set of analyses enables any relationships among S, β, and σ_M and is, therefore, most reliable for subsequent empirical examination because it does not rely on the untested assumptions regarding those relationships. In the second scenario, S and β are set to be perfectly negatively codetermined and are, therefore, aggregated in a single construct of relatedness that is still kept separate from ambiguity σ_M. In that second scenario, ambiguity may or may not be codetermined with relatedness. In the third scenario, S, β, and σ_M are set to be perfectly codetermined and are, thus, aggregated in a single construct of relatedness.

Scenario 1: Separate operationalizations of redeployability, synergy, and ambiguity

Implications of redeployability and ambiguity for acquisition due diligence

Figure 1 shows the effects of redeployability and ambiguity on the optimal due diligence effort (Panel A), and on the net return to the acquirer that results from that optimal due diligence effort (Panel B). In addition, the figure illustrates the net return to the acquirer that occurs when the due diligence effort is lower (Panel C) and higher (Panel D) than optimal. In these analyses, synergy is assumed to be absent ($\beta = 1$), and thus redeployability is the only scope economy in the deal. Accordingly, redeployability placed along the horizontal axis is the only manifestation of relatedness in this experiment. Also, because the model operationalizes redeployability inversely with the marginal redeployment cost S, higher levels of redeployability and of relatedness along the horizontal axis represent lower levels of S.

The key observation in Panel A is that it contains a diagonal ridge for the optimal due diligence effort. Given that redeployability is the only manifestation of relatedness in Figure 1, that result suggests that neither the weakest nor the strongest relatedness between the target and the acquirer requires the highest due diligence effort. Similarly, neither the lowest nor the highest ambiguity about the target leads to the highest due diligence effort. That non-monotonicity of the effects of relatedness and ambiguity on the due diligence effort is a novel finding that is provided by the present formal model and can be explained intuitively with the following three patterns.

Insert Figure 1 here

First, the optimal due diligence effort is zero in the bottom right corner in Panel A. What makes due diligence unneeded in that corner? That result occurs because, at the right margin of the panel, businesses i and j have identical resource requirements (*i.e.*, i and j are perfectly related), and the rule for resource redeployment is simple: the acquirer redeploys resources from the target whenever the margin is greater in the acquirer's business than in the target's business $(C_{jt}^{y} > C_{it}^{x})$. Moreover, zero redeployment cost makes economies from redeployment the highest possible. That peak gain attracts not only the acquirer but also a representative buyer. Because ambiguity is the lowest in the bottom right corner of the panel, due diligence cannot create significant information asymmetry between the two bidders. Thus, the acquirer confronts a high competitive bid from a representative buyer for the high gain and would have to pay for the target nearly as much as the target is worth to the acquirer regardless of due diligence.

Second, farther to the left of the right margin of Panel A, businesses i and j become less similar in resource requirements (*i.e.*, i and j become less related), and the simple rule for the acquirer to redeploys resources from the target whenever the margin is greater in the acquirer's business than in the target's business $(C_{jt}^{y} > C_{it}^{x})$ becomes less adequate. Farther to the left in Panel A, the redeployment decision becomes more and more selective: not only the advantage of the current margin in the acquirer's business over the target's business should exceed the cost of redeployment but also time t considered for such redeployment should be better than any future time. The more restrictive rule for resource redeployment with greater redeployment costs (*i.e.*, lower redeployability) poses higher demand on the quality of information about such costs, thus justifying the increase of the optimal due diligence effort in the direction from the right margin of Panel A to the ridge in that panel. Moreover, with lower quality of publicly available information closer to the top margin of Panel A, the stronger demand for improving that quality becomes pertinent with lower redeployment costs (*i.e.*, higher redeployability). That increasing demand for due diligence with higher ambiguity and lower redeployability renders the growth of the optimal due diligence effort from the bottom right corner to the diagonal ridge in Panel A.

Third, a dark blue quarter circle to the north-west of the ridge in Panel A shows that the acquirer undertakes no due diligence with the combinations of redeployability and ambiguity present in that area. What makes the optimal research effort drop abruptly from the ridge to the quarter circle? That drop occurs because, keeping ambiguity constant and going from the right margin to the left in Panel A, redeployment cost reaches a threshold above which the estimate $\bar{S}_t^D$ for that cost that is held by the acquirer becomes so high that the acquirer would never redeploy the target's resources. That threshold depends not only on the feasible current advantage of C_{jt}^y over C_{it}^x but also on the possibility of a decline or even a reversal of that advantage in the future. From that threshold point to the left margin of Panel A, the acquirer sees no economies from acquiring the target and redeploying the target's resources to the acquirer's business, thus fully refraining from the deal. Letting ambiguity σ_M vary affects how far from the right margin the threshold for redeployability is located. That happens because the costliness of the research effort adds to the costs of the would-be redeployment. With those two costs both contributing to the disutility of the deal and thus substituting for each other, lower values of the redeployment cost (*i.e.*, higher values of redeployability) become the threshold with higher ambiguity, explaining the quarter-circle shape of the dark blue area in the top left corner of Panel A in Figure 1.

The main result in Panel B of Figure 1 is that the filled contour map for the acquirer's net return with the optimal due diligence has an interior peak, even though that peak is close to the bottom right corner where redeployability is the highest and ambiguity is the lowest. The corner that entails the highest economies from redeployment and demands the lowest due diligence to apprehend those economies would be suitable for the peak. Why doesn't the peak occur right in that corner? The peak does not coincide with the bottom right corner where, as was explained with Panel A of Figure 1, the acquirer does not find it profitable to bid for the target as much as a representative buyer offers and nearly as much as the target is worth. The location of the peak in Panel B determines that the net return to the acquirer has inverse U-shaped relationships both with redeployability (*i.e.*, with relatedness) and with ambiguity. In other words, neither the lowest nor the highest redeployability leads to the highest net return to the acquirer. Similarly, neither the lowest nor the highest ambiguity leads to the highest net return to the acquirer.

Another observation in Panel B is that the highest net return to the acquirer does not necessarily derive from the highest due diligence effort that is reported in panel A. For example, the diagonal ridge in Panel A where the maximal due diligence effort is exerted maps on the dark blue area in Panel B where the acquirer gets very low (but not zero) net return. Alternatively, the dark blue area in the bottom right part of Panel A where the minimal research effort is committed matches the red area in Panel B where the acquirer gets the highest net return. That misalignment emerges because the disutility of the research effort offsets the arbitrage opportunity that derives from the information advantage an acquirer would obtain *vis-à-vis* a representative buyer.

Ultimately, the change of the tone of the filled contour maps from including the red area with high net returns to the acquirer in Panel A to having no red area in Panels C and D of Figure 1 demonstrates the loss that occurs when the acquirer applies the due diligence effort arbitrarily rather than strategically. In the cases of the insufficient (Panel C) and of the excessive (Panel D) due diligence effort, the acquirer under-realizes the economies of scope that are untapped by a representative buyer of the target. Meanwhile, Panels C and D reconfirm the existence of the interior peak for the net return to the acquirer with respect to both redeployability and ambiguity.

Implications of synergy and ambiguity for acquisition due diligence

Figure 2 shows the effects of synergy and ambiguity on the optimal due diligence effort (Panel A), and on the resulting acquirer return (Panel B). Besides, Figure 2 displays the acquirer return with insufficient (Panel C) and excessive (Panel D) due diligence. In this analysis, redeployment of resources from the target to the acquirer is disallowed ($\omega_{it} = \omega_{i0}$ for $0 < t \leq T$), and synergy is the unique type of scope economies. The following three regularities in Figure 2 are noteworthy.

Insert Figure 2 here

The first pattern in Figure 2 is that, in contrast to the continuous effect of redeployability, synergy has a discrete effect on the optimal due diligence. Thus, the absence of synergy $(\beta = 1)$ at the left margin of Panel A totally discourages due diligence. If i and j have no commonality (are unrelated) in served consumers or used knowledge, synergy is unlikely anyway. That case by itself is the worst case for scope economies. In other words, regardless of whether resources have ever been tried to be shared between i and j (*i.e.*, regardless of ambiguity about such sharing), trivial synergy leaves no room for information asymmetry between the acquirer and a representative buyer. Conversely, if synergy is nontrivial, that is always optimal for the acquirer to undertake some due diligence, to acquire the target, and to share knowledge or distribution between i and j. Beyond enabling the effect of ambiguity, non-trivial synergy has no individual effect on optimal due diligence. In that case, ambiguity σ_M becomes the dominant determinant of due diligence. The greater the ambiguity σ_M faced by a representative buyer, the more the acquirer is motivated to profit from that ambiguity by bringing $\underline{\beta}_t^D$ closer to β and farther from $\underline{\beta}_t^M$. Why doesn't ambiguity interact with synergy just as it interacts with redeployability in Panel A of Figure 1? That difference takes place because, in contrast to the very selective use of resource redeployment with intermediate values of redeployability, synergy is used by the acquirer permanently from the time of the acquisition to the end of the lifecycle of the target's resources regardless of current values of the margins C_{it}^x and C_{jt}^y. In other words, the choice to acquire the target is congruent with the choice to share resources between the merged businesses.

The second pattern in Figure 2 is that, when the acquirer uses due diligence optimally, its net return has a peak that is situated exactly on the right margin and very close to but not exactly on the bottom margin of Panel B. Why isn't the peak located in the bottom right corner, where the economies from sharing resources are the highest while the effort needed to apprehend those economies is the lowest? The peak does not occur in the bottom right corner because, on the bottom margin, the acquirer does not find it profitable to bid for even very high synergy as much as a representative buyer offers and as much as that synergy is actually worth. Why is, in contrast to Panel B of Figure 1, the peak located exactly on the right margin of Panel B in Figure 2 rather than stands out of that margin? This difference with Figure 1 occurs because synergy, in contrast to redeployability, does not have a natural upper bound. While redeployability is capped by zero redeployment costs and cannot be better than that, synergy can be unlimitedly high in principle. (Indeed, when the horizontal axis was calibrated to end with higher values of synergy, the peal always moved to the new right margin in the modified graph.) Thus, the location of the peak in Panel B of Figure 2 reconfirms the result observed in Panel B of Figure 1: the net return to the acquirer has an inverse U-shaped relationship with ambiguity. However, in contrast to the result for redeployability in Figure 1, synergy monotonically increases the net return to the acquirer. In other words, while the highest relatedness involved in redeployment does not lead to the highest return to the acquirer, the highest relatedness involved in synergy does lead to the highest return.

The final result in Figure 2 is that, Panel D with excessive due diligence does not have the red area with the highest return to the acquirer, whereas Panel C with insufficient due diligence contains the red area. Both Panel C and Panel D reconfirm the result with the highest acquirer return situated on the right margin and very close to but not on the bottom margin.

Implications of redeployability, synergy, and ambiguity for acquisition due diligence

Whereas Figures 1 and 2 illustrated the contexts where only one type of economies of scope, redeployability or synergy, was allowed by the model and was coupled with ambiguity; Figure 3 generalizes the acquisition deal to the context where redeployability and synergy are present simultaneously but may not be perfectly co-determined with each other. The following three results summarize the most robust patterns in Figure 3. First, ambiguity tend to call for more research effort, as seen the expansion of the red area from Panel A through Panel B to Panel C. Second, the net return to the acquirer that results from the optimal due diligence effort is suppressed by ambiguity as evident in the reduction of the red segment from Panel C through Panel B to Panel A. Third, the optimal due diligence effort has an inverse U-shaped relationship with redeployability, especially when ambiguity about economies of scope is higher. Finally, the net return to the acquirer that results from the optimal due diligence has an inverse U-shaped relationship with redeployability, especially when ambiguity about economies of scope is lower.

Insert Figure 3 here

Scenario 2: Combined operationalization of relatedness with redeployability and synergy, but separate operationalization of ambiguity

Although existing theoretical and empirical studies have not managed to carefully justify the conjecture that redeployability and synergy are strongly positively related to each other, the present study considers the possibility that relatedness is a single construct that involves both considerations. In Figure 4, the marginal redeployment cost S and the sharing factor β are set to be perfectly negatively codetermined and are, therefore, aggregated in a single construct of relatedness; ambiguity σ_M is kept separate from relatedness in this experiment.

Insert Figure 4 here

The topography of Panel A of Figure 4 turns out to be quite complex. In most of Panel A, the trend for the due diligence effort in the direction of increasing relatedness changes from the rise to the decline, and then from the decline to the rise. That switching back and force in the effect of relatedness on due diligence takes place because, even though relatedness is artificially forced to be a single construct in this experiment, it still features differently in scope economies from redeployability and from synergy. As a result, in some domains of relatedness its role as the marginal redeployment cost dominates its role as the sharing factor, whereas in other domains the role of the sharing factor takes over the role of the redeployment cost. Meanwhile, two robust observations in Panel A are (a) that highest ambiguity calls for a highest due diligence effort (like in Panel A of Figure 2), and (b) that the highest due diligence effort corresponds to intermediate levels of relatedness (like in Panel A of Figure 1).

Relationships in Panel B of Figure 4 are more 'well-behaved.' Thus, the net return that accrues to the acquirer has inverse U-shaped relationships with both ambiguity (like in Panels B of Figures 1 and 2) and relatedness (like in Panel B of Figure 1).

Scenario 3: Combined operationalization of relatedness with redeployability, synergy, and ambiguity

The final experiment is designed to consider the possibility that strong relatedness between two businesses motivates frequent cases of redeployment and sharing of resources between those businesses. The experiment implements that possibility by making relatedness simultaneously (a) perfectly negatively affect the marginal redeployment cost, (b) perfectly positively affect the sharing factor, and (c) perfectly negatively affect ambiguity faced by a representative buyer. Panel A of Figure 5 demonstrates that, if the specified strong co-determination of relatedness and ambiguity were true, the optimal due diligence effort would have an inverse U-shaped relationship with the aggregated exhaustive construct of relatedness. The changes in the magnitude of the negative effect of relatedness in the downward-sloping part of the line in Panel A can be again attributed to the switching of the role of relatedness in the different parts of its domain. The main takeaway from Panel A of Figure 5 is that neither the lowest nor the highest levels of the aggregated relatedness require the highest due diligence effort; such high effort is demanded when the aggregate relatedness is low-to-medium.

Insert Figure 5 here

Panel B reveals that, if the strong co-determination of relatedness and ambiguity held, the net return to the acquirer would also have an inverse U-shaped relationship with the aggregated relatedness. That result suggests that neither the lowest nor the highest levels of the aggregated relatedness lead to the highest net returns to the acquirer; the highest net return occurs when the aggregate relatedness is medium-to-high.

The most robust results presented in the current section are summarized in Table 1 in the form of hypotheses for the two considered outcomes: the optimal due diligence effort and the resulting net return to the acquirer. Reflecting the three scenarios presented in the current section, the hypotheses are clustered into three groups. Also, the first eight hypotheses in Scenario 1 are developed for the cases where one type of economies of scope is absent in order to make clean predictions for the likely situation where the acquirer seeks only one type of economies.

Insert Table 1 here

DISCUSSION

The idea that corporate acquirers cannot be too diligent in assessing the decision to buy another firm has been prevalent among acquisition consultants, market analysts, and scholars. Extensive due diligence has been advertised in cases that teach students of business administration how exemplar corporate acquirers withdraw numerous key employees from own functional areas, send those employees to acquired companies, engage own top executives in the evaluation process, and apply multiple valuation techniques. Business gurus regularly advise corporate acquirers to be very skeptical about the target's asking price and to be ready to cancel the deal if that price exceeds the value diagnosed in extensive due diligence. Acquirers are also regularly reminded that many acquisitions do not deliver the expected value, specifically due to the lack of proper due diligence. In accord with this advice, hundreds of research articles published in top management journals appear to support the conventional wisdom that acquirers should always be very diligent. One consideration that has been often named as a peril of inferior due diligence is insufficient understanding of economies of scope (casually named 'synergy') by acquirers.

This study challenges these assumptions and received wisdom in scholarship and practice by developing a more-nuanced view of due diligence in corporate acquisitions. Whereas the careful assessment of a target's value could protect an acquirer from the adverse selection problem, due diligence is an expensive commitment of resources of the acquirer's management. To restore the balance in considerations of due diligence, this study places due diligence in the specific context of the economies of scope that are inherent in an acquisition but that may also be compromised by the incomplete information regarding the target's value. Following precedents in the literature on economies of scope, this study uses a formal model to build a theory of acquisition due diligence. The model predicts both an acquirer's optimal due diligence effort and the net return to that acquirers based on the most popular determinant of economies of scope—relatedness between the merged businesses, and on the key determinant of incomplete information in acquisitions—ambiguity about economies of scope aimed in the acquisition.

The results that are derived with the model demonstrate that an acquirer should not apply the most extensive, or another uniform, level of due diligence to all deals. The seventeen hypotheses that are derived from the formal models express the optimal due diligence and the net return to the acquirer as functions of parameters that characterize the acquisition context based on the key considerations raised in previous research. The developed hypotheses can be tested in future empirical research on corporate acquisitions. The predictions may also guide corporate acquirers on the optimal allocation of their research effort in acquisition deals.

An additional implication of the offered theory is that it elaborates upon how resource relatedness, the chief determinants of economies of scope, affects value realized in corporate acquisitions when information about such economies is incomplete. The presence of ambiguity about economies of scope substantially revises the well-known relationship with which relatedness was argued conceptually and shown empirically to enhance value realized in multi-business firms. When ambiguity is present and due diligence is considered a costly commitment, an intermediate rather than the highest level of relatedness involved in redeployment of resources between the merged businesses is shown to lead to the highest net return that the acquirer.

The final ramification of the offered theory involves the strategic use of incomplete information, with which the quality of information about the target is managed by an acquirer rather than is taken as given. In contrast to the prevalent view that is based on avoidance of deals involving targets that are difficult to evaluate, this study demonstrates that some ambiguity about economies of scope between the merged businesses is the necessary condition to make the deal profitable to an acquirer. In the absence of such ambiguity, even very high economies of scope alone cannot justify the deal and would not lead to returns to an acquirer. The developed formal model indicates that, with either type of economies of scope—synergy or redeployability, an intermediate rather than the lowest or the highest level of ambiguity about such economies leads to the highest net return to the acquirer.

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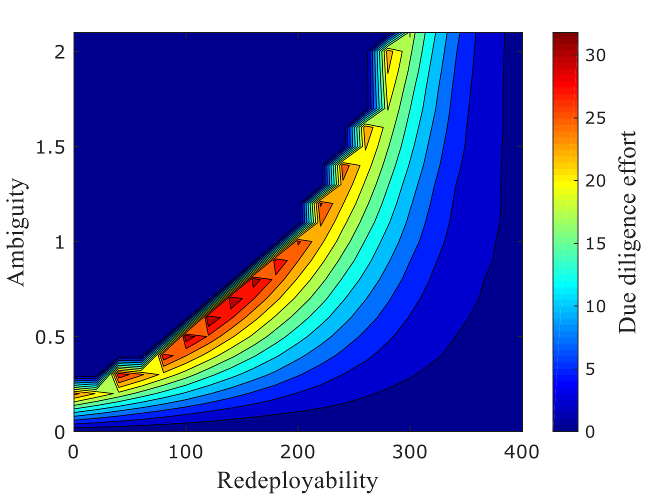
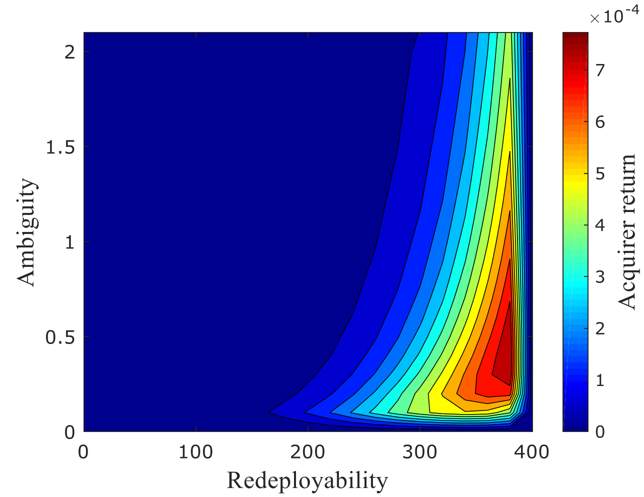
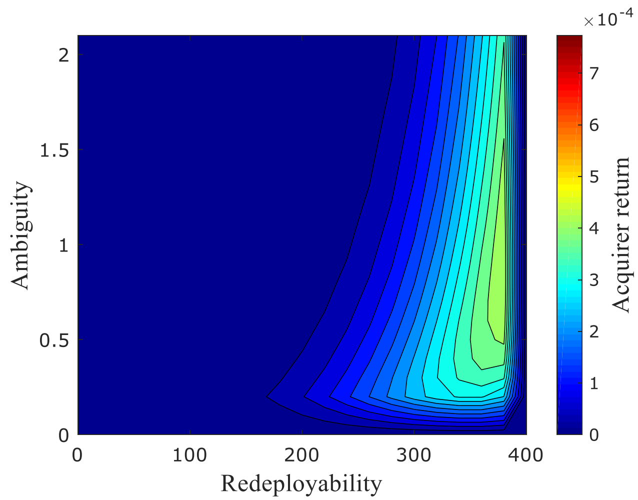


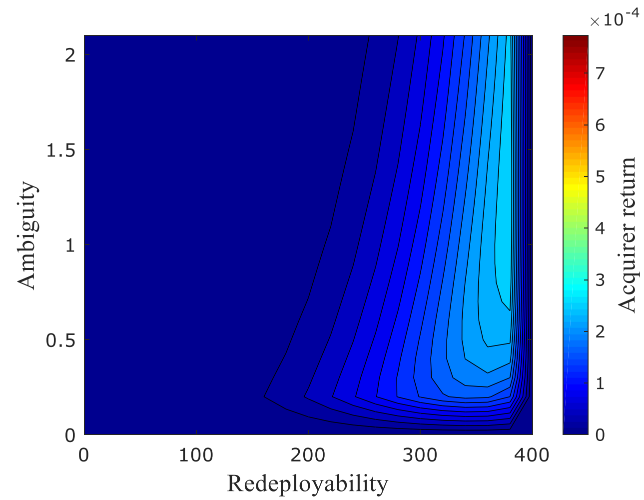
Panel A. Optimal due diligence effort



Panel B. Acquirer return with optimal due diligence effort

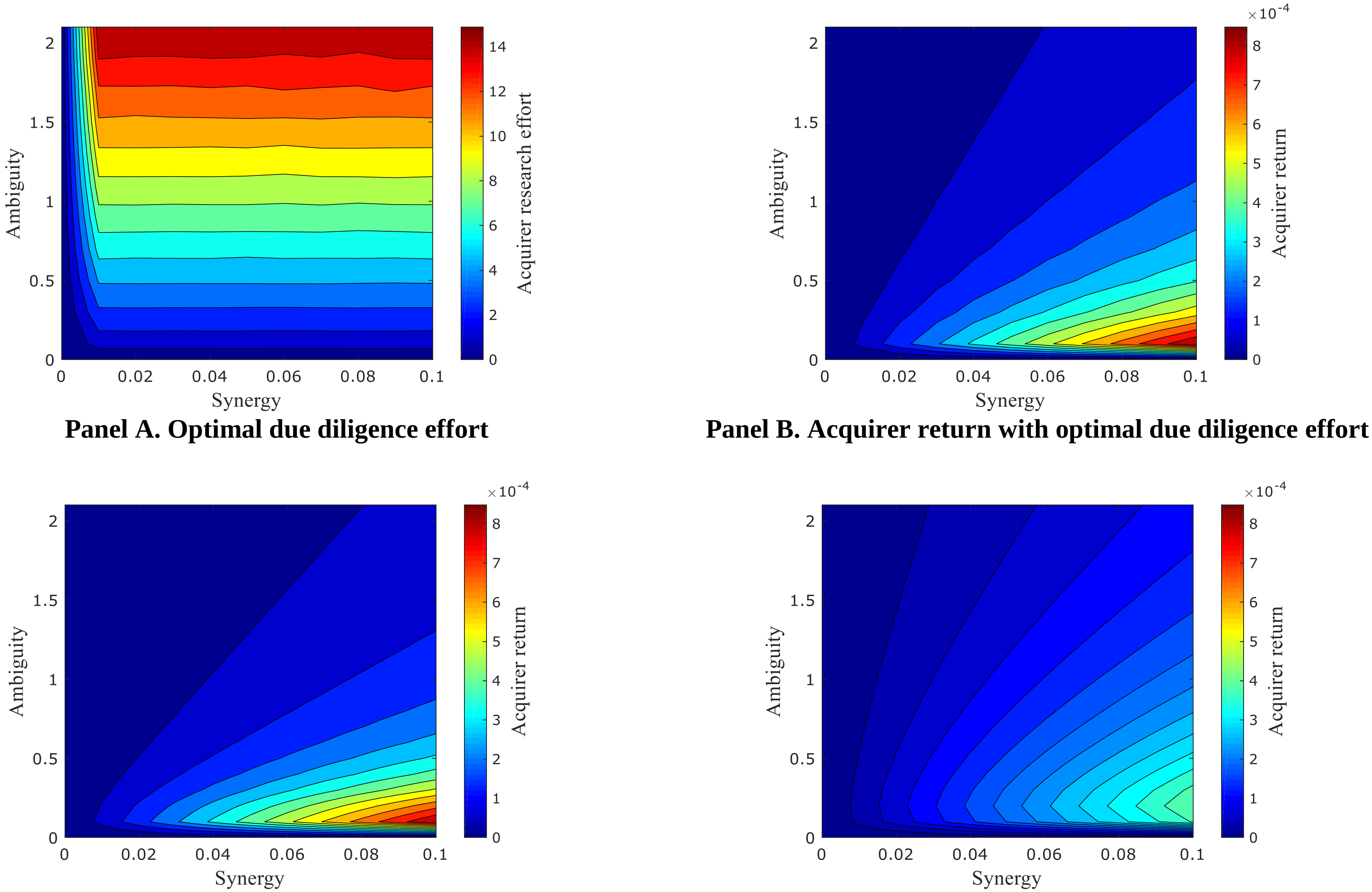


Panel C. Acquirer return with insufficient due diligence effort



Panel D. Acquirer return with excessive due diligence effort

Figure 1. Implications of redeployability and ambiguity for due diligence effort and acquirer return



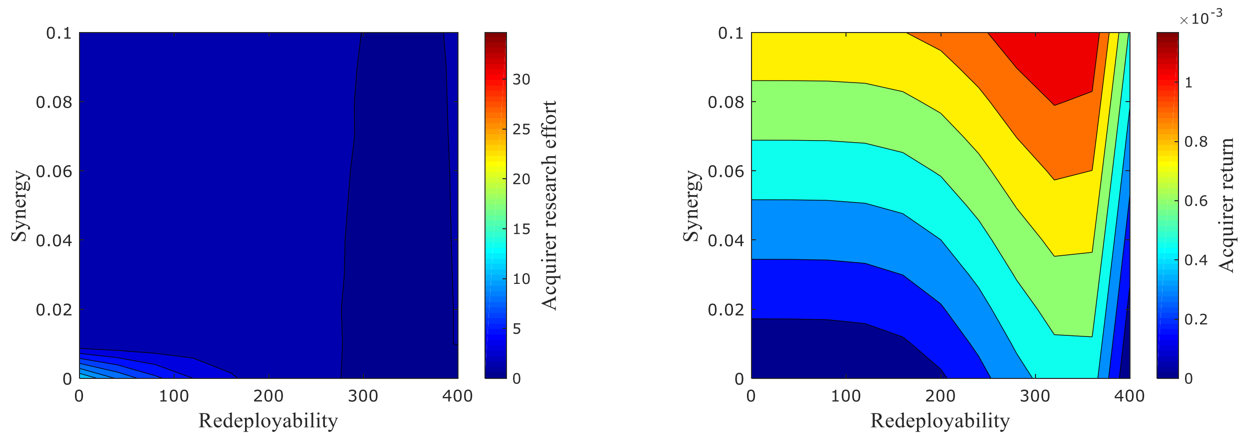
Panel A. Optimal due diligence effort

Panel B. Acquirer return with optimal due diligence effort

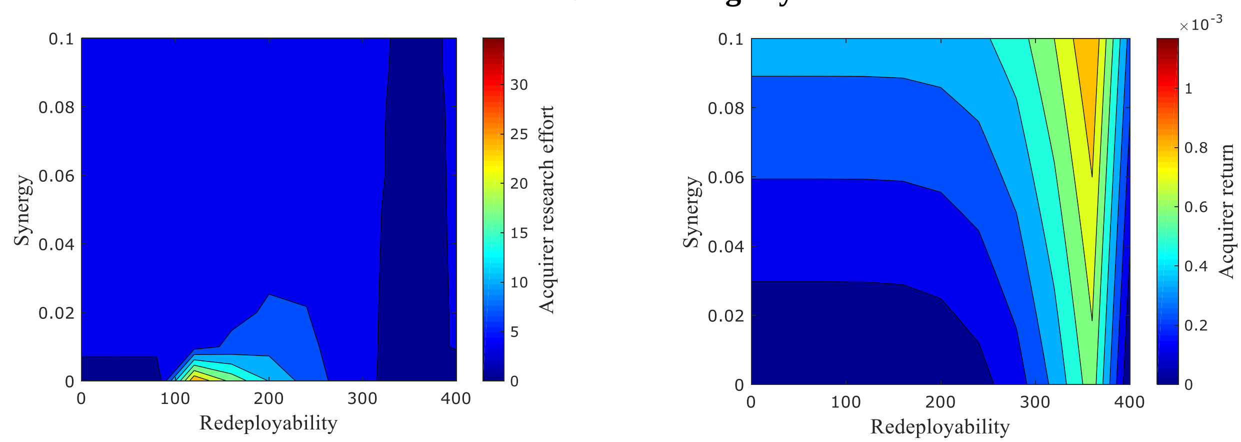
Panel C. Acquirer return with insufficient due diligence effort

Panel D. Acquirer return with excessive due diligence effort

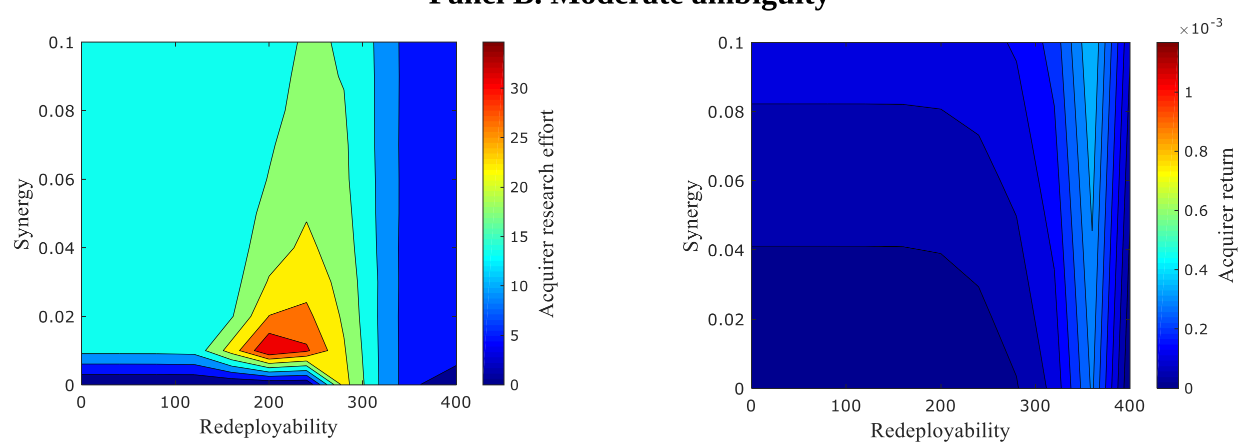
Figure 2. Implications of synergy and ambiguity for due diligence effort and acquirer return



Panel A. Low ambiguity

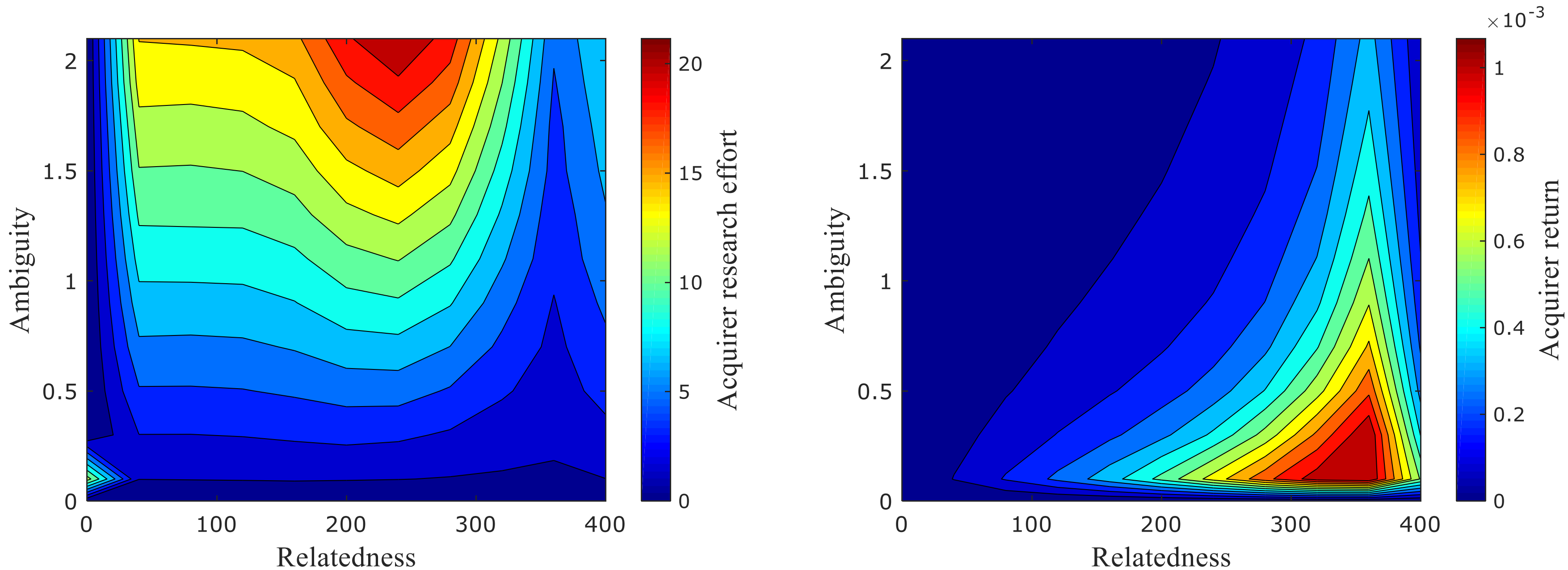


Panel B. Moderate ambiguity



Panel C. High ambiguity

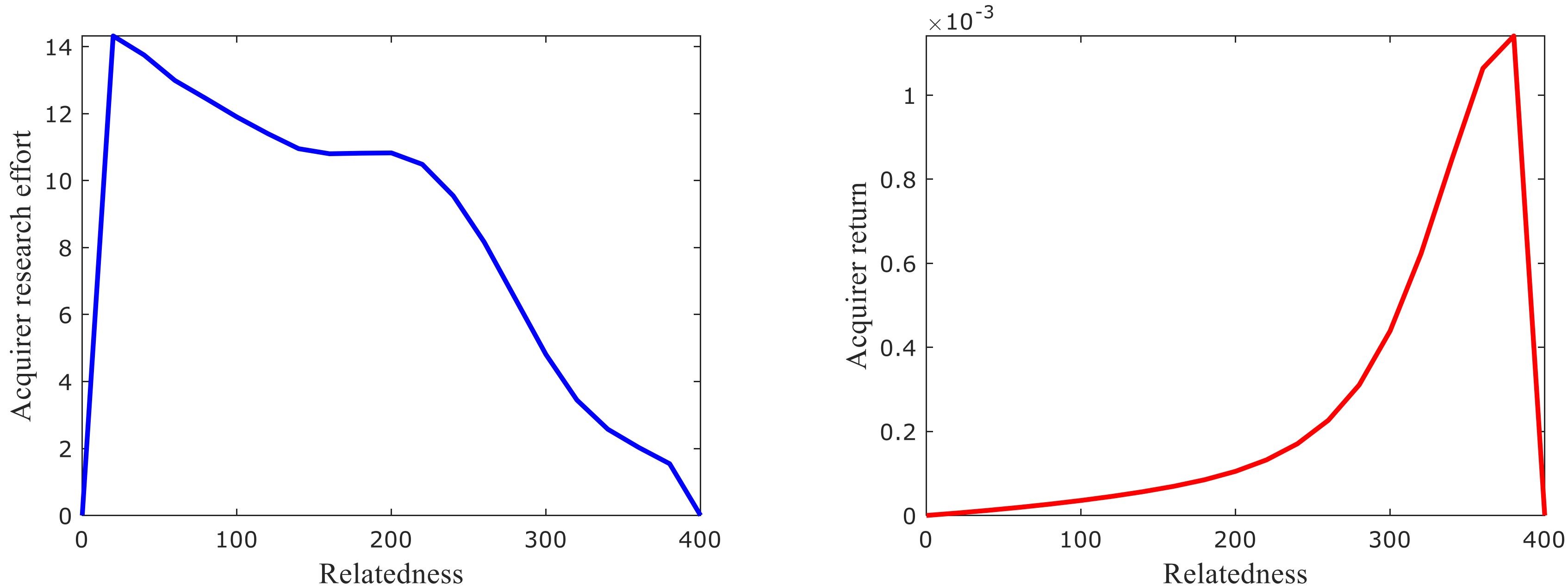
Figure 3. Implications of redeployability, synergy, and ambiguity for due diligence effort and acquirer return



Panel A. Optimal due diligence effort

Panel B. Acquirer return with optimal due diligence effort

Figure 4. Implications of relatedness (redeployability and synergy) and ambiguity for due diligence effort and acquirer return



Panel A. Optimal due diligence effort **Panel B. Acquirer return with optimal due diligence effort**

Figure 5. Implications of relatedness (redeployability, synergy, and ambiguity) for due diligence effort and acquirer return

Table 1. Summary of theoretical predictions

Assumptions about relationships among predictors	Focal predictor	Presence of another type of economies of scope	Predicted outcome	
			Optimal due diligence effort	Net return to the acquirer
Scenario 1: Redeployability, synergy, and ambiguity are not perfectly co-determined with each other	Relatedness as redeployability	Intra-temporal economies of scope based on resource sharing are absent	H1: an inverse U-shaped relationship	H2: an inverse U-shaped relationship
	Ambiguity	Intra-temporal economies of scope based on resource sharing are absent	H3: an inverse U-shaped relationship	H4: an inverse U-shaped relationship
	Relatedness as synergy	Inter-temporal economies of scope based on resource redeployment are absent	H5: zero when synergy is zero and positive but invariant to synergy otherwise	H6: a monotonic positive relationship
	Ambiguity	Inter-temporal economies of scope based on resource redeployment are absent	H7: a monotonic positive relationship	H8: an inverse U-shaped relationship
	Relatedness as redeployability		H9: an inverse U-shaped relationship	H10: an inverse U-shaped relationship
	Ambiguity		H11: a monotonic positive relationship	H12: a monotonic negative relationship
Scenario 2: Redeployability and synergy are perfectly co-determined with each other, but are not perfectly co-determined with	Relatedness as redeployability and synergy			H13: an inverse U-shaped relationship
	Ambiguity		H14: a monotonic positive relationship	H15: an inverse U-shaped relationship
Scenario3: Redeployability, synergy, and ambiguity are perfectly co-determined with each other	Relatedness as redeployability, synergy, and ambiguity		H16: an inverse U-shaped relationship	H17: an inverse U-shaped relationship

APPENDIX S1: NUMERICAL VALUATION

To implement numerical estimations of the target's market value V_0^M and of the target's value as seen by the diligent acquirer V_0^D, the continuous-time geometric Brownian processes for margins C_{it} and C_{jt} specified with Equations 1–3 are approximated with the discrete-time binomial lattice, where the next-period margins $C_{it+\partial t}$ and $C_{jt+\partial t}$ take one of four states: $C_{it+\partial t}^u$ and $C_{jt+\partial t}^u$ with probability q^{uu}, $C_{it+\partial t}^u$ and $C_{jt+\partial t}^d$ with probability q^{ud}; $C_{it+\partial t}^d$ and $C_{jt+\partial t}^u$ with probability q^{du}; or $C_{it+\partial t}^d$ and $C_{jt+\partial t}^d$ with probability q^{dd} (Boyle, Evnine, and Gibbs, 1989). With N time discretization steps each of the length $\partial t = T/N$, values of the margins in the immediate next time are assessed as follows:

$$C_{it+\partial t}^u = u_i C_{it} \qquad \text{(S1.1)}$$
$$C_{it+\partial t}^d = d_i C_{it} \qquad \text{(S1.2)}$$
$$C_{jt+\partial t}^u = u_j C_{jt} \qquad \text{(S1.3)}$$
$$C_{jt+\partial t}^d = d_j C_{jt}, \qquad \text{(S1.4)}$$

where

$$u_i = e^{\sigma_i \sqrt{\partial t}} \qquad \text{(S1.5)}$$
$$d_i = 1/u_i \qquad \text{(S1.6)}$$
$$u_j = e^{\sigma_j \sqrt{\partial t}} \qquad \text{(S1.7)}$$
$$d_j = 1/u_j\,. \qquad \text{(S1.8)}$$

Transition probabilities on the binomial lattice for the margins are calculated as follows[1]:

$$q^{uu} = \frac{1}{4}\left[1 + \sqrt{\partial t}\left(\frac{r - \frac{1}{2}\sigma_i^2}{\sigma_i} + \frac{r - \frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right] \qquad \text{(S1.9)}$$

$$q^{ud} = \frac{1}{4}\left[1 + \sqrt{\partial t}\left(\frac{r - \frac{1}{2}\sigma_i^2}{\sigma_i} - \frac{r - \frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right] \qquad \text{(S1.10)}$$

$$q^{du} = \frac{1}{4}\left[1 + \sqrt{\partial t}\left(-\frac{r - \frac{1}{2}\sigma_i^2}{\sigma_i} + \frac{r - \frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right] \qquad \text{(S1.11)}$$

[1] To avoid the general limitation of Boyle *et al*. (1989), all transition probabilities are checked to be non-negative.

$$q^{dd} = \frac{1}{4}\left[1+\sqrt{\partial t}\left(-\frac{r-\frac{1}{2}\sigma_i^2}{\sigma_i}-\frac{r-\frac{1}{2}\sigma_j^2}{\sigma_j}\right)\right]. \quad \text{(S1.12)}$$

Similarly, the immediate-next-time values of the marginal redeployment cost and of the sharing factor as seen by a representative buyer are assessed as follows:

$$S_{t+\partial t}^{uM} = u_M S_t^M \quad \text{(S1.13)}$$
$$S_{t+\partial t}^{dM} = d_M S_t^M \quad \text{(S1.14)}$$
$$\beta_{t+\partial t}^{uM} = u_M \beta_t^M \quad \text{(S1.15)}$$
$$\beta_{t+\partial t}^{dM} = d_M \beta_t^M , \quad \text{(S1.16)}$$

where

$$u_M = e^{\sigma_M \sqrt{\partial t}} \quad \text{(S1.17)}$$
$$d_M = 1/u_M . \quad \text{(S1.18)}$$

Likewise, the immediate-next-time values of the marginal redeployment cost and of the sharing factor as seen by the diligent acquirer are assessed as follows:

$$S_{t+\partial t}^{uD} = u_D S_t^D \quad \text{(S1.19)}$$
$$S_{t+\partial t}^{dD} = d_D S_t^D \quad \text{(S1.20)}$$
$$\beta_{t+\partial t}^{uD} = u_M \beta_t^D \quad \text{(S1.21)}$$
$$\beta_{t+\partial t}^{dD} = d_M \beta_t^D , \quad \text{(S1.22)}$$

where

$$u_D = e^{\sigma_D \sqrt{\partial t}} \quad \text{(S1.23)}$$
$$d_D = 1/u_D . \quad \text{(S1.24)}$$

The method based on the 'maxmin' principle of Gilboa and Schmeidler (1989) does not require the knowledge of the transition probabilities for S_t^M , β_t^M , S_t^D , or β_t^D .

Then, the principle of dynamic optimality (Bellman, 1957) is used to compute the target's market valuation V_t^M and the targets value as seen by the diligent acquirer V_t^D at time t under the known probability distribution:

$$V_t^{xyM} = \max_{\omega_{it}^{xy}}\{F_t^{xyM}(\omega_{it}^{xy}) + e^{-r\partial t}[q^{uu}V_{t+\partial t}^{uuM}\left|\omega_{it}^{xy*}\right. + q^{ud}V_{t+\partial t}^{udM}\left|\omega_{it}^{xy*}\right. + q^{du}V_{t+\partial t}^{duM}\left|\omega_{it}^{xy*}\right. + q^{dd}V_{t+\partial t}^{ddM}\left|\omega_{it}^{xy*}\right.]\}, \quad \text{(S1.25)}$$

$$V_t^{xyD} = \max_{\omega_{it}^{xy}}\{F_t^{xyD}(\omega_{it}^{xy}) + e^{-r\partial t}[q^{uu}V_{t+\partial t}^{uuD}\left|\omega_{it}^{xy*}\right. + q^{ud}V_{t+\partial t}^{udD}\left|\omega_{it}^{xy*}\right. + q^{du}V_{t+\partial t}^{duD}\left|\omega_{it}^{xy*}\right. + q^{dd}V_{t+\partial t}^{ddD}\left|\omega_{it}^{xy*}\right.]\}. \quad \text{(S1.26)}$$

In Equation S1.25, $V_{t+\partial t}^{uuM}\left|\omega_{it}^{xy*}\right.$, $V_{t+\partial t}^{udM}\left|\omega_{it}^{xy*}\right.$, $V_{t+\partial t}^{duM}\left|\omega_{it}^{xy*}\right.$, and $V_{t+\partial t}^{ddM}\left|\omega_{it}^{xy*}\right.$ capture four possible realizations of the target's market value (corresponding to the four possible realizations of C_{it+1} and C_{jt+1} on the lattice) at the immediate next time $t+\partial t$ that are conditioned on a selected current choice, ω_{it}^{xy*} and are weighted by their respective probabilities. In Equation S1.26, $V_{t+\partial t}^{uuD}\left|\omega_{it}^{xy*}\right.$, $V_{t+\partial t}^{udD}\left|\omega_{it}^{xy*}\right.$, $V_{t+\partial t}^{duD}\left|\omega_{it}^{xy*}\right.$, and $V_{t+\partial t}^{ddD}\left|\omega_{it}^{xy*}\right.$ capture four possible realizations of the immediate-next-time target's value as seen by the diligent acquirer that are conditioned on a selected current choice, ω_{it}^{xy*} and are weighted by their respective probabilities. (Optimal current choices ω_{it}^{xy*} can differ between Equations S1.25 and S1.26.) Wherever superscript M is combined with subscript t for $F(\bullet)$ (or with subscript $t+1$ for $V(\bullet)$) in Equation S1.25, the lowest possible value of β_t^M (or β_{t+1}^M) and the highest possible value of S_t^M (or S_{t+1}^M) on their respective lattice at time t (or $t+1$) should be used to reflect the worst-case scenario as per Gilboa and Schmeidler (1989). Likewise, wherever superscript M is combined with subscript t for $F(\bullet)$ (or with subscript $t+1$ for $V(\bullet)$) in Equation S1.26, the lowest possible value of β_t^D (or β_{t+1}^D) and the highest possible value of S_t^D (or S_{t+1}^D) on their respective lattice at time t (or $t+1$) should be used to reflect the worst-case scenario as per Gilboa and Schmeidler (1989). To derive present values V_0^M and V_0^D, calculation starts at time $t=T-\partial t$ with the terminal conditions $V_T^M=0$ and $V_T^D=0$, and proceeds recursively backward in time until it reaches the present time $t=0$.

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