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Earnouts: The real value of disagreement in mergers and acquisitions

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Abstract

Earnout agreements link part of the payment for an acquired company to its future performance. Despite their option-like features, they cannot be valued using vanilla option-pricing methods. Two peculiar sources of risk affect these contracts: Bidder default before the earnout expiration (default risk) and potential litigation associated with earnouts (litigation risk). We developed an option-pricing model that encompasses these sources of risk, showing that counterparty and litigation risk can have a remarkable impact on earnout values. Our model's relevance is further enhanced by recent accounting standards that require contingent payments to be valued at fair value.

KEYWORDS

default, default risk, earnout, litigation, M&A, real options

JEL CLASSIFICATION

G12, G13, G33, G34, K41

1 | INTRODUCTION

The number of mergers and acquisitions (M&As) that include earnouts, that is, clauses that link part of the payment to the target's performances after the deal closing, has mushroomed in recent years. Though seminal papers on this topic showed that these clauses were included only

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in 4% of deals during the 1990s (Datar et al., 2001; Kohers & Ang, 2000), the most recent papers underscore that earnouts are now incorporated into more than 15% of acquisitions (Allee & Wangerin, 2018; Bates et al., 2018). The economic uncertainty originated by the COVID outbreak will most likely mean earnouts will be used even more frequently than before (Franklin, 2020a, 2020b). The increasing relevance of earnouts in M&As was accompanied by a growing academic interest in the topic. Earnouts were studied with respect to their rationale, whether it be to reduce information asymmetry (Choi, 2017; Datar et al., 2001; Kohers & Ang, 2000) or contribute to deal financing (Bates et al., 2018); their positive effect on bidder announcement returns (Barbopoulos, Danbolt, et al., 2018; Barbopoulos, Paudyal, et al., 2018; Barbopoulos & Sudarsanam, 2012; Kohers & Ang, 2000; Kohli & Mann, 2013); and the optimal proportion of earnout payment with respect to the total consideration Lukas et al. (2012).

One highly pertinent question, however, still remains unresolved: How should these contracts be valued? As an earnout is part of the total payment, an accurate valuation of the former is necessary to price the deal correctly. This is salient from an academic point of view because it contributes to the literature that tries to explain the relative importance of earnouts with respect to total payment (Allee & Wangerin, 2018; Cadman et al., 2014; Cain et al., 2011). More generally speaking, the broader literature on M&As could benefit as well: The deal value, expressed as the total deal payment, or the premium paid in an acquisition, are frequently the pivotal point of the analysis (Barbopoulos & Adra, 2016; de la Bruslerie, 2013; Nathan & O'Keefe 1989; Wu & Chung, 2019). The question is also salient from the standpoint of the parties involved in a deal that includes an earnout because to make informed decisions, they need to know the value of the consideration paid and received. Our paper aims to tackle this question by providing a valuation framework for earnouts.

Earnouts are often structured as real options on a predetermined measure related to the profitability of the acquired company (e.g., EBITDA or revenues) or to the achievement of certain targets or milestones (e.g., successful completion of specified contracts, or attaining preset key events like passing Food and Drug Administration (FDA) trials in the pharmaceutical business).[1] If the performance measure is realized beyond the given threshold, or if the agreed milestones are achieved, additional payments are made to the former shareholders of the target entity. Given the option-like features of earnouts, option-pricing techniques are called for to value these contracts. Arzac (2004), Bruner (2001), Bruner & Perella (2004) and Caselli et al. (2006) claim that earnouts should be valued as ordinary (nondefaultable) European calls. However, the characteristics of earnout clauses and the context in which they are used, make this equivalence less than perfect.

Differently from most real options studied in the field of corporate finance, earnouts are affected by two peculiar sources of risk that could influence their final payoff: Default risk and litigation/measurement risks. Default risk concerns the fact that earnouts will be honoured only if, and up to the point in which, the bidder is still a going concern when the earnout payment is due (i.e., it has not defaulted). Earnouts are options that expire up to several years after the moment in which they are written, that is, at deal closing.[2] Moreover, on average, bidders that use earnouts are smaller than those that do not (Bates et al., 2018; Kohers & Ang, 2000). For this reason, the risk of default of the bidder might not be negligible.

[1]Cain et al. (2011) show that, out of a sample of 498 earnouts, 86% are based on accounting measures, 12.2% are structured on nonfinancial milestones, 1.2% are linked to stock prices and 0.6% to other parameters.

[2]Cain et al. (2011) show that the average horizon is 2.57 years and that it can be as long as 20 years.

Instead, litigation/measurement risk arises because, after the deal closing, the former shareholders of the target relinquish control of their company to the bidder. Thus, the bidder is in charge of measuring the performance of the target company. As the performance measures used in designing earnout agreements are mainly accounting figures, there is always a certain degree of risk related to earnings management (Ball & Shivakumar, 2008; Erickson & Wang, 1999; Lennox et al., 2018). This does not necessarily imply an opportunistic intent of the bidder, as subjectivity and flexibility are natural characteristics of accounting figures[3] (Nelson et al., 2002; Parfet, 2000). Litigation risk might also arise in relation to the fact that it might not be feasible for the seller to monitor whether the bidder exerted its best effort to realize the conditions that trigger the earnout payment.[4] As a consequence, the seller might not believe that the target company's realized performance, as reported by the bidder, was indeed properly measured, or that the bidder acted in good faith in developing the business of the target company. For these reasons, the seller might seek the protection of the courts and take legal action[5]. Thus, the value of an earnout will also be influenced by the expected outcome of a potential litigation. This issue is quite material; clauses that link the payment of an acquisition to accounting variables are likely to originate litigation. Özdem and İnce (2019) indeed claim that disputes related to purchase price adjustments tend to arise quite frequently in M & As. Furthermore, a survey performed by Grant Thornton (2019) showed that, alongside completion accounts, earnouts are the most disputed area of M&As. In light of the above, we aim to provide a valuation model that is able to properly consider the payoff structure of earnouts and the peculiar sources of risk that affect these clauses.

We provide, as examples, brief descriptions of two acquisitions that highlight the relevance of our model. The first involves First Wind Holdings LLC, a leading wind development and asset management platform, acquired by SunEdison Inc, one of the world's largest renewable energy developers. The deal, closed in 2015 with an upfront payment of around $1 billion, included an earnout based on the development of First Wind's business, providing for a contingent consideration of $510 million. Then, SunEdison faced bankruptcy in April 2016 and, in the same month, filed for Chapter 11. Approximately half of the earnout was unpaid at that date. The second example is the 2011 Sanofi-Genzyme acquisition. Genzyme, the target in this case, is a biotech company that developed a promising multiple sclerosis drug called Lemtrada; Sanofi is one of the largest pharmaceutical companies worldwide. In addition to $20.1 billion upfront, the deal included an earnout based on the marketability of Lemtrada which could have generated additional payments of $3.8 billion, or $14 per share acquired. The earnout was securitized and traded on the NASDAQ.[6] On the basis of its expected cash flows, the earnout

[3]It is possible that the earnout contract allows the former owner/manager of the target company to remain in charge of managing the company after the closing. In this case, the seller could have a better chance to prevent the misbehaviour of the bidder, who might find it impossible to manipulate accounts. However, litigation on measuring target company performances often arises in connection with the specification of the accounting items that should be included when computing the performance measure (see e.g., Hodges vs. Medassets Net Revenue Systems, LLC, 2008, WL476140—N.D.Ga. 2008). In such a case, continued involvement in the management of the target provides the seller no clear advantage.

[4]From the seller's perspective, assessing the performance of the target may be easier if the company remains a separate subsidiary with respect to the bidder. There is no clear evidence in the literature regarding the frequency of targets operating as separate subsidiaries. However, even when this is the case, the bidder is still likely to have a relevant influence on the managerial decisions, the resources available and the reporting behaviour of the target.

[5]Enlightening, in this sense, are the words of a judge who had to settle a dispute on the payments related to an earnout: 'An earnout often converts today's disagreement over price into tomorrow's litigation over outcome'. Judge Trevis Laster, Airborne Health, Inc. and Weil, Gotshal & Manges LLP vs. Squid Soap, LP, C.A. No. 4410-VCL (Del. Ch. Nov. 23, 2009). Airborne acquired Squid Soap in 2007, paying $1 million upfront and including an earnout capped at $26.5 million. This case will be discussed in Section 7.2.2 of the paper.

[6]Earnouts that are securitized are also called contingent value rights (CVRs). The security started trading on the NASDAQ on 4 April 2011. The ISIN of the security is US80105N1138.

was valued at $5.58 by the deal advisors,[7] and around $4 by other analysts,[8] yet the initial trading price was $2.35. There was a real risk of legal disputes over Sanofi implementing its pledge to make 'diligent efforts' to develop Lemtrada and this was clearly acknowledged in the press.[9] In fact, in subsequent years, this risk actually materialized and the drug failed to reach its marketing targets. This led the former shareholders of Genzyme to file a lawsuit against Sanofi. Despite the fact that the contingent payments were forfeited due to the poor performances of the drug, the quoted value of the earnout did not drop to zero. Instead, it reflected the expected outcome of the litigation. When, on 13 October 2019, Sanofi signed a settlement agreement that resulted in a $0.88 payment for each earnout traded in the market, the market price of the security aligned with that value. Vanilla option-pricing models would not have been able to price the earnouts in these examples, which is precisely why we propose a new model that can encompass the peculiarities of these clauses.

Our paper provides an appropriate valuation model for earnouts that explicitly takes into consideration default risk and litigation risk. The model we propose takes the pricing of plain vanilla European calls as a baseline (Arzac, 2004; Bruner, 2001; Bruner & Perella, 2004; Caselli et al., 2006). We enrich this framework to capture the remaining sources of uncertainty associated with these contracts. We include default risk in the framework by explicitly modelling the possibility of the bidder going bankrupt (Klein, 1996; Klein & Inglis, 2001), which would make it impossible to pay in full the liability arising from the earnout. To do so, we model the joint dynamics of the assets and liabilities of the bidder and the performance measure of the target via correlated geometric Brownian motions. As there is a positive relation between managing earnings and being sued (Ibrahim et al., 2011), to include litigation risk we explicitly model the sellers' choice of either (1) accepting the bidder's payment based on the reported target performance or (2) taking legal steps based on the belief that the reported performance is the result of earnings management or inadequate effort by the bidder. The payoff following the second choice depends on the judge's decision, with a number of implications in terms of uncertainty and legal costs. The sellers would decide to go to court if they expect to gain more from the trial than from the bidder's initial offer. We show that the reduction in value that results when considering default and litigation risk can be material. The more the bidder is leveraged and the less the profitability of the bidder and the target are correlated, the higher the impact of the default risk on the value of the earnout. The easier it is for the bidder to manage earnings and in general to behave opportunistically, the more uncertain the outcome of the trial and the longer its duration in general, all adds up to greater the relevance of litigation risk. Similarly, higher direct costs of litigation, such as attorneys' fees, will reduce the value of earnouts.

Our model is a useful tool to quantify the consideration paid in M&As that incorporate earnouts. As the total payment includes the value of the earnout, this amount must be determined accurately to price the M&A deal correctly. As previously discussed, this is a key step to inform the literature on the determinants of means of payment and takeover premia in M&As. Moreover, our model is particularly timely because contingent considerations are used more frequently in times of uncertainty to hedge the risk of target misevaluation. The uncertainty caused by the Covid-19 outbreak enhances the usefulness of

[7]Advisors' valuation of the CVR. Source: Genzyme's form SC 14D9/A dated 7 March 2011 (page 42).

[8]See 'Investors place discount on Sanofi's offer' by Andrew Jack, Financial Times, 18 February 2011.

[9]See 'Investors place discount on Sanofi's offer' by Andrew Jack, Financial Times, 18 February 2011.

earnouts, as the future performance of acquired companies has become less predictable (Franklin, 2020a, 2020b). However, the same reason that makes earnouts more compelling to the bidder makes them less valuable to the sellers; in uncertain times, the likelihood of the bidder's bankruptcy is magnified. This paper helps deepen our understanding of the relation between the earnout payments and the bidder's default risk, quantifying its effect on the value of the earnout. By the same token, the financial difficulties arising from the pandemic might increase the incentive of the bidder to reduce the payments related to an earnout, thus making litigation more likely. Even setting aside bidders' opportunistic considerations, often unexpected events such as pandemics are not disciplined by earnout agreements, thus, the parties involved might end up in court to decide who is responsible for missing the additional payment triggers.

The model we propose is relevant also because the accounting standards on business combinations, that is, FASB ASC 805 in the United States and IFRS 3 in Europe, require contingent payments to be estimated on the acquisition date and recorded at fair value (Allee & Wangerin, 2018; Cadman et al., 2014).[10] Fair value is defined as the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants on the measurement date, based on the same assumptions that the market participants would use when pricing the asset or the liability in their economic best interest (FASB ASC 820 and IFRS 13). These standards add that, when measuring the fair value of a liability, an entity should take into account the effects of its default risk and any other factor that could influence the likelihood that the obligation will or will not be fulfilled.

Our analysis contributes to the literature on earnout valuation by providing a model that is a better fit for these contracts than the simplistic models currently used (Arzac, 2004; Bruner, 2001; Bruner & Perella, 2004; Caselli et al., 2006). Moreover, studying the effects of default and litigation risk on the value of earnouts can inform the growing body of empirical work on the use of these contracts. Empirical papers on earnouts report that their use is growing, but is still confined to a fraction of deals. The default and litigation risks associated with earnouts can help to explain this evidence and inform the literature mentioned. Moreover, the effect of these two sources of risk on the value of earnouts can provide additional explanations for the abnormal returns experienced by bidders in earnout deals.

From a more general perspective, default risk has been proven to play a key role in M&As. Acquisitions tend to increase the risk of default of the bidder (Bruyland et al., 2019; Furfine & Rosen, 2011), whose abnormal returns are influenced by its leverage (Murray et al., 2017). Our paper verifies that the return obtained by the seller, or its premium, can also be influenced by the default risk of the bidder: In M&As that include earnouts, the more the bidder is exposed to default risk, the lower the value of the consideration received by the sellers. Litigation risk, as we demonstrate with our model, lowers the value of the

[10]Our aim to provide a valuation model for earnouts also follows from the fact that there has been significant diversity in methods and lively debate among practitioners in search of the best practice to valuate these contracts. Though certain experts seem to recognize, to some extent, the need to consider default risk (e.g.: Thompson & Schnorbus, 2010), litigation risk has largely been ignored. Moreover, no clear guidance has been provided so far on how to estimate the fair value of earnout liabilities, by either academics or practitioners. Consequently, best practices on how to measure earnouts at fair value are yet to be developed. We inspected the annual reports of a sample of US companies that used earnouts in acquisitions in the period from 2009 to 2011, that is, after the implementation of the new standards. In 48% of cases, there is no information on how the fair value of earnout was estimated. Among those that provide such information, the large majority estimate the fair value through a very basic discounted cash flow (DCF) model (34% of cases) or a probability-weighted DCF model (57% of cases). Only a very small percentage (9%) employ more sophisticated models. Unfortunately, even in these cases, the financial reports do not clearly indicate how the parameters used in the models were defined. It is, therefore, impossible to know whether and to what extent the companies took into consideration counterparty and litigation/measurement risk. Partially similar results were found by examining European companies applying IFRS 3(R). In this case, 82% of acquirers do not specify the model utilized to estimate the fair value of earnouts. Only 4% used a DCF model, whereas only 16% declare that they use option models or other models for the valuation.

consideration paid as well. This result contributes to the literature studying the effect of this second source of risk on M&A activity (Abbott et al., 2017; Chung et al., 2020; Maux & Francoeur, 2014).

Lastly, our paper contributes more generally to the literature on vulnerable options, which focuses on the valuation of options for which the payment of the final payoff is uncertain (e.g., Hull & White, 1995; Jarrow & Turnbull, 1995; Johnson & Stulz, 1987; Klein, 1996; Klein & Inglis, 2001). The main source of uncertainty considered in this stream of literature is default risk. We argue that the source of uncertainty in the payoff of real options can also arise from the risk of litigation and we propose a method to model the effect of this source of risk in the pricing of real options. Our paper, to the best of our knowledge, is the first to model the different seniority of the liabilities of the writer of a vulnerable option (in our case, the bidder) within the framework of M&As. Moreover, we are also the first to explicitly include the mechanics of the litigation process that arise if there is room for a moral hazard on the side of the writer of an option (e.g., incentive to manipulate reports on the realized value of the underlying) and information asymmetry on the side of the holder of the option (imperfect verifiability of the realized value of the underlying). Thus, our work provides a meaningful contribution to the real options literature as well.

The remainder of the paper is organized as follows. Section 2 reviews the literature on the questions. Section 3 briefly describes the structure of earnouts. Section 4 presents the model. Sections 5 and 6 offer two case studies and Section 7 provides evidence of the relevance of our model. Section 8 concludes the paper.

2 | LITERATURE ON EARNOUTS

Seminal papers on earnouts (Datar et al., 2001; Kohers & Ang, 2000; Ragozzino & Reuer, 2009) found that such contracts are generally used in transactions where substantial uncertainties exist about the future performance of the acquired entity, or in general about its intrinsic value. By linking part of the payment to the performance of the target following the closing of the deal, earnouts allow for an ex-post verification of the target's value, thus limiting information asymmetry issues (see also Jansen, 2020). Indeed, the authors documented that these contracts are mainly applied in the acquisition of private companies and subsidiaries, for which no market price is available to shed light on their value; in cross-industry acquisitions, where the bidder may lack sufficient expertise on the target's business and, thus, the risk of an over-payment is higher; in the acquisition of startups and in general firms with sizeable growth opportunities, or firms with large amounts of intangible assets, all cases where the uncertainties in the target's future prospects are particularly severe. Kohers and Ang (2000) and Datar et al. (2001) verified that earnouts are used more frequently in the acquisition of high-tech or pharmaceutical companies or firms operating in the service sector. It is interesting to notice that all these sectors are associated with a heightened risk of litigation (Brown et al., 2005; Francis et al., 1994; Kim & Skinner, 2012; Rogers & Stocken, 2005). Kohers and Ang (2000) and Datar et al. (2001) also observed that the size of the bidder, both in absolute terms and relative to the target, seems to be negatively related to the likelihood of using earnouts. That is, earnouts are used more frequently by small acquirers, as they can least absorb misevaluation risk. This evidence is of particular importance with respect to our paper, as the likelihood of experiencing default is higher for small companies. This speaks to the weight of default risk on the value of earnouts.

Bates et al. (2018) showed that earnouts can also be utilized as liquidity management tools for acquirers, as they delay part of the acquisition payment to future years. Applying a variety of measures of financial constraints, the authors find that financially constrained acquirers are more likely to set up earnout agreements than unconstrained acquirers. Moreover, greater access to public and commercial loan markets reduces the use of earnouts in acquisitions. The authors also underscore that the use of earnouts is eased by the liquidity of corporate parents of targets and, as such is more likely if the corporate parents of targets are not financially constrained. As earnouts are more likely used by financially constrained bidders, their default risk should reasonably be higher than that characterizing bidder in nonearnout deals.

Earnouts can serve an additional purpose as well. In case part of the value of the target depends on the human capital of its former owner/manager, earnouts could work as retention and incentive mechanisms to encourage managers to stay on board and to put forth their best efforts to develop the business of the target (Kohers & Ang, 2000). Finally, the use of earnouts has been related to cultural determinants. Elnahas et al. (2017) contended that earnouts violate Islamic law and, therefore, are infrequently used in Islamic countries. Ewelt-Knauer et al. (2021) found that the use of earnouts is linked to the acquirer's cultural background, measured using Hofstede's country-level indices. The authors found that the use of earnouts is significantly negatively associated with the acquirer's power distance, a measure of organizational hierarchy, and uncertainty avoidance indices.

By reducing information asymmetry and the risk of overbidding on the target, earnouts are especially beneficial for the bidder. This explains why their use is positively associated with the post-closing returns on the shares of acquirers (Barbopoulos, Danbolt, et al., 2018; Barbopoulos, Paudyal, et al., 2018; Barbopoulos & Sudarsanam, 2012; Kohers & Ang, 2000; Kohli & Mann, 2013). Barbopoulos et al. (2016) showed that this is also true for deals in the financial sector, adding that the retention of target institution's management team during the postacquisition period has a significantly positive impact on acquirers' announcement returns, also in light of the fact that in the financial sector managers can influence the retention of clients. The higher acquisition returns associated with earnouts, however, seem to pertain only to low-risk bidders: Alexakis and Barbopoulos (2020) underscored that only bidders that have low idiosyncratic stock returns experience positive returns. Barbopoulos and Adra (2016) documented that the higher returns of the bidder in deals involving earnouts are matched by the gains obtained by the sellers. The target's shareholders in an earnout deal are compensated for sharing the post-acquisition risk with the acquiring firm by obtaining a relatively higher takeover premium compared to nonearnout deals.

Previous literature also analyzed the design of earnouts. Earnouts, on average, represent a substantial portion of the total consideration. Cain et al. (2011) reported an average ratio of 33%. Viarengo et al. (2018) found similar evidence in a cross-country study. Cain et al. (2011) also showed that the proportion of the earnout payment with respect to the total consideration is positively related to the impact of managerial effort to drive the target's growth and negatively related to the precision with which that effort can be measured. The time span over which the performance of the target company is measured seems to vary widely across deals. The horizon of earnouts in the study in question can be as long as 20 years, with an average of 2 years and a half. As the risk of default of the bidder clearly increases over time, the evidence the authors provided hints at the weight of default risk for earnouts characterized by longer maturities.

The use of earnouts has been studied from an accounting perspective as well. By exploiting the change in accounting rules that imposed the measurement of the earnout at fair value for reporting purposes, Cadman et al. (2014) documented variations in initial earnout fair value estimates and earnout fair value adjustments. These modifications are related to the motivation that led to use of such agreements in the first place: The desire to reduce moral hazard and adverse selection problems, bridge valuation gaps and retain target firm managers. These authors also revealed that earnout fair value adjustments are negatively related to the likelihood of contemporaneous and future goodwill impairments. Allee and Wangerin (2018) attested to the fact that, after the change in accounting principles, acquisitions are more likely to incorporate earnout agreements. In addition, they found that earnouts tied to accounting-based performance measures constitute a larger portion of total payment when acquiring firms are audited by one of the major four auditing firms.

A few papers focused on earnouts from a theoretical standpoint, providing models that describe their optimal use. Choi (2017) showed that contingent payments and, in particular earnouts, can mitigate the problems of private information because they function as an imperfect verification mechanism. Moreover, similar contracts can reduce the difference in opinion on the value of the target between the bidder and the seller, modelled as agents with nonconvergent priors, because they allow the parties to define a price structure compatible with their nonconvergent beliefs, that is, with their disagreement. Lukas et al. (2012) focused instead on the optimal structure of the acquisition, characterizing the optimal time of the acquisition and the optimal proportion between the upfront and the earnout payment. With respect to acquisition timing, the authors substantiated that the larger the transaction costs, the greater the uncertainty of the target's cash flows and the longer the earnout period, the greater tendency for the parties to postpone the closing. The authors also demonstrated that an escalation in uncertainty or in the horizon of the earnout leads to a higher ratio of earnout payments on the total consideration. In contrast, the greater the required performance increase in the target cash flows, the lower the ratio of earnout payments on the total consideration.

Despite the fact that it also deals with the value of earnouts, the paper by Lukas et al. (2012) is profoundly different from ours, both in the aim and motivation and in the underlying assumptions. Specifically, the aim of these authors was to identify the optimal acquisition structure with respect to the timing of the acquisition (and not the length of the earnout, which is not optimally determined but instead is fixed) and the proportion of earnout versus nonearnout payments. The framework they used greatly simplifies the structure of the earnout, as it is not the focus of their analysis. Our paper, in contrast, seeks to build an evaluation model of earnouts able to encompass the complexities of these agreements. With respect to assumptions, Lukas et al. (2012) built a framework where the earnout payment was assumed to have a digital payoff on the performance measure, that is, the target net cash flow stream, which they parsimoniously modelled as an arithmetic Brownian motion. At the cost of being far from realistic earnout payoff and law of motion, this allowed them to obtain closed-form solutions for the optimal acquisition structure. However, as Lukas et al. (2012) did not model the bidder capital structure, they could not assess the impact of the acquisition on the bidder's liabilities and, therefore, could not estimate the bidder's default risk that the earnout bears. Moreover, they assumed that both the bidder and the target can perfectly observe the performance measure and that the target retains full control of the net cash flow stream even after the acquisition. In this way, there is no information asymmetry between the bidder and the target, and no source of litigation risk. In our paper, we take the acquisition structure as given, and evaluate the earnout allowing for a more general and encompassing structure of the contract and of the process underlying it. We also assess the impact of default risk and litigation risk on the value of earnouts.

The relevance of litigation risk with respect to the decision to include an earnout contract in an M&A deal was confirmed by Viarengo et al. (2018). Performing a cross-country study involving 40 major economies, they show that both the frequency of earnouts and the proportion of earnout payments over the total consideration is positively related to the judicial efficiency of the country in which the deal takes place. Given the risk of litigation that affects earnouts, the parties involved in an acquisition tend to refrain from using these contracts in case they feel that the protection that a court could grant is weak.

The growing body of empirical research on earnouts is not matched by the literature on their valuation, which is still in its infancy. Arzac (2004), Bruner (2004), Bruner (2001) and Caselli et al. (2006) described the option-like features of these contracts and claim that they should be valued as vanilla European calls. However, vanilla option-pricing methods are not able to incorporate default risk and litigation risk. Default risk has been extensively studied in the literature on vulnerable options, from which we draw inspiration. Johnson and Stulz (1987), in their seminal paper on this topic, built a model that links the value of an option not only to the realizations of the underlying security but also to the value of its writer. The intuition underpinning the model is that as the final payment of the option cannot exceed the wealth of the writer of the option itself, its value will be a function of the writer's creditworthiness. Further extensions of this study are provided by Hull and White (1995), Jarrow and Turnbull (1995), Klein (1996) and Klein and Inglis (2001). The model we propose has some similarities to that presented by Klein (1996) and Klein and Inglis (2001), in that it explicitly takes into account the impact of the correlation between the value (thus, the creditworthiness) of the writer and the value of the underlying and clearly defines the event of default. We enrich the conventional framework of this literature by modelling the financial structure of the writer of the option (the bidder, in our case).[11] By drawing the distinction between the bidder's senior and junior debt and allowing for the chance that the bidder's liability emerging from the earnout payment could be placed among the latter, we can better capture the impact of the event of default on the earnout's value.

Default risk plays a major role in other areas of M&As as well. Furfine and Rosen (2011) examine the impact of mergers on bidder's default risk. Despite the potential for asset diversification, the authors find that, on average, mergers augment the default risk of the acquiring company. They link this evidence not only to acquirers purchasing riskier targets or increasing leverage postacquisition but also to managerial motivations. In particular, increments in risk are more significant for bidders having executives' option-based compensation or bidders with poor stock performances. Hagendorff and Vallascas (2011) confirmed this idea by substantiating that CEOs with higher pay-risk sensitivity tend to carry out acquisitions that raise default risk. Murray et al. (2017) provide further evidence that when the payment method or the methods for deal financing increase leverage, the bidder's risk of default sees an upturn as well. These authors went on to verify that this increase in leverage is positively related to the bidder's abnormal equity returns, which they see as compensation for the heightened risk borne by stockholders. Bruyland et al. (2019) investigated the takeover strategies of bidders characterized by a high risk of default, determining that they tend to acquire larger unrelated targets which are frequently

[11]In this respect, our paper draws near the analysis of Riis Flor (2008), who examines the relation between capital restructuring decisions and the uncertainties on the value of the assets to be restructured. Our model also has similarities with the work of Peleg-Lazar and Raviv (2017), who model the riskiness of a borrower's assets using a geometric Brownian motion to analyze the risk-taking behaviour of banks by considering the strategic relationship between the debtor and creditor.

unprofitable; this implies that they seem to worsen their financial condition. Contrary to this evidence, Koerniadi et al. (2015) pointed out that, if we limit the focus to cross-border deals, acquisitions tend to reduce the bidder's default risk.

Litigation risk has received much less attention in the literature on real options. To the best of our knowledge, we are the first to consider the effect of potential litigation on the value of an option from an analytical standpoint. However, a few papers have used a real options framework to study the value of litigation in itself. Grundfest and Huang (2005) drew similarities between lawsuits and real options, asserting that by paying litigation costs (e.g., attorneys' fees), the claimants obtain the right to benefit from uncertain but nonnegative outcomes; these authors developed a model of the value of litigation as a function of the uncertainty of the lawsuit. Marco (2005) studied the value of patents, seen as an option to file a lawsuit against an alleged infringer. Despite having been neglected in the literature on real options, we can find evidence of the relevance of litigation risk on the price of securities, for example, in the literature related to the underpricing of initial public offerings (IPOs). Hughes and Thakor (1992) built a model to explain how the risk of litigation related to the potential underperformance of a stock and the associated costs could explain the underpricing of IPOs; underpricing is insurance against litigation. The lower the issue price, the lower the risk of future underperformance and the lower the potential damage to buyers; thus, the lower the probability of litigation. Lowry and Shu (2002) empirically confirmed this idea, demonstrating the impact of litigation costs on IPOs: The average settlement payment to investors of the cases brought to court corresponded to 11% of the total proceeds raised with the IPO. With respect to M&As, Maux and Francoeur (2014) established that the premium on the acquisition of a block of shares is significantly reduced when the target company operates in a sector associated with higher litigation risk. The authors motivated this finding by claiming that acquirers tend to discount expected litigation costs from the bid price. Abbott et al. (2017) studied reverse mergers to examine the impact of litigation risk on audit fees. The authors determined that auditors inflate their fees substantially after these deals, because a public company is more prone to litigation risk than a private one, hence, the audit is more complex. Chung et al. (2020) confirmed that shareholder litigation rights help prevent managers from carrying out acquisitions that minimize downside risk and allow empire building rather than maximizing shareholder value.

Despite the fact that the above-mentioned literature testifies their relevance in M&As and in the pricing of securities, default risk and litigation risk received little attention with respect to their impact on acquisition consideration. Considering the case of earnouts, by developing an appropriate valuation model, we demonstrate that these two sources of risk can significantly affect the value of such contracts and, in turn, the price of the acquisition.

3 | THE STRUCTURE OF EARNOUTS

In this section, we provide a brief overview of the structure of earnout contracts, to facilitate the exposition of the model in the remainder of the paper. As discussed in Section 1, earnouts can be seen as options for the future performance of the target company. Similar to financial options, their structure is defined by the payoff profile chosen (e.g., European or digital options), the exercise time and the strike price. Yet, unlike financial options, which are written on publicly traded securities, whose prices are quoted continuously, earnouts are written on performance measures meant to capture the growth of the value of the target company. These values are reported at specific (and infrequent) time intervals and can be subject to manipulation or opportunistic behaviour on the side of the bidder.

The choice of the performance measure is a critical one when structuring an earnout. Cain et al. (2011) point out that the choice should be driven by the ability of the performance measure to reflect the growth in the value of the target company and by its verifiability, to reduce the probability of future disputes. Yet it is possible that the two required features of the performance measure (tracking ability and verifiability) are in contrast with each other and compromise is, therefore, necessary. Consider, for example, the use of earnings before interest and taxes (EBIT) versus net sales as possible performance measures. The former could be more informative on the value of the target than the latter, as it provides more information on the target's ability to generate profits (and, therefore, cashflows). However, EBIT is affected by a higher degree of subjectivity in the definition and computation of the items considered in their calculation. This issue makes the EBIT measure more informative but harder to verify compared to net sales (which could also be subject to manipulation). It follows that the verifiability of the performance measure is often an issue in earnout contracts. Even sales, which are deemed to be the most reliable accounting figure, can be anticipated or postponed to influence a company's performance (Ahearne et al., 2016).

The payoff profile of earnouts can take various forms. Earnouts can be structured as European calls, where the contingent payment grows linearly with the performance of the target that exceeds a given threshold or structured as digital options, where a fixed payment is made if a given condition is met. Digital payoff structures are more frequent when earnouts are linked to milestones. Earnout payoffs can also be structured as a stepwise or piecewise linear function of the underlying performance measure. The payments related to earnouts are frequently capped so that the bidder can avoid the uncertainty of the maximum acquisition consideration.

The choice of exercise time has a major impact on the value of the earnout. Bruner (2004), Bruner (2001) and Arzac (2004) claimed that, as earnouts have option-like features, the value of these contracts is positively correlated with their horizon. We observed that this is true only if we ignore default risk. The longer the horizon, the higher the probability of the bidder going bankrupt. This risk has an opposite effect on the value of the earnout; therefore, the effect of time on the value of these contracts depends on the net effect of these two contrasting forces. The horizon of an earnout influences the likelihood of earnings management and, thus, of litigation. Though the risk of earnings management may be low for contracts that settle under 3 or 6 months,[12] it can be substantial for longer earnout periods. Cain et al. (2011) documented that earnouts with a horizon of 1 year or more account for at least 75% of the distribution.

4 | THE MODEL

To value these contracts, we take the perspective of the holder of the option. For our discussion to be as general as possible, we want to characterize earnouts as generic derivatives on the parameter chosen in the contract. Thus, we set X to be the earnout value at maturity, with $X = F(S(T))$, where F is a deterministic function of the realization of the terminal underlying parameter S at T, the time in which the performance of the target company will be measured.

[12]However, if part of an acquisition payment has a horizon of 3 months, it could be more likely be a purchase price adjustment rather than an earnout. Cain et al. (2011) show that earnouts tend to consider on average the performances of the target over a period of 2.57 years and that the interquartile range for the earnout period is from 1 to 3 years, with some earnouts having a horizon as long as 20 years.

This approach accommodates the various specifications that these contracts can take. If the earnout is structured as an ordinary option on the parameter chosen, with strike price K, F would take the following form:

$$X = F(S(T)) = (S(T) - K)^{+} = \begin{cases} S(T) - K & \text{if } S(T) > K \\ 0 & \text{if } S(T) \leq K \end{cases}$$

Two other examples are earnouts structured as binary options or as piecewise linear functions of the underlying parameter, respectively:

$$X = F(S(T)) = \begin{cases} a & \text{if } S(T) > K \\ 0 & \text{if } S(T) \leq K \end{cases}$$

$$X = F(S(T)) = \begin{cases} a_1 S(T) & \text{if } K_1 \leq S(T) < K_2 \\ a_2 S(T) & \text{if } K_2 \leq S(T) < K_3 \\ a_3 S(T) & \text{if } K_3 \leq S(T) < K_4 \\ a_4 & \text{if } K_4 \leq S(T) \end{cases}$$

with $a, K_i, a_i > 0$ for $i = 1, \ldots, 4$. Unlike options that are publicly traded on organized exchanges, the risk of default of the issuer (the bidder in our case) is nonnegligible: The earnout will be fully paid out only if the bidder has not gone bankrupt before time T or if the earnout and/or other liabilities contracted by the bidder do not trigger default at time T. We, therefore, need to model the bidder's creditworthiness and its effect on the expected earnout payments. We do so by including a structural model of the bidder's solvency (i.e., the difference between the value of bidder's assets and liabilities) in our option-pricing framework.

Our framework is quite different from that proposed by Lukas et al. (2012), who investigate the optimal earnout structure within an M&A deal and not the value of these contracts. In particular, they determine τ_1, the optimal time of acquisition of the target company as the optimal time to invest in the target net cashflow stream $x(t)$, which follows an arithmetic Brownian motion. Due to the *perpetual* horizon of the investment problem, it is optimal for the bidder to invest as soon as the target net cashflow stream exceeds a constant *threshold value*. The buyer pays an upfront payment I on the acquisition date and a cash-or-nothing sum Q if the target net cashflow stream exceeds a prespecified performance benchmark Ω after a predetermined period T. Importantly, immediately after the bidder acquires the target at τ_1, the target net cash flow stream is multiplied by a positive, monotonically increasing and concave function of the target's cooperation costs. After the acquisition, the bidder still controls the net cash flow stream and selects the optimal cooperation cost to maximize the probability that the modified net cashflow stream will exceed the performance benchmark Ω after a period T. Solving for the optimal threshold value and cooperation costs leads to a Pareto-efficient acquisition contract, with an optimal decomposition between the upfront and earnout payments.

The aim of our paper is also rather different. We want to investigate, in detail, the impact of default and litigation risk on arbitrary earnouts, which is impossible in the framework of Lukas et al. (2012). In fact, they only model the performance process, that is the target net cash flow stream, disregarding the bidder's assets and liabilities. They also focus on digital earnouts and evaluate the bidder's option to invest and the earnout value under the assumption that both the target and the bidder are risk-neutral. We build a multivariate framework where the performance process, the debt process and the value of the bidder's assets exhibit a general correlation structure and whose drifts are unrestricted under the valuation measure $\widehat{\mathbb{P}}$.

In the following sections, we first evaluate the earnout as an option free of both default and litigation risk. We then take into consideration the event of bidder default, which makes the earnout a vulnerable option and evaluate its credit value adjustment. Finally, we consider the potential litigation risk, as the performance measure is not perfectly observable by the target after the acquisition and we evaluate its impact on the earnout value.

4.1 | The primitives of the model

In our model, uncertainty is described by the historical probability space $(\Omega, \mathbb{P}, (\mathcal{F}_t)_t)$, by a three-dimensional standard Brownian motion $W^{\mathbb{P}}$. The three independent components of the Brownian $W^{\mathbb{P}}$ represent the diffusive risk that affects the fundamental variables of our problem: The performance process S, the debt process D and the value of assets of the bidder V. The processes are lognormally distributed, according to the following stochastic differential equation:

$$\frac{dS(t)}{S(t)} = \mu_S dt + \sigma_S dW^{\mathbb{P}}(t),$$
$$\frac{dV(t)}{V(t)} = \mu_V dt + \sigma_V dW^{\mathbb{P}}(t),$$
$$\frac{dD(t)}{D(t)} = \mu_D dt + \sigma_D dW^{\mathbb{P}}(t),$$

where μ_V, μ_S and μ_D, the drift of the processes, are real positive constants and σ_S, σ_V and σ_D are volatility vectors belonging to $\mathfrak{R}^3_+$.

The correlation of these processes is represented in the following matrix:

Correlation	*S*	*V*	*D*
S	1	$\rho_{V,S}$	$\rho_{D,S}$
V	·	1	$\rho_{D,V}$
D	·	·	1

where

$$\rho_{i,j} = \frac{\sigma_i \cdot \sigma_j}{|\sigma_i| \cdot |\sigma_j|} \quad \text{with } i, j = S, V, D,$$

and $|\ \ |$ indicates the Euclidean norm of a vector. The correlation $\rho_{V,S}$ describes the dependence structure between the bidder's assets and the target's performance. Synergies arising from the acquisition are, thus, parsimoniously embedded in our framework. The management of the acquired firm selects a *subjective stochastic discount factor* to evaluate future risky cashflows. Given the subjective prices of risk, collected in the vector $\theta \in \mathfrak{R}^3$, the management selects an equivalent probability measure $\widehat{\mathbb{P}}$, the *valuation measure* and a discount rate $\hat{r}$. Girsanov results for diffusion processes (see e.g., Björk, 2009) allow to write the dynamics of fundamental processes with respect to the valuation measure $\widehat{\mathbb{P}}$ as follows:

$$\begin{aligned}\frac{dS(t)}{S(t)} &= (\mu_S - \sigma_S\theta)dt + \sigma_S d\widehat{W}(t),\\ \frac{dV(t)}{V(t)} &= (\mu_V - \sigma_V\theta)dt + \sigma_V d\widehat{W}(t),\\ \frac{dD(t)}{D(t)} &= (\mu_D - \sigma_D\theta)dt + \sigma_D d\widehat{W}(t),\end{aligned} \tag{1}$$

where $\widehat{W}$ is a three-dimensional standard Brownian motion[13] with respect to the valuation measure $\widehat{\mathbb{P}}$.

The parameter θ captures the attitudes of the former shareholders of the target towards risk. If $\theta = 0$, all the subjective prices of risk are null and the acquired firm is risk-neutral ($\widehat{\mathbb{P}} = \mathbb{P}$). If $\theta \in \Re^3_+$, the firm is averse to the diffusive risk.

If all the primitive processes S, V and D are *spanned by traded assets*, the prices of risk θ correspond to the market ones, the discount rate $\hat{r}$ equals the risk-free rate r and $\widehat{\mathbb{P}}$ becomes an *equivalent martingale measure*. However, this does *not* imply that the discounted processes $\{S(t)e^{-rt}\}$, $\{V(t)e^{-rt}\}$ and $\{D(t)e^{-rt}\}$ are $\widehat{\mathbb{P}}$-martingales. Indeed, this is true if and only if S, V and D coincide with the values of *traded* self-financing portfolios at *any* date t, which is seldom the case for real asset values (see Battauz et al., 2012, 2015). It follows that, even under the spanning condition, the risk-adjusted percentage drifts of S, V and D

$$\begin{aligned}\widehat{\mu}_S &= \mu_S - \sigma_S\theta,\\ \widehat{\mu}_V &= \mu_V - \sigma_V\theta,\\ \widehat{\mu}_D &= \mu_D - \sigma_D\theta,\end{aligned}$$

typically differ from the discount rate $\hat{r}$.

4.2 | Valuing earnout as European options

If we do not consider default risk and litigation risk, in other words, we apply the valuation models commonly used, we can value the earnout as an ordinary European call:

$$E_{\text{ord}}(0) = e^{-\hat{r}T}\widehat{\mathbb{E}}[X], \tag{2}$$

where $\widehat{\mathbb{E}}[\cdot]$ denotes the expectation under the valuation measure $\widehat{\mathbb{P}}$. But doing this flies in the face of common sense. It would be hard to believe that someone would attribute the same value to a promise of payment made by a big unlevered company and the same promise made by a small, highly levered firm. So we need to augment the model in such a way that it enables us to capture the effect of the creditworthiness of the writer on the value of the option.

[13]The density of the probability $\widehat{\mathbb{P}}$ with respect to $\mathbb{P}$ is

$$L(T) = \frac{d\widehat{\mathbb{P}}}{d\mathbb{P}},$$

given by

$$L(t) = \exp\left(-\frac{1}{2}|-\theta|^2 t - \theta W^{\mathbb{P}}(t)\right).$$

(See Björk, 2009, Section 11.3).

4.3 | Including default risk

To include default risk, we have to divide the cases in which the bidder is and is not creditworthy at time T. As the earnout will be added to the liabilities of the bidder, the ability of the latter to repay its debt will also depend also on the earnout itself.

We want to consider two sources of default risk. The first is related to the asset side: The success and the viability of a business depend on several factors (e.g., the entrepreneurial ability of the management, the preference of consumers, the entrance of competitors in the market). This makes the cash flow stream generated by the bidder uncertain and time-varying. The uncertainty with regard to the bidder value is captured by the bidder's asset value being modelled as a stochastic process. The second source is related to the liability side. The more the bidder is levered, the higher its default risk. Moreover, once the deal is closed, there is nothing preventing the bidder from increasing its leverage. The former shareholders of the target have no influence over the financing decisions of the bidder; quite the contrary, they are subjected to these decisions. This is why debt is also modelled as a stochastic process.

To tackle this issue, we define the event of default in the following way:

$$\{\text{default}\} = \{V(T) < X + D(T)\},$$

that is, the bidder goes default if the value of its assets is lower than the value of its liabilities, which includes also the payment due for the earnout.

At this point, we can define an indicator function for distress, $\mathbb{I}_{\text{def}}$, and an indicator function for creditworthiness, $\mathbb{I}_{\text{def}^C}$. These indicator functions allow us to distinguish between the payment that the sellers can get if the bidder is creditworthy and the one that they can get in case of default. We call $\widehat{X}$ the final payoff of the earnout that considers the possibility of the bidder defaulting:

$$\widehat{X} = X\cdot(\mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}}),$$

$$rec = \left(\frac{(1-\alpha)V(T) - \delta_S D(T)}{X + (1-\delta_S)D(T)}\right),$$

where rec is the fraction of the earnout the former shareholders of the target get in case of default, δ_S is the fraction of total debt which is senior with respect to the earnout and α is the value lost in the process of liquidation in case of distress.

Therefore, if the bidder is creditworthy the former shareholders of the target receive the full payment arising from the contract. In case of default, however, their payment is reduced by the factor $((1-\alpha)V(T) - \delta_S D(T))/(X + (1-\delta_S)D(T))$.

The ratio $(V(T) - \delta_S D(T))/(X + (1-\delta_S)D(T))$ captures the fact that in case of default the portion of the earnout that can be paid out depends on the importance of the claim with respect to the others, both in terms of seniority and relative dimensions. Indeed, the claim related to the earnout will be paid after senior debt is satisfied (this is expressed in the numerator) and in proportion to the value of the claim with respect to the other junior creditors (this is expressed in the denominator).

The factor $(1-\alpha)$ captures the cost of distress. In case of default the value of the assets of a company is further reduced by the costs of liquidation and the fact that the procedure may last years, thus reducing the actual value of the creditors' claim (Almeida & Philippon, 2007; Andrade & Kaplan, 1998). This effect is captured by α.

Under these conditions, the value of the earnout becomes:

$$
\begin{aligned}
E_{\text{vuln}}(0) = e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] &= e^{-\hat{r}T}\widehat{\mathbb{E}}\left[X\cdot\left(\mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}}\right)\right],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}\left[X\cdot\left(\mathbb{I}_{\text{def}^C} \pm \mathbb{I}_{def}\right) + rec\cdot X\cdot\mathbb{I}_{\text{def}}\right],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot 1 - X\cdot\mathbb{I}_{\text{def}} + rec\cdot X\cdot\mathbb{I}_{\text{def}}],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot 1 - X\cdot\mathbb{I}_{\text{def}}(1 - rec)],\\
&= \widehat{\mathbb{E}}\left[e^{-\hat{r}T}X\right] - \widehat{\mathbb{E}}\left[e^{-\hat{r}T}X\cdot\mathbb{I}_{\text{def}}(1 - rec)\right].
\end{aligned}
$$

Denoting with

$$
CVA = \widehat{\mathbb{E}}[e^{-\hat{r}T}X\cdot\mathbb{I}_{\text{def}}(1 - rec)], \tag{3}
$$

we get that

$$
E_{\text{vuln}}(0) = \widehat{\mathbb{E}}\left[e^{-\hat{r}T}X\right] - CVA, \tag{4}
$$

that is, including default risk in the picture entails correcting the value of the earnout for the potential inability of the bidder to fully pay what is due. Equation (4), indeed, illustrates that the value of the earnout, including default risk, is equal to the valuation of the earnout using the simple option-pricing method minus a credit value adjustment, CVA defined in Equation (3), which reflects the creditworthiness of the bidder.

The valuation of an earnout using the simple option-pricing method, in other words, not considering default risk, is an upper bound to the valuation given by considering an earnout as a vulnerable option. If the value of the bidder is very high compared to the target's, if leverage is very low, and if the correlation between the two company is perfect or almost perfect, the risk that the bidder will not be able to make the additional payment for the acquisition would be very small, thus, the *CVA* would be negligible. If the leverage of the bidder is high, or if the correlation between the two companies is low, the *CVA* could erode a substantial part of the earnout value. In the latter case, our model is especially useful to avoid overvaluing earnouts.

4.4 | Including litigation risk

After the closing of the deal, the former shareholders of the target relinquish control of their company to the bidder, and thus, the possibility to verify its performances directly. In our option-pricing framework, this means that earnouts are options structured on an underlying that cannot be precisely measured. For this reason, disagreement might arise when the time comes for the earnout to be paid out.

Disagreement can spring from two sources. The first is the fact that the sellers might mistrust the accounting reports provided by the bidder, as it is possible that the figures were subject to earnings management for the purpose of reducing the earnout payment. The second is related to the fact that, if the performances of the target are disappointing, the sellers are not able to distinguish between the possibility that the bidder did not put enough effort in managing the business of the target or if instead, the sellers themselves were overconfident in estimating the future profitability of their company.

Thus, if the performances of the target company at the end of the earnout period, as reported by the bidder, are lower than what expected by sellers, they might blame the bidder, and decide to go to court to obtain what they think they deserve. Clearly, doing that is costly, mainly for three reasons. The first is that the trial has direct and indirect costs that need to be paid, such as lawyers' fees, the time spent to arrange the trial, the cost of the trial itself. The second reason relates to the fact that the proportion of the claim that the judge will grant is not known in advance, and even if their allegations are founded, this is no guarantee that the former shareholders of the target will win their suit.[14] This is very understandable: In assessing the profitability of the target company, the judge must contend with information asymmetry with respect to the bidder that is even stronger than that affecting the sellers. Even if the discovery process is thoroughly performed, this is an issue that the judge cannot completely overcome. Hence, the proportion of the claim that the judge will grant is deemed to be uncertain. The last reason that must be considered is the length of the trial. If the judge ultimately rules in favour of the plaintiffs, the payment will be postponed to the end of the trial. In light of this, the length of the trial itself will have a negative influence on the present value of the payment that the plaintiffs will receive.

Thus, the target's former shareholders would take legal steps only if what they expect to get from the trial, net of the costs related to it, is higher than what the bidder is willing to pay.

We model these issues by defining two functions: λ_{notrial}, which we call the mistrust function, that captures the fact that the sellers expect the bidder to try to lower the payment due to the earnout, and λ_{trial}, which we call the litigation function, that describes the fraction of the earnout that could be granted by the judge in a trial.

Before specifying the form these functions take, we can describe how we model the decision of the sellers to go to court and how this affects the value of the earnout. The actual earnout payout, that is, the earnout payout as proposed by the management of the bidder, is:

$$\widetilde{X} = \lambda_{\text{notrial}} \cdot \widehat{X} \leq \widehat{X},$$

with $\lambda_{\text{notrial}} \in (0, 1)$. If they go to trial at date T, the shareholders get

$$\lambda_{\text{trial}} \cdot \widehat{X}.$$

Therefore, the former shareholders of the target go to trial at date T if it is convenient, that is, if:

$$\lambda_{\text{trial}} \cdot \widehat{X} > \lambda_{\text{notrial}} \cdot \widehat{X} \quad \text{iff } \lambda_{\text{trial}} > \lambda_{\text{notrial}}.$$

The indicator function of going to trial is $\mathbb{I}_{\text{trial}} = \mathbb{I}_{\lambda_{\text{trial}} > \lambda_{\text{notrial}}}$. Therefore, the earnout payoff, adding to the default risk the issues arising from lack of measurability, is:

$$\lambda_{\text{trial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}} + \lambda_{\text{notrial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}^C}.$$

Thus, the value of the earnout becomes:

$$\begin{aligned}
E_{\text{lit}}(0) &= e^{-\hat{r}T} \widehat{\mathbb{E}}[\lambda_{\text{trial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}} + \lambda_{\text{notrial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}^C}], \\
&= e^{-\hat{r}T} \widehat{\mathbb{E}}[\pm \widehat{X} + \lambda_{\text{trial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}} + \lambda_{\text{notrial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}^C}], \\
&= e^{-\hat{r}T} \widehat{\mathbb{E}}[\widehat{X} - \widehat{X}(\mathbb{I}_{\text{trial}^C} + \mathbb{I}_{\text{trial}}) + \lambda_{\text{trial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}} + \lambda_{\text{notrial}} \cdot \widehat{X} \cdot \mathbb{I}_{\text{trial}^C}], \\
&= e^{-\hat{r}T} \widehat{\mathbb{E}}[\widehat{X} - \widehat{X} \cdot \mathbb{I}_{\text{trial}}(1 - \lambda_{\text{trial}}) - \widehat{X} \cdot \mathbb{I}_{\text{trial}^C}(1 - \lambda_{\text{notrial}})].
\end{aligned}$$

[14]Whether merit matters in trials on M&As is a topic of debate in the literature. See for example Alexander (1990) or Romano (1991).

From the last equation we see that the risk of litigation diminishes the value of the earnout ex ante:

$$E_{\text{lit}}(0) = e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] - e^{-\hat{r}T}(\widehat{\mathbb{E}}[(1-\lambda_{\text{trial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] + \widehat{\mathbb{E}}[(1-\lambda_{\text{notrial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}]). \tag{5}$$

The quantity

$$LitVA = e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda_{\text{trial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] + e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda_{\text{notrial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}] \tag{6}$$

can be thought of as a *litigation value adjustment*. The *LitVA* includes two elements: The adjustment for the costs and the risks of going to trial, $e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda_{\text{trial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}]$, and the risk of having to accept the reduced payment $\lambda_{\text{notrial}}\widehat{X}$ instead of $\widehat{X}$, when going to trial is not convenient: $e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda_{\text{notrial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}]$.

We provide possible specifications for λ_{notrial} and λ_{trial}. The fraction of the earnout $\widehat{X}$ the bidder is willing to pay depends on the outcome of the earnout. The higher the outcome, the more significant the temptation for the bidder to reduce the cash outflow. For the sake of simplicity, to define λ_{notrial} we select a piecewise linear function of X, the earnout payment, but we allow for a more general time dependence:

$$\lambda_{\text{notrial}}(x,T) = \begin{cases} 1-\alpha_\lambda(T)x & \text{for } x \in [0; x_{\text{cap}}] \\ \lambda_{\min}(T) & \text{for } x > x_{\text{cap}} \end{cases}$$

where x_{cap} is the cap usually set in earnout contracts as a limit to future payments[15] and with[16]:

$$\begin{aligned} \alpha_\lambda(T) &= \frac{|\,\sigma_S\,|\,\phi(T)}{x_{\text{cap}}} > 0, \\ \lambda_{\min}(T) &= 1 - |\,\sigma_S\,|\,\phi(T) \in (0;1). \end{aligned}$$

In the spirit of Beyer (2009), we propose linking the ability of the bidder to manage the performance measures both to the volatility of this measure, that is $|\,\sigma_S\,|\,\sqrt{T}$, which gains over time, and its distance from the threshold of the earnout, which represents the expectation of the bidder for the realization of the parameter.[17] The intuition behind this is the following: If the measure is noisy, and its realization was higher than expected, the bidder can manage how its value is reported, by reducing it, without the seller being able to infer this. This means defining $\alpha_\lambda(T)$ in the following way[18]:

---

[15]If the contract does not provide an upper bound for the payoff of the earnout, as in the case of a standard call option, x_{cap} can be set, for example, equal to the 95%-quantile of the earnout payoff.

[16]We need a further restriction to guarantee that the received payoff is increasing with respect to x:

$$\alpha_\lambda(T) = \frac{|\sigma_S|\phi(T)}{x_{\text{cap}}} < \frac{1}{2x_{\text{cap}}}. \tag{7}$$

Though it is reasonable to think that the incentive for the bidder to reduce the outflow is *marginally* increasing in the realized payoff, it would be less reasonable to imagine that an increase in the actual payoff would lower the *total* outflow that the bidder is willing to bear. The derivation of this condition () can be found in the appendix.

[17]Which can be more conservative if compared to the expectations of the sellers.

[18]If the owners/managers of the target company are retained after the closing, the possibilities to manage earnings faced by the bidder are reduced. To incorporate this, it is possible to reduce the factors α_λ and $\lambda_{\min}$ by a parameter $k \in (1,+\infty)$:

$$\begin{aligned} \alpha_\lambda &= \frac{|\,\sigma_S\,|\,\sqrt{T}}{k\cdot x_{\text{cap}}}, \\ \lambda_{\min} &= \frac{1-|\,\sigma_S\,|\,\sqrt{T}}{k}. \end{aligned} \tag{8}$$

$$\alpha_\lambda(T) = \frac{|\sigma_S|\sqrt{T}}{x_{\mathrm{cap}}}. \tag{9}$$

Defining a manipulation function that is increasing with the horizon of the earnout is appropriate for the characteristics of the companies that tend to be acquired in earnout deals. These companies are in an expansion phase, thus, they have considerable growth opportunities. However, the longer the expected growth trend, the higher the risk of falling short of it. Alternative definitions of the manipulation function can also be provided that reflect a non-monotonic time dependence. In this case, the function $\phi(T)$ captures the possibility that earnings management can manifest mean reversion in the short to medium term, which is more likely if the target has limited growth opportunities (Healy et al., 2014). As an example, we provide a specification of the function $\phi(T)$ that is consistent with the possibility that the manipulation can be stronger in the first years after the closing but will be lower on longer horizons. This allows for flexibility in determining the horizon associated with its peak:

$$\phi(T) = \alpha T^\gamma \exp(-\beta T^\zeta),$$

with $\alpha, \beta, \gamma, \zeta > 0$. The parameters β, ζ define the time-decay of the ability to manipulate the performance measure.[19] In the appendix, we provide a graphical representation of ϕ for different parameter values.

The function λ_{trial}, which captures instead the payment that can be obtained from a lawsuit, can be specified in the following way:

$$\lambda_{\mathrm{trial}} = (\Gamma e^{-\hat{r}L_{\mathrm{trial}}} - c),$$

where Γ is the proportion of the claim that the sellers expect the judge to grant, L_{trial} is the length of the trial, and c is the upfront proportional cost of litigation (e.g., lawyers' fees). The parameter Γ, assumed to be lower than 1, captures the fact that going to court does not imply obtaining in full what requested. This is because the judge must contend with the same information asymmetry on the realization of the parameter that affects the sellers; added to this is the fact that there is always a degree of discretionality in determining an accounting figure. For this reason, the judge could decide to indemnify the plaintiff only partially. In addition to that, it is possible that the former shareholders of the target were overconfident in their expectations on the profitability of their company. So, it is also possible that the judge, recognizing this, would deny their request. The other issue to reckon with when going to court is that the trial could last several years. Thus, to know the current value of what the judge is expected to grant, discounting is necessary.

Using a specific value for λ_{trial} is a choice that simplifies the exposition. The model could be easily extended to capture the fact that λ_{trial} is indeed a random variable. As the proportion of the claim that the judge will grant is likely to be uncertain, λ_{trial} can be thought of as an *independent*[20]

[19]As the derivative of ϕ is

$$\phi'(T) = \alpha\gamma T^{\gamma-1}\exp(-\beta T^\zeta) + \alpha T^\gamma(-\beta\zeta T^{\zeta-1})\exp(-\beta T^\zeta) \geq 0$$
$$\gamma + (-\beta\zeta T^\zeta) \geq 0$$
$$T \leq T^* = \left(\frac{\gamma}{\beta\zeta}\right)^{\frac{1}{\zeta}},$$

the function ϕ is increasing for $T < T^* = \left(\frac{\gamma}{\beta\zeta}\right)^{\frac{1}{\zeta}}$ and decreasing for $T > T^*$. The maximum value is

$$\phi(T^*) = \alpha\left(\frac{\gamma}{\beta\zeta}\right)^{\frac{\gamma}{\zeta}}\exp\left(-\frac{\gamma}{\zeta}\right).$$

[20]The random variable λ_{trial} is assumed to be independent of all the processes V, S and D with respect to the valuation measure $\widehat{\mathbb{P}}$.

random variable, with realizations $0 < \lambda^L_{\text{trial}} \le \lambda^M_{\text{trial}} \le \lambda^H_{\text{trial}}$, occurring with probability $\widehat{p}^L_{\text{trial}} = \widehat{\mathbb{P}}\left[\lambda_{\text{trial}} = \lambda^L_{\text{trial}}\right], \widehat{p}^M_{\text{trial}} = \widehat{\mathbb{P}}\left[\lambda_{\text{trial}} = \lambda^M_{\text{trial}}\right], \widehat{p}^H_{\text{trial}} = 1 - \widehat{p}^L_{\text{trial}} - \widehat{p}^M_{\text{trial}}$. Because of the independence assumption, formula (5) with a constant λ_{trial} can be immediately extended obtaining:

$$E_{\text{lit}}(0) = \sum_{l=L,M,H} [E_{lit}(0)]_{\lambda_{\text{trial}}=\lambda^l_{\text{trial}}} \widehat{p}^l_{\text{trial}},$$

where $[E_{\text{lit}}(0)]_{\lambda_{\text{trial}}=\lambda^l_{\text{trial}}}$ is the value of the earnout, adjusted for the risk of litigation, with a constant $\lambda_{\text{trial}} = \lambda^l_{\text{trial}}$ in Equation (5).

For simplicity, we stick to the use of a specific average value of λ_{trial}. Our results, however, are robust to this extension.

4.5 | Litigation risk and default risk combined

In the previous section, to express the value of the earnout, we considered the effect of litigation risk on $\widehat{X}$, that is the value of the final payoff already including the default risk. To see the effects of both sources of risk, we can plug the expression for $\widehat{X}$ in the valuation formula we previously derived:

$$E_{\text{lit}}(0) = e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] - e^{-\hat{r}T}(\widehat{\mathbb{E}}[(1-\lambda_{\text{trial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] + \widehat{\mathbb{E}}[(1-\lambda_{\text{notrial}})\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}]),$$

with

$$\widehat{X} = X\cdot(\mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}}).$$

This allows us to express the value of the earnout in the following way (the explicit derivation of the formula is given in the appendix):

$$\begin{aligned} E_{\text{lit}}(0) = {} & e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}\cdot(1 - rec\cdot\lambda_{\text{trial}})] \\ & - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}\cdot(1 - rec\cdot\lambda_{\text{notrial}})] \\ & - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}}(1-\lambda_{\text{trial}})] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}^C}(1-\lambda_{\text{notrial}})]. \end{aligned} \tag{10}$$

This equation reveals that there are four terms that correct the value of the earnout computed as an ordinary call. Indeed, the two events that we consider, default and litigation, divide the state space into four partitions. In all these partitions the value of the final payoff gets reduced, as the Table 1 shows:

TABLE 1 Earnout payoff across states

This table summarizes the values taken by the earnout payoff across the partitions of the state space emerging from the events of default or litigation.

	No default	Default
No trial	$\lambda_{\text{notrial}}\cdot X$	$rec\cdot\lambda_{\text{notrial}}\cdot X$
Trial	$\lambda_{\text{trial}}\cdot X$	$rec\cdot\lambda_{\text{trial}}\cdot X$

Thus, the four terms that correct the value of the earnout arise as the composition of the litigation value adjustment, discussed in the previous section, and the credit value adjustment, discussed in the one before.

5 | CASE STUDY I: THE ACQUISITION OF THE CENTER FOR PAIN MANAGEMENT (CPM) BY PAINCARE HOLDINGS

To illustrate the impact of default risk and litigation risk on the value of earnouts, we refer to an actual contract, stipulated for the acquisition of CPM by Paincare holdings. To obtain the information needed on the details on the earnout agreement, we retrieved the acquisition contract from the SEC filings database.

In December 2004, Paincare holdings, a company that provides highly specialized health services, acquired CPM, a company which owns several hospitals in Maryland, in the United States. Given that it was a private company, there was considerable uncertainty on the profitability of CPM. For this reason, the final agreement provided for an upfront payment of \$6.37 million in cash and \$10.69 in stocks, plus an earnout, linked to EBITDA, providing for three contingent payments, one for each of the 3 years following the acquisition. The total payment for the earnout was capped at \$13.75 million.

The earnout formula was the following:

$$E(t) = \begin{cases} \$4,58 \text{ million} & \text{if } \mathrm{EBITDA}_t \geq 5,5 \\ \$4,12\left(\frac{\mathrm{EBITDA}_t}{5,5}\right) & \text{if } 5,5 > \mathrm{EBITDA}_t \geq 4,8 \\ \$3,20\left(\frac{\mathrm{EBITDA}_t}{5,5}\right) & \text{if } 4,8 > \mathrm{EBITDA}_t \geq 4,1 \\ \$2,30\left(\frac{\mathrm{EBITDA}_t}{5,5}\right) & \text{if } 4,1 > \mathrm{EBITDA}_t \geq 3,5 \end{cases} \quad \text{with } t = 1,2,3$$

As a base case for our analysis, we focus on the option structured in the third year after the acquisition. Similar to the previous chapter, we first describe the effect of default risk, and then we introduce litigation risk.

5.1 | Default risk

To capture the effect of default risk, we need to model the possible evolution of the value of the bidder and its liabilities. To do that, we retrieved the data needed from Compustat and CRSP. Table 2 summarizes the parameters that we computed and used in our model.

As for the cost of distress, α, we obtained it from Moody's ultimate recovery database: The average cost of distress on senior unsecured bonds, computed over all the observations in the database, is 51.6%. Thus, we set α to 0.5.

Given these parameters, we run Monte Carlo simulations[21] to assess the value of the earnout on the EBITDA obtained 3 years after the closing. Table 3 outlines the result of the

[21]We run one million simulations of the outcome value of the three diffusions.

TABLE 2 Earnout parameters

This table illustrates the values assigned to the parameters of the model in the case study referring to the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings.

V	160	$\rho_{S,V}$	0.41	$\| \sigma_V \|^2$	0.3
D	47	$\rho_{S,D}$	0.6	$\| \sigma_D \|^2$	0.3
S	3.5	$\rho_{D,V}$	0.3	$\| \sigma_S \|^2$	0.3
K	5.5	δ_S	0.02	r_f	0.03

TABLE 3 Earnout value

This table illustrates the result of the application of the vanilla option-pricing method, and the model that includes default risk to the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings. The numbers in brackets indicate the width of the confidence interval.

	Vanilla	Default risk
Earnout value	820.0	702.5
Confidence interval	(3.0)	(2.7)

application of the vanilla option-pricing method and the one that includes default risk. The numbers in brackets represent the radius of the confidence interval of the estimation, corresponding to a confidence level of 95%.

Notice that, in our valuation, for comparison with the literature, we use as valuation measure the risk-neutral one, that is, $\widehat{\mathbb{P}} = \mathbb{Q}$, as discount rate the risk-free one $\hat{r} = r_f$, and assume the risk-neutral drifts of all the processes V, D and S coincide with the risk-free interest rate.

The following tables help us to see how the value of the earnout, including default risk, changes in relation to modifications in the parameters. All the parameters, apart from the ones specified in the tables, are set to our base case.

Let us first study the effect of (initial) debt and time.

Table 4 shows that the value of the earnout decreases as debt increases. This is because the likelihood of the bidder experiencing default increases with leverage, thus, the probability that the earnout's payoff gets reduced by the factor *rec* grows. With respect to time, the sign of its effect on the value of an earnout is ambiguous. This fact differentiates earnouts and vulnerable options in general, from ordinary options, the value of which monotonically escalates with time. The longer the horizon, the higher the probability that the earnout will be in the money at expiry. However, time might also augment the likelihood of the bidder defaulting. Thus, the net impact of time on the value of the earnout depends on which of the two conflicting effects is stronger. As the second effect intensifies with the level of debt, as this parameter increases, the horizon at which time ceases to have a positive influence on the value of the earnout shortens. This relation is clearly depicted in Figure 1.

With respect to the correlation between the performance measure and the value of the bidder, as we can see, it has a positive impact on the value of the earnout (see Table 5). This is because the lower the correlation, the higher the probability that when S is high, V is low; thus

TABLE 4 Earnout sensitivity to debt and horizon

This table illustrates how the value taken by the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings varies with the length of the earnout and bidder's levarage. The numbers in brackets indicate the width of the confidence interval.

Debt\Horizon	1Y	2Y	3Y	4Y	5Y	6Y
7	659.6	801.2	817.3	792.9	752.9	705.1
	(2.7)	(2.9)	(3.0)	(3.0)	(2.9)	(2.9)
47	634.9	727.0	702.5	659.3	608.9	560.1
	(2.6)	(2.8)	(2.7)	(2.7)	(2.6)	(2.6)
87	550.8	607.6	585.0	550.1	511.7	479.0
	(2.4)	(2.5)	(2.5)	(2.4)	(2.4)	(2.3)

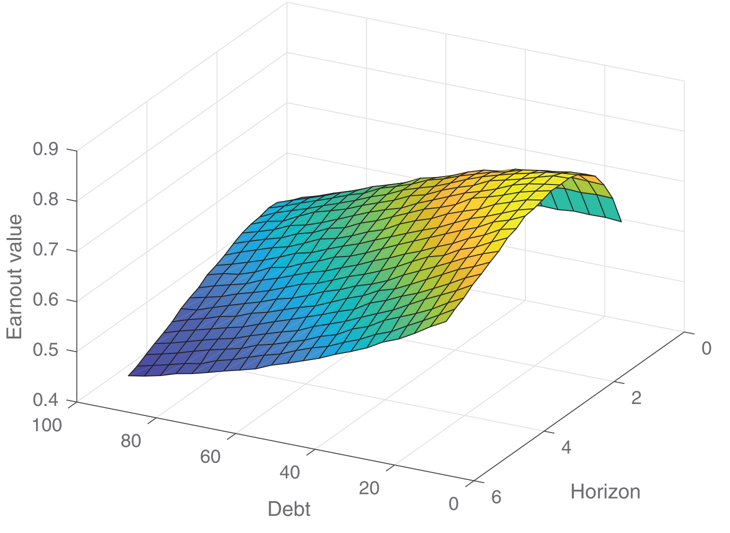

FIGURE 1 Sensitivity of the value of the earnout to time and bidder's leverage. This figure shows the sensitivity of the value of the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings to the length of the earnout (horizon) and to bidder's leverage

the greater the probability that when the earnout payoff is high the bidder will be in financial distress. Also, the correlation between bidder's assets and liabilities has the same influence on the contract value. This implies that when the value of the assets is low, debt is likely to be high, and thus the portion of the earnout payment that will be satisfied, captured by *rec*, reduces. Figure 2 illustrates these relations.

Table 6 captures the fact that both the volatility of bidder's assets and liabilities are factors of risk. The volatility of the underlying has a positive impact on the value of an option because unfavourable realizations of the parameter have limited effect on the final payoff, which is bounded to zero, whereas favourable realizations increase the payoff. However, the opposite happens for the volatility of the net worth of the issuer of the option, which is given by the

TABLE 5 Earnout sensitivity to correlations

This table illustrates how the value taken by the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings varies with the correlation between the value of the earnout parameter and the value of the bidder and with the correlation between the value of bidder's debt and the value of the bidder. The numbers in brackets indicate the width of the confidence interval.

$\rho_{S,V} \backslash \rho_{D,V}$	0	0.2	0.4	0.6	0.8
0	585.0	597.9	620.6	655.8	739.8
	(2.4)	(2.5)	(2.5)	(2.6)	(2.8)
0.2	631.9	648.4	673.4	707.4	763.1
	(2.6)	(2.6)	(2.7)	(2.7)	(2.9)
0.4	672.5	690.2	714.6	745.9	790.7
	(2.7)	(2.7)	(2.8)	(2.8)	(2.9)
0.6	706.9	728.3	748.5	778.7	812.4
	(2.8)	(2.8)	(2.8)	(2.9)	(3.0)
0.8	738.2	758.7	779.4	799.9	817.7
	(2.8)	(2.9)	(2.9)	(2.9)	(3.0)

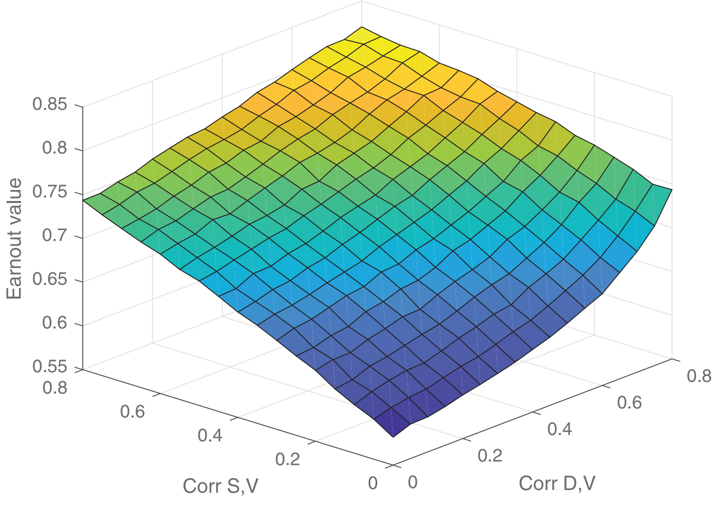

FIGURE 2 Sensitivity of the value of the earnout to correlations. This figure shows the sensitivity of the value of the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings to the correlation between the value of the earnout parameter and the value of the bidder, and to the correlation between the value of bidder's debt and the value of the bidder

combination of the volatility of its assets and the volatility of debt. Positive realizations of the value of V will have limited impact on the payoff because the payoff is bounded to the realization of X, whereas negative realizations of V, that lead to default, do have a negative impact on the payoff. In a figurative way, we can say that, though $|\sigma_S|^2$ is good variance, $|\sigma_V|^2$ is bad

TABLE 6 Earnout sensitivity to volatility

This table illustrates how the value taken by the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings varies with the volatility of the value of the bidder and with the volatility of the value of bidder's debt. The numbers in brackets indicate the width of the confidence interval.

$\| \sigma_V \|^2 \backslash \| \sigma_D \|^2$	0.1	0.2	0.3	0.4
0.1	793.8	767.8	751.6	735.9
	(2.9)	(2.9)	(2.8)	(2.8)
0.2	764.1	742.7	728.1	718.0
	(2.9)	(2.8)	(2.8)	(2.8)
0.3	733.3	712.8	704.0	694.1
	(2.8)	(2.8)	(2.8)	(2.7)
0.4	702.6	688.3	679.2	675.2
	(2.7)	(2.7)	(2.7)	(2.7)

variance. Analogous reasoning holds for $| \sigma_D |$: if assets and liabilities are less than perfectly correlated, a high variance of liabilities reduces what is left to satisfy creditors in case of default. Figure 3 illustrates the sensitivity of the value of the earnout with respect to the variance of the bidder's assets and liabilities.

5.2 | Litigation risk

To capture the effect of litigation risk on the valuation of the earnout in question, we need to pin down the values of λ_{notrial} and λ_{trial}. As the earnout thresholds for the third year earnout (the one that we are considering) are similar to those specified for the first- and second-year earnouts, the expected growth of CPM is small. For this reason, we specify the function λ_{notrial} as having a mean-reverting trend.[22] To define the function λ_{trial}, we did the following. In a survey on M&A litigations along the horizon between 1996 and 2011, Cornerstone Research demonstrated that the settlements related to such legal actions show strong heterogeneity: The median clustered by deal value span widely between 2% and a bit more than 53% of the damages demanded in the lawsuit. We used settlements as a proxy for Γ because they can be seen as expected values of what the plaintiff expects to get; our reasoning is that plaintiffs will reject a settlement only if they think that they would be better off going to trial. Despite the fact that the survey was not focused on litigation related to earnouts, the aforementioned proportions can be considered a good indicator of what the sellers might expect to get if they filed a lawsuit. To be conservative in our estimations, we set Γ to be equal to 53%. As for the length of

[22]Thus, we set λ_{notrial} to be equal to:

$$\lambda_{\text{notrial}} = 1 - \frac{|\sigma_S|}{x_{\text{cap}}}(2.3y^{1.6}\exp(-0.8y))\cdot x,$$

that is, we set the peak of the manipulation in the second year after the earnout, the average contingent payment horizon. We obtain similar results, available upon request if we consider the simpler specification of the function λ_{notrial}, where $\phi(T)$ is equal to $\sqrt{T}$.

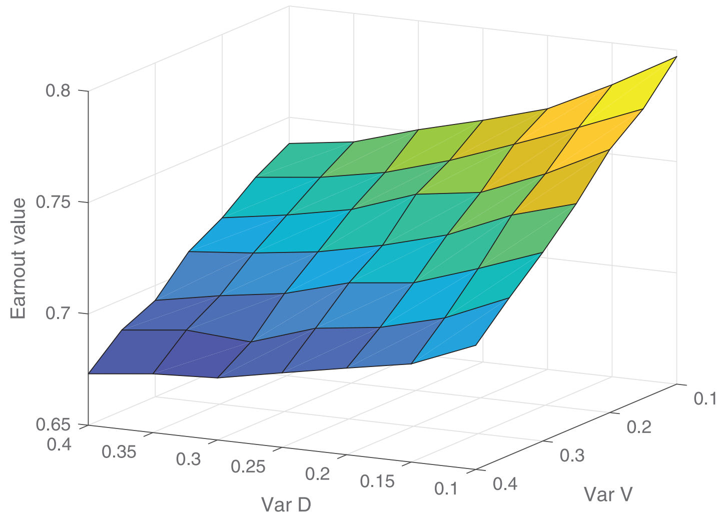

FIGURE 3 Sensitivity of the value of the earnout to volatility. This figure shows the sensitivity of the value of the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings to the volatility of the value of the bidder and to the volatility of the value of bidder's debt

TABLE 7 Earnout value

This table illustrates the value of the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings when applying three alternative methods: The vanilla option-pricing method, the model with default risk and the model with litigation risk. The numbers in brackets indicate the width of the confidence interval.

	Vanilla	Default risk	Litigation risk
Earnout value	820.0	702.5	313.2
Confidence interval	(3.0)	(2.7)	(1.3)

the procedure leading to the settlement, the same survey confirmed that it can vary between 2 and more than 5 years. We set L_{trial} to be equal to 2 years. With respect to c, the upfront cost of the litigation, which mainly reflects the attorneys' fees, we set it at 5%, in keeping with the recommendation of a law firm with which we consulted.

For our base case, the value of the earnout (also including litigation risk) is outlined in Table 7. For the sake of comparison, the table also gives the results we previously illustrated.

As we can see, the value of the earnout, under our specifications, shrinks dramatically.

As we did in the previous section, we want to check how the valuation changes in relation to changes in λ_{trial} and λ_{notrial}, so for each of the two scenarios, we modify an element. For λ_{trial}, we make Γ vary between 0.3, 0.53 and 0.8. For λ_{notrial}, we make α_λ vary between half, one and two times of its size. The values taken by the earnout are illustrated in Table 8.

The results of the valuation procedure are clearly sensitive to the parameters chosen, but even in the most favourable conditions, the value of the contracts is sharply reduced in the presence of litigation risk. Figure 4 shows the sensitivity of the earnout's value to the parameter Γ and α_λ.

TABLE 8 Earnout sensitivity to litigation risk

This table illustrates how the value taken by the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings varies with λ_{notrial} and λ_{trial}. The numbers in brackets indicate the width of the confidence interval.

$\lambda_{notrial} \backslash \lambda_{trial}$	$\Gamma = 0.3$	$\Gamma = 0.53$	$\Gamma = 0.8$
$2\alpha_\lambda$	163.7	311.0	495.2
	(0.6)	(1.2)	(1.9)
α_λ	237.5	313.2	495.7
	(0.9)	(1.3)	(1.9)
$\frac{1}{2}\alpha_\lambda$	470.4	472.6	499.6
	(1.8)	(1.8)	(1.9)

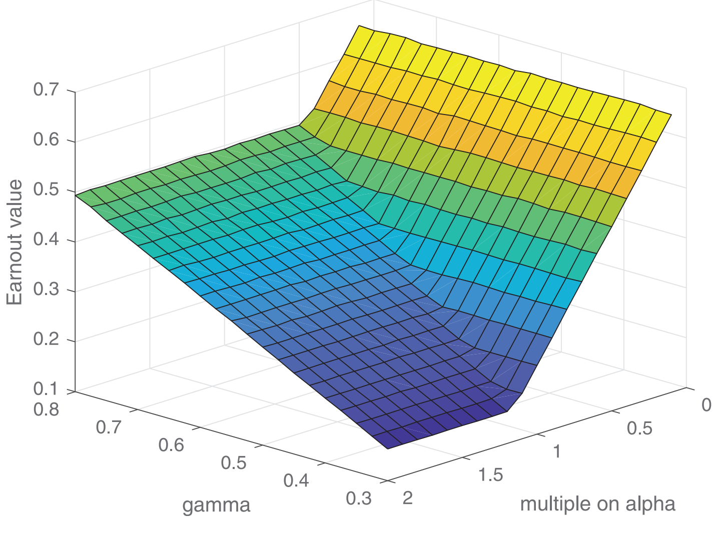

FIGURE 4 Sensitivity of the value of the earnout to litigation risk. This figure shows the sensitivity of the value taken by the earnout included in the acquisition of The Center for Pain Management by Paincare Holdings to the value taken by λ_{notrial} and λ_{trial}

6 | CASE STUDY II: THE ACQUISITION OF GENZYME BY SANOFI

In April 2011, Sanofi, one of the biggest companies in the pharmaceutical industry, acquired Genzyme, a biotech company that had developed a promising multiple sclerosis drug called Lemtrada. The deal marked the second-biggest acquisition in biotech history after Roche's purchase of Genentech in 2009. In addition to a $20.1 billion cash offer, the consideration included an earnout based on several milestones that could have generated up to an additional $3.8 billion for the sellers. The earnout helped the parties to close the deal, despite the disagreement on the value of Genzyme, which was mainly related to the likelihood of Lemtrada passing FDA trials and the future sales of this new drug.

The earnout was based on six milestones:

- An additional payment of 1$ per earnout (the Production Milestone) was to be paid if the production of two drugs (other than Lemtrada) reached a prespecified threshold.[23] This portion of the earnout can be analytically described as follows:

$$X_1 = 1\cdot\mathbb{I}_{\text{threshold}}.$$

- An additional payment of $1 per earnout (the Approval Milestone) was due at the approval by the U.S. FDA, on or before 31 March 2014, of the use of Lemtrada to treat multiple sclerosis. This portion of the earnout can be analytically described as follows[24]:

$$X_2 = 1\cdot\mathbb{I}_{\text{FDAappr}}.$$

- An additional payment of $2 per earnout (Sales Milestone 1) if Lemtrada net sales postlaunch exceed an aggregate of $400 million within specified periods per territory. This portion of the earnout can be analytically described as follows:

$$X_3 = 2\cdot\mathbb{I}_{\tau_3<T},$$

where T is the expiration of the earnout, that is on 31 December 2020, and τ_3 is the first time in which cumulative sales in one of the relevant territories[25] exceed $400 million:

$$\tau_3 = \min\left\{t\colon \sum_{s<t} S_i(s) \geq \$400,000,000,\ \ i \in \{\text{relevant territories}\}\right\}.$$

- An additional payment of $3 per earnout (Sales Milestone 2) upon the first instance in which global Lemtrada net sales for a four-calendar quarter period were equal to or in excess of $1.8 billion.[26] This portion of the earnout can be analytically described as follows:

$$X_4 = 3\cdot\mathbb{I}_{\tau_4<T}\cdot\mathbb{I}_{\text{FDAappr}} + 4\mathbb{I}_{\tau_4<T}\cdot(1 - \mathbb{I}_{\text{FDAappr}}),$$

where τ_4 is the first time in which global sales exceed $1.8 billion:

$$\tau_4 = \min\left\{t\colon \sum_{s=t,t-q,t-2q,t-3q} S(t) \geq \$1,800,000,000\right\}.$$

- An additional payment of $4 per earnout (Sales Milestone 3) upon the first instance in which global Lemtrada net sales for a four-calendar quarter period were equal to or in excess of $2.3 billion (excluding the sales of the quarters computed to determine the previous contingent payments). This portion of the earnout can be analytically described as follows:

[23] The additional payment was related to the sales of a drug called Cerezyme and another called Fabrazyme. The additional payment of $1 per earnout was due if both Cerezyme production met or exceeded 734,600 400-unit vial equivalents and Fabrazyme production met or exceeded 79,000 35-mg vial equivalents during calendar year 2011. The indicator function $\mathbb{I}_{\text{threshold}}$ would take the value of 1 if the aforementioned conditions were met.

[24] $\mathbb{I}_{\text{FDAappr}}$ is an indicator function for the successful approval of Lemtrada by the FDA before 31 March 2014.

[25] United States of America, United Kingdom, Germany, France, Italy and Spain.

[26] This payment could have been increased to $4 per earnout if the sales threshold has reached without having previously obtained approval from the FDA on time to trigger the approval milestone.

$$X_5 = 4 \cdot \mathbb{I}_{\tau_5 < T},$$

where τ_5 is the first time in which global sales exceed \$2.3 billion:

$$\tau_5 = \min \left\{ t > \tau_4 : \sum_{s=t,t-q,t-2q,t-3q} S(t) \geq \$2,300,000,000 \right\}.$$

- An additional payment of \$3 per earnout (Sales Milestone 4) upon the first instance in which global Lemtrada net sales for a four-calendar quarter period were equal to or in excess of \$2.8 billion (excluding the sales of the quarters computed to determine the previous contingent payments). This portion of the earnout can be analytically described as follows:

$$X_6 = 3 \cdot \mathbb{I}_{\tau_6 < T},$$

where τ_6 is the first time in which global sales exceed \$2.8 billion:

$$\tau_6 = \min \left\{ t > \tau_5 : \sum_{s=t,t-q,t-2q,t-3q} S(t) \geq \$2,800,000,000 \right\}.$$

Thus, the total earnout payoff was:

$$X = \sum_{i=1}^{6} X_i.$$

The earnout was securitized and traded on the NASDAQ.[27] Despite being valued at \$5.58 by the deal advisors, who based their calculation purely on its expected cash flows, the initial trading price was \$2.35. The following figure depicts the quoted price of the earnout from the first day of trading, that is, 4 April 2011 to 31 December 2019 (Figure 5).

We use our model to provide a possible explanation for the difference between the price computed according to the expected earnout cashflows and its quoted price at trading inception. In this case study, we mute the default risk component of our model, as the default probability of Sanofi is almost zero,[28] and we focus on litigation risk.

Lemtrada's sales growth was estimated according to the expected sales growth of the drug,[29] as depicted in Figure 6; the quarterly volatility of sales was set to 0.21[30]; the initial value of sales was set to \$49 million, consistently with Genzyme's expectations, and the probability of reaching the production milestone was set to 70%.[31] Finally, given the advanced stage of development of the drug, the probability of obtaining approval from the FDA was set to 90%.[32] Modeling the price of the earnout under these assumptions, we obtain a value of \$5.47,

[27]When earnouts are securitized and traded in the market they tend to be called CVRs.

[28]Sanofi has a market capitalization of around 100 billion Euros, a debt to asset ratio in the range between 15% and 25% and a high rating: For example, Moody's (Fitch) long term Issuer Rating as of June 2020: A1 (A+)–as of February 2011: A2 (AA−).

[29]That were estimated by Genzyme and were the same used for the estimation of the price of the CVR by the advisors.

[30]Estimated using the quarterly volatility of another multiple sclerosis drug called Tysabri.

[31]Consistently with advisors estimates, which can be found on Genzyme's form SC 14D9/A dated 7 March 2011.

[32]Consistently with advisors estimates, which can be found on Genzyme's form SC 14D9/A dated 7 March 2011.

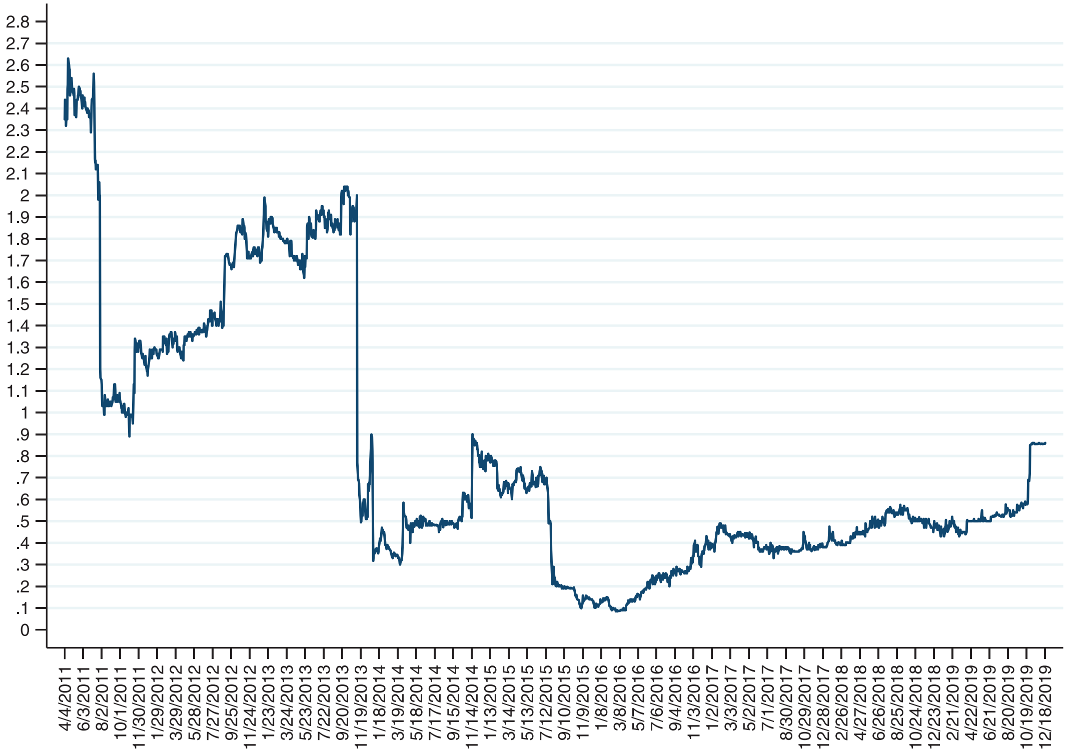

FIGURE 5 Quoted price of the Genzyme CVR. This figure shows the quoted price of the earnout from the first day of trading, 4 April 2011 to 31 December 2019, expressed in US dollars

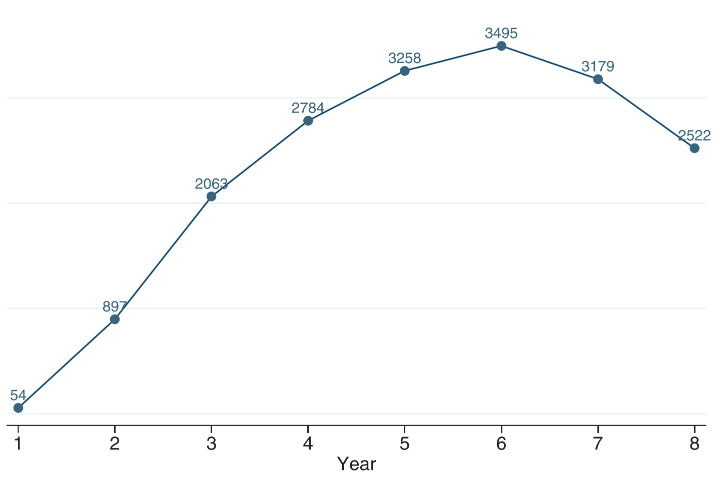

FIGURE 6 Lemtrada's expected sales in the years following the acquisition. The figure shows the expected evolution of Lemtrada's sales estimated by Genzyme in the years following the acquisition. Values are expressed in million dollars

slightly lower than the one computed by the advisors. To include litigation risk, we model λ_{trial} setting Γ to be equal to 53%, L_{trial} to be equal to 2 years and c to be equal to 5%, consistent with what we did in our previous example. We model λ_{notrial} using our basic specification, where $\alpha_\lambda(T)$ is defined as

$$\alpha_\lambda(T) = \frac{|\sigma_S|\sqrt{T}}{x_{\text{cap}}},$$

as this specification, as we explained in Section 4.4, is more suitable for acquisitions with notable growth opportunities. This gives us an estimate of the value of the earnout of \$2.33, slightly lower than the actual market price of the security. Table 9 provides the point estimates and the standard deviations of the valuations under the two scenarios.

Our model attests to the fact that the market might have priced the risk of disputes arising from the earnout. As we mentioned in the introduction, the press realized the presence of the risk of litigation arising from the earnout. In fact, issues with the incentive structure of the earnout were indeed quite severe. As an example, the \$2 payoff arising from Sales Milestone 1 would have forced Sanofi to pay more than the revenues triggering the earnout payment.[33] In addition to this, in the same period, Sanofi was developing its own multiple sclerosis drug, Aubagio, which may have represented competition for Lemtrada.

In the earnout period, no event-triggering contingent payments materialized. This had a significant effect on the price of the CVR. For example, when in June 2011 Sanofi announced that it would not meet the production objectives linked to the Production Milestone, the price dropped by 40%. At the end of 2013, the FDA raised concerns about safety issues regarding Lemtrada and claimed that Sanofi-Genzyme had not submitted evidence from adequate and well-controlled testing demonstrating that the benefits of Lemtrada outweighed its adverse effects. At this point, the probability that the drug would be approved by 31 March 2014 became almost null. The price of the CVR dropped dramatically, also because this meant realizing sufficient revenues to trigger the remaining contingent payments was less likely.

In November 2015, a lawsuit against Sanofi was filed by the earnout holders.[34] In the following days and months, as the case was built, the value of the CVR rose significantly, in light of the expected indemnification that the earnout holders may have received. Even before that time, an article by Evaluate Pharma clearly recognized that, given the low probability of achieving even Sales Milestone 1 without passing FDA trials, 'the only remaining value [...of the CVR] lies not in any payout from Sanofi but in the outcome of litigation'.[35]

During the trial, Sanofi was accused not only of failing to make a diligent effort to pass the FDA trials, but worse still, deliberately submitting inadequate data to the FDA. The plaintiffs claimed that immediately after the Approval Milestone expired, Sanofi promptly provided the FDA with 32 additional submissions based on the previous trials. Such information 'could have and should have been supplied in an earlier time period that would have allowed Sanofi to meet the Approval Milestone Deadline'.[36] Moreover, in a videotaped deposition, filed partially under seal on 13 September 2019, emails were disclosed from certain Sanofi executives

[33]The number of CVRs issued at the closing was around 270 million, which means that the payment arising from Sale Milestone 1 would have been close to \$540 million.

[34]The lawsuit was filed in the Court of the Southern District of New York—case UMB Bank, N.A. versus Sanofi (1:15-cv-08725-GBD).

[35]The article, by Jacob Plieth of Evaluate Parma, is available at https://www.evaluate.com/vantage/articles/analysis/value-sanofis-genzyme-security-rests-law-courts.

[36]Case 1:15-cv-08725-GBD, Document 5, Filed 11/09/15. Available at https://www.courtlistener.com/recap/gov.uscourts.nysd.449662.5.0.pdf.

TABLE 9 Earnout value

This table illustrates the value of the earnout included in the acquisition of Genzyme by Sanofi when applying two alternative methods: The vanilla option-pricing method and the model with litigation risk. The numbers in brackets indicate the width of the confidence interval.

	Vanilla	Litigation risk
Earnout value	5.47	2.33
Confidence interval	(0.002)	(0.001)

revealing that the company was possibly actively seeking to prevent Sales Milestone 1 from being achieved.[37]

On 31 October 2019, the earnout owners and Sanofi signed a settlement agreement, subject to court approval, pursuant to which the parties fully and completely resolved the action, 'without any admission of liability or wrongdoing'.[38] According to the agreement, Sanofi would pay the earnout holders $315 million. Part of this sum, $107 million, would repay fees and expenses, including legal costs and success fees, whereas the remainder, $208 million, would be distributed to the earnout holders. As, by that time, there were about 236 million CVRs outstanding, each CVR entitled its holder to receive about $0.88, an amount that was close to the price of the security, which as of 31 December 2019, was $0.86. In other words, the value of the earnout became almost equal to the payment arising from litigation.

7 | DOES THE MODEL CAPTURE REALITY?

In this section, we aim to provide empirical evidence corroborating the fact that M&A deals involving earnouts have characteristics associated with default risk and litigation risk. As our model proves that valuation methods that do not include these sources of risk tend to overestimate the value of earnouts, the evidence presented substantiates that the possibility of using misspecified models to value earnouts may be widespread.

Considering default risk, the lower the correlation between bidder and target and the more the bidder is levered, the greater the overestimation. As for litigation risk, indirect evidence of the relevance of litigation risk lies in the significant proportion of deals that involve bidders and targets that operate in sectors prone to litigation: Technology, services and healthcare.[39] In addition to that, we provide evidence of pertinent cases in which earnouts ended in disputes. What we want to show is that our model has an impact in general on the valuation of earnouts, because no bidder is perfectly correlated with the target while being financially unconstrained. We also point out that there are cases in which the use of our model might dramatically reduce the valuation of these contracts because more than one of the previously stated conditions might be met simultaneously.

[37]Here is an excerpt: '[...]Between increase in dollar value impacting ex-U.S. sales and Lemtrada USA adjustment on 15F1 (we adjusted approximately minus 40 million euros downward due to delays in market access and reimbursement) we are now in the "safe" zone at approximately $320 million versus the target of $400 million [...]'.

[38]See the press release available at https://www.bloomberg.com/press-releases/2019-10-31/sanofi-sanofi-announces-settlement-agreement-related-to-contingent-value-rights-cvrs-litigation.

[39]See the previously cited Francis et al. (1994), Brown et al. (2005), Rogers and Stocken (2005) and Kim and Skinner (2012).

The data that we apply in this empirical section come from different sources. From Thomson One Banker we obtained data on deals completed between 2000 and 2015 that involved bidders and targets both incorporated in the United States for which an earnout agreement was used. This data set consists of a total of 2,713 acquisitions. To glean information on the capital structure of the companies involved in the acquisitions and on returns of the firms that were publicly traded, we merged this data set with CRSP and Compustat.

7.1 | Default risk

7.1.1 | Correlation

A first indicator of the correlation between bidders and targets can be given by the comparison of their SIC codes. The following table presents the proportion of deals for which bidder and target operate in different industries or sectors according to four-, three- or two-digit SIC codes, all divided by year and overall.

As Table 10 shows, the overall percentage of deals involving bidders and targets operating in different sectors or industries is considerable. Even looking at the broadest definition of industry, that is considering two-digit SIC codes, almost half of the deals in which earnouts are used are cross-industry acquisitions. These results are consistent with the evidence in Kohers and Ang (2000), Datar et al. (2001) and Cain et al. (2011).

It is reasonable to believe that different industries are not perfectly correlated, so this alone is evidence of the fact that our model captures the features of actual deals.

However, to have a more direct measure of correlation, we adopted the following procedure. Starting from the information on returns of traded stocks in CRSP, we built a proxy of cross-industry correlation. For each month in the years between 2000 and 2015, for each group of firms defined by four-digit SIC codes, we computed the average return. Then we determined the cross-industry correlation for each pair of SIC codes and each month, by computing the correlation of the average returns over the previous 36 months. For each deal in the sample for which we were able to compute this correlation, we associated the correlation between the industry of the bidder and the industry of the target in the month in which the deal took place. Over the 2,713 deals involving bidders and targets operating in different industries, we had data to compute the cross-industry correlation for 1,556. The results are reported in Table 11.

Table 11 shows that the correlation between bidder and target, given that they operate in different industries, is on average 0.55, significantly less than one. Moreover, this correlation dips very low, sometimes hitting negative values. This again supports the contention that the model we propose might do a better job in valuing earnouts than the ones currently in use.

7.1.2 | Leverage

Using the information obtained from Compustat on the financial structure of the bidders, we computed both their book and market leverage, defined as Liabilities/Assets. We had sufficient information for 1,320 deals in our data set. The average (median) book leverage is 44% (43%), the average (median) market leverage is 29% (24%). Despite not being dramatically high, such leverage levels are sufficient to have an impact on the valuation of earnouts using our model. This effect, as discussed in the previous section, grows stronger the higher the leverage ratio.

TABLE 10 Distribution of inter industry deals

This table presents data on deals completed between 2000 and 2015 that involved bidders and targets both incorporated in the United States for which an earnout agreement was used. For each year, the table indicates the number of deals performed and the number of deals in which bidder and target operate in different industries or sectors according to four-, three- or two-digit SIC codes (as well as the proportion on total deals).

Year	Obs (*N*)	Diff (*N*) 4-digits	Diff (%) 4-digits	Diff (*N*) 3-digits	Diff (%) 3-digits	Diff (*N*) 2-digits	Diff (%) 2-digits
2000	186	135	72.58	101	54.30	79	42.47
2001	159	125	78.62	110	69.18	91	57.23
2002	192	137	71.35	107	55.73	92	47.92
2003	152	107	70.39	83	54.61	65	42.76
2004	200	125	62.50	99	49.50	80	40.00
2005	210	137	65.24	106	50.48	83	39.52
2006	209	142	67.94	112	53.59	93	44.50
2007	218	161	73.85	134	61.47	108	49.54
2008	177	103	58.19	81	45.76	70	39.55
2009	136	81	59.56	66	48.53	56	41.18
2010	134	93	69.40	74	55.22	52	38.81
2011	182	114	62.64	91	50.00	81	44.51
2012	154	104	67.53	77	50.00	63	40.91
2013	116	75	64.66	58	50.00	47	40.52
2014	167	118	65.74	92	55.09	77	46.11
2015	121	78	61.96	63	52.07	50	41.32
Total	2,713	1,835	67.47	1,454	53.47	1,187	43.55

Table 12 illustrates how the deals in which the bidder's leverage is significantly higher are a nonnegligible portion of the total. Market leverage is higher than 60% in one-tenth of the deals; and for 5% of deals, it is 76% or higher.

Table 12 also shows that there are a number of bidders of deals involving earnouts that are extremely leveraged. In these cases, it would be vital to use a model like ours, to avoid being misled by promises made by bidders who face a high risk of default.

7.2 | Litigation risk

7.2.1 | Industries where litigation is more frequent

An initial indirect way to prove that there is a risk of litigation is to observe that the majority of earnouts are used in deals for which the target is in an industry with a high likelihood of litigation. According to Kim and Skinner (2012), these are the technology, service,

TABLE 11 Correlation

This table presents data on deals completed between 2000 and 2015 that involved bidders and targets both incorporated in the United States for which an earnout agreement was used. For each year, the table shows the average (as well as the median, standard deviation, min. and max.) correlation between the returns of the industries in which the bidders and the targets operate.

Year	Avg. correlation	Median correlation	Standard deviation	Min. correlation	Max. correlation
2000	0.517	0.527	0.225	−0.252	0.862
2001	0.509	0.513	0.272	−0.304	0.928
2002	0.504	0.475	0.293	−0.100	0.926
2003	0.579	0.572	0.231	0.141	0.955
2004	0.585	0.613	0.236	−0.063	0.933
2005	0.530	0.527	0.253	−0.085	0.935
2006	0.459	0.469	0.272	−0.232	0.937
2007	0.481	0.488	0.252	−0.179	0.880
2008	0.524	0.586	0.267	−0.082	0.901
2009	0.636	0.672	0.199	−0.066	0.902
2010	0.651	0.664	0.210	0.083	0.953
2011	0.657	0.695	0.201	−0.009	0.937
2012	0.648	0.670	0.196	−0.052	0.939
2013	0.645	0.707	0.207	0.160	0.926
2014	0.514	0.494	0.231	−0.071	0.917
2015	0.505	0.542	0.229	0.010	0.851
Overall	0.551	0.584	0.248	−0.304	0.955

pharmaceutical/chemical and financial industries. In our data set, in fact, 74% of the deals involve targets in one of these industries. Table 13 provides details on this percentage.

7.2.2 | Anecdotal evidence

To provide a more direct perception of the fact that litigation is a possible result of earnouts, we present a few significant cases in which these contingent payments ended in litigation. Various sources of information are tapped to detect these cases. The most important is Factiva, paired with the verdicts on these cases publicly available and accessible via the Internet (mainly websites of law firms).

The first case we examine relates to the acquisition of Harmonix Music Systems, Inc. by Viacom International, Inc. On 20 September 2006, when Harmonix was enjoying the success of its popular video game, Guitar Hero, and was developing a new game, Rock Band, Viacom and Harmonix entered into an acquisition agreement. Viacom agreed to pay $175 million in cash at

TABLE 12 Market leverage

This table presents data on deals completed between 2000 and 2015 that involved bidders and targets both incorporated in the United States for which an earnout agreement was used. For each year, the table shows the average (as well as standard deviation, 75th, 90th and 95th percentile) of the leverage of the bidders included in our sample.

Year	Avg. leverage (%)	Standard deviation (%)	75th percentile (%)	90th percentile (%)	95th percentile (%)
2000	0.25	0.26	0.45	0.63	0.72
2001	0.30	0.28	0.38	0.83	0.94
2002	0.31	0.24	0.42	0.65	0.85
2003	0.32	0.24	0.43	0.70	0.79
2004	0.28	0.23	0.43	0.62	0.77
2005	0.27	0.22	0.36	0.64	0.75
2006	0.23	0.20	0.29	0.44	0.81
2007	0.25	0.18	0.36	0.46	0.57
2008	0.26	0.17	0.37	0.53	0.55
2009	0.28	0.20	0.40	0.55	0.58
2010	0.29	0.18	0.38	0.53	0.64
2011	0.30	0.22	0.42	0.62	0.77
2012	0.36	0.23	0.48	0.65	0.85
2013	0.27	0.22	0.33	0.54	0.66
2014	0.31	0.21	0.44	0.56	0.80
2015	0.31	0.22	0.39	0.66	0.78
Overall	0.29	0.22	0.39	0.60	0.76

closing and also promised the sellers earnout payments based on the financial performance of Harmonix in 2007 and 2008. Those contingent payments were equal to 3.5 times the amount by which Harmonix's gross profits exceeded $32 million in 2007 and $45 million in 2008. In 2008, Viacom paid $150 million as an advance on Earnout payments, in relation to 2007 gross profits. No additional payments were made with respect to 2008 profits. In 2008, Electronic Arts, the distributor of Harmonix games, offered to reduce the distribution fees payable by Harmonix in exchange for receiving other, separate benefits. This offer, which could have improved Harmonix's gross profit and, thus, the earnout payment, was refused by Viacom. The former shareholders of the acquired company filed a case against Viacom claiming that this decision breached the implied covenant of good faith and fair dealing. The Delaware Supreme Court, which decided the case in favour of Viacom in 2013, held that the acquisition agreement did not imply any explicit obligation to maximize earn-out income.

The second case relates to the acquisition by 3M, the well-known multinational company, by Acolyte, a UK-based company that developed BacLite, a test for MRSA (methicillin-resistant *Staphylococcus Aureus*). The acquisition took place in 2007. Apart from an upfront payment of £10.5 million, the former shareholders of Acolyte were entitled to receive a maximum of

TABLE 13 Percentage of deals in sectors prone to litigation

This table presents data on deals completed between 2000 and 2015 that involved bidders and targets both incorporated in the United States for which an earnout agreement was used. For each year, the table shows the proportion of deals that involve targets that operate in the sectors considered having a higher likelihood of litigation: The technology, service, pharmaceutical/chemical and financial sectors.

Year	HighTech (%)	Pharma/Chem. (%)	Services (%)	Financial (%)	Total (%)
2000	20	5	38	10	74
2001	24	7	33	14	78
2002	16	4	40	17	77
2003	16	9	36	16	76
2004	19	6	38	14	76
2005	18	8	39	13	77
2006	18	9	38	15	80
2007	16	9	38	15	78
2008	15	6	31	15	67
2009	22	13	29	13	76
2010	22	10	33	14	79
2011	16	9	30	14	69
2012	13	13	22	13	61
2013	12	16	19	16	62
2014	10	14	27	22	72
2015	09	15	40	15	79
Overall	17	9	34	15	74

£41 million in additional payments, which were made contingent on the revenues of the acquired company over the subsequent 3 years. 3M was expected to obtain the approval of the FDA to sell BacLite in the United States as well, but the product never passed the FDA trials. Moreover, other competing products were put in the market, including some that were cheaper than BacLite. For these reasons, 3M discontinued the production of BacLite in 2008, offering the former shareholders $1 million in a settlement on the earnout contract. The ex-shareholders of Acolyte refused the offer and decided instead to sue 3M, alleging that it breached its contractual obligations to actively market the product, diligently seek regulatory approvals, and provide the financial resources necessary for product development. After a trial that lasted until 2011, the claimants received damages for $1.3 million, slightly more than what they would have obtained if they accepted what 3M offered, but certainly far less than the maximum earnout payment.

Another case is the 2000 acquisition of Indeck Capital by the Black Hills Corporation. The parties to this deal agreed on an upfront payment of $38 million in Black Hills shares and an earnout capped at $35 million. Only a portion of the earnout, that is $11.3 million, was due according to the bidder and thus paid. In 2004 the former shareholders of the target went to court, claiming that the bidder did not provide audited documentation of the performances of the target during the earnout period and, thus, they did not believe in the prospectuses provided by the bidder. They asserted instead that the actual performances of the target were better than what the acquirer claimed and, thus, they had the right to higher earnout payments. In 2008, the court denied all the plaintiffs' motions.

Another interesting case is the one involving Squid Soap and Airbone Health. Airborne acquired Squid Soap in 2007 with an upfront payment of $1 million and an earnout capped at $26.5 million. Shortly after the acquisition, the business of the bidder began to deteriorate for reasons that were independent of the acquisition. For this reason, after the deal, the bidder was distracted by the necessity of solving these issues and did not make its best effort to manage the acquired company. In 2009, this case was settled with a ruling recognizing, in part, the allegations of the plaintiff.

8 | CONCLUSIONS

Earnouts can be valuable instruments that make it possible to close deals even when there is disagreement between the parties with respect to the value of the target. The valuation of these contracts, however, is far from straightforward. Their option-like features require option-pricing methods to be applied. However, considering earnouts as ordinary calls, as suggested by the previous literature, would imply a misvaluation of their value. Indeed, two additional sources of risk, default risk and litigation risk may influence the payoff of these contracts. Taking an income approach, we build a model that explicitly considers the potential losses arising from a case in which the bidder goes bankrupt before the expiration of the earnout; we factor in the costs and the potential outcome of a lawsuit that might arise in connection to disagreement on the earnout payoff. The sensitivity analysis performed and the case studies presented here demonstrate that including default risk and litigation risk might have a dramatic impact on the value of these contracts.

The contribution of our paper goes beyond providing a valuation model for earnouts. As the empirical literature on earnouts has not adequately considered the effects of default and litigation risk on earnouts, our paper paves the way for further research on this topic. In addition, a proper evaluation of earnouts is fundamental to quantify the total consideration paid in M&As that use these contracts. Thus, our paper informs the literature on the relation between means of payment and takeover premia, as mis-valuing deals can lead to biased conclusions. Moreover, this paper can be a useful tool to satisfy the revised US and European accounting standards that require companies to value earnouts at fair value. These new standards regulating contingent payments also motivated new research on these contracts in the field of accounting, which could benefit from the valuation framework that we provide in our paper.

Our work contributes to the literature on real options and vulnerable options as well. To the best of our knowledge, we are the first to explicitly model the effect of litigation on the value of real options. Our framework could inspire further research in this field.

Finally, understanding the risks affecting earnouts might be particularly important in uncertain times. Economic uncertainty, like that originated by the Covid-19 outbreak, enhances the usefulness of earnouts (Franklin, 2020a, 2020b), as the future performance of acquired companies becomes less predictable. However, financial difficulties emerging from the pandemic might increase the likelihood of the bidder's default and its incentive to reduce the payments related to an earnout, making litigation more likely. Hence, during uncertain times, earnouts could also be less valuable despite being more useful.

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APPENDIX A

In the following appendix, we denote $\lambda = \lambda_{\text{notrial}}$ and $\psi = \lambda_{\text{trial}}$.

A.1. | Derivation of the valuation formula (10)

Taking into account the default risk embedded in $\widehat{X}$, we obtain:

$$E_{\text{lit}}(0) = e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] - e^{-\hat{r}T}(\widehat{\mathbb{E}}[(1-\psi)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] + \widehat{\mathbb{E}}[(1-\lambda)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}]).$$

The three addends can be rewritten as

$$\begin{aligned}
e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] &= e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot(\mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}})] = e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot(\mathbb{I}_{\text{def}^C} \pm \mathbb{I}_{\text{def}} + rec\cdot\mathbb{I}_{\text{def}})],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot(1-rec)],\\
e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] &= e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot(X\cdot(\pm\mathbb{I}_{\text{def}} + \mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}}))\cdot\mathbb{I}_{\text{trial}}],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot X\cdot\mathbb{I}_{\text{trial}}] - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}],\\
e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] &= e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(X\cdot(\pm\mathbb{I}_{\text{def}} + \mathbb{I}_{\text{def}^C} + rec\cdot\mathbb{I}_{\text{def}}))\cdot\mathbb{I}_{\text{trial}^C}],\\
&= e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot X\cdot\mathbb{I}_{\text{trial}^C}] - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}].
\end{aligned}$$

so that

$$\begin{aligned}
E_{\text{lit}}(0) &= e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}] - e^{-\hat{r}T}(\widehat{\mathbb{E}}[(1-\psi)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}] + \widehat{\mathbb{E}}[(1-\lambda)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}^C}]),\\
&= \underbrace{e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot(1-rec)]}_{e^{-\hat{r}T}\widehat{\mathbb{E}}[\widehat{X}]}\\
&\quad -\left(\underbrace{e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot X\cdot\mathbb{I}_{\text{trial}}] - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}]}_{e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot\widehat{X}\cdot\mathbb{I}_{\text{trial}}]}\right)\\
&\quad -\left(\underbrace{e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot X\cdot\mathbb{I}_{\text{trial}^C}] - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}]}_{e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot X\cdot\mathbb{I}_{\text{trial}^C}]-e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}]}\right).
\end{aligned}$$

$$\begin{aligned}
E_{\text{lit}}(0) = {} & e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot(1-rec)] - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot X\cdot\mathbb{I}_{\text{trial}}]\\
& + e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}]\\
& - e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot X\cdot\mathbb{I}_{\text{trial}^C}] + e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}]
\end{aligned}$$

In details:

$$
\begin{aligned}
E_{\text{lit}}(0) = {} & e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot(1-rec)\cdot(\mathbb{I}_{\text{trial}}+\mathbb{I}_{\text{trial}^C})] \\
& -e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot X\cdot\mathbb{I}_{\text{trial}}\cdot(\mathbb{I}_{\text{def}}+\mathbb{I}_{\text{def}^C})] \\
& +e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\psi)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}] \\
& -e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot X\cdot\mathbb{I}_{\text{trial}^C}\cdot(\mathbb{I}_{\text{def}}+\mathbb{I}_{\text{def}^C})] + e^{-\hat{r}T}\widehat{\mathbb{E}}[(1-\lambda)\cdot(1-rec)X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}], \\
= {} & e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}(1-rec+1-\psi-(1-\psi)\cdot(1-rec))] \\
& -e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}(1-rec+1-\lambda-(1-\lambda)\cdot(1-rec))] \\
& -e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}}(1-\psi)] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}^C}(1-\lambda)], \\
= {} & e^{-\hat{r}T}\widehat{\mathbb{E}}[X] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}}\cdot(1-rec\cdot\psi)] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}}\cdot\mathbb{I}_{\text{trial}^C}\cdot(1-rec\cdot\lambda)] \\
& -e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}}(1-\psi)] - e^{-\hat{r}T}\widehat{\mathbb{E}}[X\cdot\mathbb{I}_{\text{def}^C}\cdot\mathbb{I}_{\text{trial}^C}(1-\lambda)].
\end{aligned}
$$

A.2. | Derivation of condition (7) on α_λ

In order for $\lambda_{\text{notrial}}(x)\cdot x$ to be an increasing function of x, we require $(1-\alpha_\lambda(x-x_\lambda))\cdot x$ to have positive derivative for $x \in [x_\lambda; x_{\text{cap}}]$. This is equivalent to

$$
\begin{aligned}
-\alpha_\lambda\cdot x + 1 - \alpha_\lambda(x - x_\lambda) &> 0 \quad \text{for all } x \in [x_\lambda; x_{\text{cap}}], \\
-2\alpha_\lambda\cdot x + 1 + \alpha_\lambda x_\lambda &> 0 \quad \text{for all } x \in [x_\lambda; x_{\text{cap}}], \\
-2\alpha_\lambda\cdot x_{\text{cap}} + 1 + \alpha_\lambda x_\lambda &> 0, \\
1 - (2x_{\text{cap}} - x_\lambda)\alpha_\lambda &> 0, \\
\alpha_\lambda &< \frac{1}{2x_{\text{cap}} - x_\lambda}.
\end{aligned}
$$

A.3. | Graphical representation of the function ϕ

We provide a graphical representation of the function ϕ for different parameter values. In green $\alpha = 15$, $\gamma = 0.67$, $\beta = 0.25$ and $\zeta = 10$; in red $\alpha = 2.4$, $\gamma = 0.5$, $\beta = 0.25$ and $\zeta = 2$; in magenta $\alpha = 2.3$, $\gamma = 1.6$, $\beta = 0.8$ and $\zeta = 1$. The three examples describe scenarios in which the chances of manipulation reach their peak at different points in time (1 year for the red curve, 2 years for the magenta curve) (Figure A1).

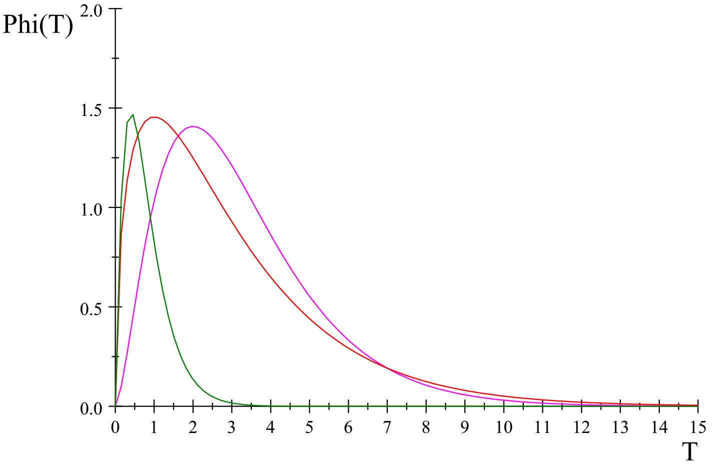

FIGURE A1 Graph of $\phi(T)$ as a function of T. This figure provides a graphical representation of the function ϕ for different parameters values In green $\alpha = 15, \gamma = 0.67, \beta = 0.25$ and $\zeta = 10$; in red $\alpha = 2.4, \gamma = 0.5, \beta = 0.25$ and $\zeta = 2$; in magenta $\alpha = 2.3, \gamma = 1.6, \beta = 0.8$ and $\zeta = 1$