FINANCING INNOVATION: BRAIDING, MONITORING, AND UNCERTAINTY

Nicholas J. Houpt[†]

An archetypal image of the secured creditor is that of the "cop on the beat" who deters misbehavior by his mere monitoring presence. Uncertainty typically confounds monitoring by making behavior unobservable and unverifiable, requiring complex contractual solutions such as braiding. This article casts doubt on the conventional wisdom that secured creditors are great monitors and that uncertainty is a fundamental informational problem that transacting parties must solve instead of simply evade. Using empirical information from actual technology contracts, I build on braiding theory and argue that secured creditors often rely on collaborators in a transaction to monitor each other, that the canonical features of secured credit are severable, and even non-creditors play the role of monitor. I also find that secured lenders use very simple, formal contracts to deal with uncertain relationships, contrary to the expected complex braiding solution. Instead of finding this anomalous arrangement to be an oversight or failure, I explain how uncertainty is relative and, using portfolio theory, how uncertainty is often diversified away for secured creditors.

CONTENTS

[†] Associate, Akin Gump Strauss Hauer & Feld LLP. J.D., Columbia Law School; B.A. University of Notre Dame. All of the views herein are solely those of the author and in no way represent the views of Akin Gump. My thanks to Robert Scott, Robert Jackson, and Richard Squire for helpful comments on this article. All errors that remain are mine.

INTRODUCTION

A recent breakthrough in contract theory identified the practice of braiding, in which parties weave informal and formal elements of contract together to overcome uncertainty. These contracts are especially prevalent in the context of collaboration for technological innovation, but they also appear in other contexts with significant uncertainty, such as preliminary agreements in mergers and acquisitions. Thus far, the literature has focused solely on the core contractual relationship—the crystallized instance of the initial agreement between two companies, such as a research collaboration between a large pharmaceutical company and a small biotechnology company.

This article builds on braiding theory in several ways. It provides new empirical information by analyzing actual contracts, modifications, and financing arrangements. It expands braiding theory's initial inquiry and seeks to understand how modifications to such original agreements affect braiding and how secured lenders finance such uncertain collaborations and monitor debtors.

Modifications reveal how parties gradually resolve uncertainty and how they respond to newly arising uncertainty. First, modifications

have shifted power within the "contract referee mechanism," suggesting that braiding also works well as a mechanism to deal with ex ante uncertainty of bargaining power, revelation of information throughout the relationship, and ex post reallocation of that power.[1] Second, modifications have formalized certain switching costs in termination provisions, and have adjusted those costs over time.[2] This formalization suggests that crowding out of informal elements (here, switching costs) is not a necessary result even when there is a high-powered formal element. Third, modifications reveal innovative nested option structures[3] that are developed in stages as nested uncertainty is revealed.[4] Low-powered formal mechanisms[5] appear to be essential in developing an option-based response to these unforeseen uncertainties.

The secured lender's behavior in these contracts is initially puzzling: neither the braiding solution nor the traditional secured credit solution is present to resolve uncertainty or even manage the risk of routine opportunism.[6] The secured credit theory predicts that the lender

1. Ronald J. Gilson et. al., *Braiding: The Interaction of Formal and Informal Contracting in Theory, Practice, and Doctrine*, 110 COLUM. L. REV. 1377, 1403 (2010) [hereinafter Gilson, *Braiding*]. A "contract referee mechanism" is a dispute resolution mechanism used in braiding contracts. *Id.* The mechanism typically requires (near) unanimous consent for certain key decisions in the collaborative relationship. *Id.* Lower-level employees are typically the ones deciding at first, with any unresolved disputes going to higher-level employees. *Id.*

2. *Id.* Switching costs are the costs of finding another partner with whom to collaborate. Gilson, *Braiding*, *supra* note 1, at 1403. These costs include the learning curve that the new partner would have to undergo to catch up to the current partner, and would include a discount for reliability and trust that has not yet been established.

3. *See id.* at 1407-09. Nested options are a mechanism used to solve potential hold-up problems that may arise once uncertainty is dissipated. For example, once a technological innovation is developed, the next stage is commercialization. One can predict these stages beforehand and use an option structure at each stage to prevent opportunism. One collaborator may have an option of first refusal on the commercialization of any product that is developed, and if that collaborator cannot reach a commercialization agreement with the other, the other has an option to purchase the product and commercialize it through other means. Without these options, the parties might try to hide their successes from each other and act opportunistically.

4. In this article, I challenge the effectiveness of nested options by pointing to evidence of nested uncertainty. As one type of uncertainty is resolved and a predictable stage is entered, another type of uncertainty may develop that presents its own opportunism problems. This unpredictable uncertainty can only be dealt with once it arises.

5. Low-powered formal mechanisms are soft commitments, like an obligation to negotiate in good faith. High-powered formal mechanisms are much harder commitments, such as the obligation to perform a certain task at a certain time. In the context of braiding contracts, low-powered formal mechanisms are used because hard terms, like price, quantity, and typical covenants, do not fit well with uncertain processes. The options that are typically used are options to negotiate about a particular term or to terminate the agreement.

6. I explain other standard theories of secured credit not discussed in the Introduction,

will take one of two measures to police opportunism: monitor the debtor's behavior or accept a bonding gesture by the debtor.[7] Here, neither of those occur in any significant way. The lender cedes control over the primary assets of the small collaborator, the intellectual property (IP), and allows the big collaborator an exclusive license. The lender also does minimal monitoring: it might receive financial statements, but it does not actively monitor debtor behavior, the collaborative process, or the collateral. Instead, the lender's primary strategy is to take a security interest in the small company's payment rights from any IP that emerges from the collaboration.

This article solves the puzzle with two steps that refine foundational assumptions in secured credit theory and the theory of transacting around uncertainty. First, it is not the secured lender who monitors the debtor, but the big collaborator. The big collaborator's monitoring acts as a substitute for the secured lender's expected monitoring. Secured credit theory typically describes the secured lender as a "cop on the beat," which allows other unsecured creditors to provide credit without worrying about monitoring. Here, the big collaborator is the "cop on the beat," and it is the secured lender who is benefitting from that diligence. This particular monitoring arrangement is also normatively optimal as the secured creditor does not have the usual combination of countervailing effects—focused monitoring and security's disincentivizing insulated recovery.[8]

Second, Knightian uncertainty is relative.[9] The underlying uncertainty problem that braiding contracts attempt to solve is not an absolute attribute of a particular event or series of events as economics literature has typically suggested. Instead, one's economic position with regard to specific uncertainties can transform an uncertain event into a risky event. This result can be seen in the secured lender's strategy. The big and small collaborators effectively solve the uncertainty problem in their technological innovation contract, but the

such as relational contracting and contextualist theory in Part IV.

7. *See* Saul Levmore, *Monitors and Freeriders in Commercial and Corporate Settings*, 92 YALE L.J. 49, 50-59 (1982) (describing monitoring and bonding as the two methods secured lenders use to manage agency costs). *See infra* Part III.A for a more thorough discussion of the many different theories of secured credit.

8. *See infra* Part IV.C (discussing Richard Squire's theory of symmetry in creditor's rights).

9. Knightian uncertainty and risk are categories of risk proposed by the economist Frank Knight. *See generally* FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 197-232 (1921). Risk is quantifiable and can be probabilistically allocated, whereas uncertainty is so radically unquantifiable that any allocation of risk would be arbitrary.

uncertainty is not automatically solved for other parties. Unlike the elimination of risk by monitoring, the uncertainty is still present and will not dissipate until the necessary information is revealed (or created). The secured lender, however, cares nothing of this uncertainty and instead makes a bet on the exogenous probability of the success of the venture. The uncertainty endogenous to the collaborative relationship determines that outcome, but need not be a part of the secured lender's risk calculus.[10] For example, any collaboration may have a ten percent chance of success, but the direction of each individual collaboration may be radically uncertain. By having a position outside of that relationship, the secured lender has a different relative position and can avoid the uncertainty problem inherent in braiding contracts. Portfolio theory provides a more rigorous explanation of this phenomenon by describing how specific uncertainty may be diversified away, a fact previously undeveloped in economic and legal academic literature.

Part II describes the theoretical background for this discussion. It describes the phenomenon of braiding contracts and how they solve problems of technological and partnership uncertainty.[11] It also considers alternative theories that seek to explain how the uncertainty problem has been solved, such as modularity theory and relational contracting theory. It also examines prior empirical literature on collaborative alliances and questions its underlying assumptions about contracts underlying this literature.

Part III examines a new example of a prototypical braiding relationship and its contractual modifications as that relationship developed over time. Specifically, it examines how modifications affect the contract referee mechanism, switching costs, and the nested options structure. The modifications of these features reveal that braiding also

10. A familiar analogy might be the way that venture capitalists fund start-up firms. The venture capitalist does not care that the entrepreneur wanted to invent a war-time anesthetic for soldiers and ended up with Novocain, a product that was successful in a different market; the venture capitalist looks for an innovative product with a chance of success. Once found, the venture capitalist typically provides funds in exchange for equity, and the venture capitalist sells off a large portion of that equity once the product has succeeded.

11. Partnership uncertainty is the uncertainty involved in finding a collaborator whom one can trust, who will fit well with one's working style, and who has the skills and know-how to make a successful collaboration. Each of these things is difficult to signal before the collaboration begins, leaving these qualities uncertain ex ante. As the collaboration proceeds, one can establish informational mechanisms to observe these qualities in the partner.

deals with uncertainty of bargaining power[12] and unforeseen uncertainties which only emerge once the relationship has developed. The formalization of switching costs through high-powered mechanisms also further undermines the explanatory power of the crowding-out phenomenon in the economics literature, but perhaps only where the formal and informal elements of the contract are tied to different information streams.

Part IV examines the third-party loan agreement with the small collaborator in that relationship. The actual structure of this loan agreement undermines the standard predictions one would make under current theories of secured credit and policing debtor opportunism. This analysis discerns a new pattern of monitoring, helps to refine existing secured credit theories and adds a new tool for solving puzzles in explaining the pattern of secured credit.

Part V considers the loan agreement's approach to the collaboration's uncertainty, finding that the only plausible explanation is that Knightian uncertainty is positionally relative.[13] The secured lender is actually operating under a risk-based scenario despite the uncertainty inherent in the collaboration that it is lending into. After describing intuitive analogies for this argument, this Part adds a first cut at using portfolio theory to establish a rigorous basis for the relativity of uncertainty. The Part concludes by considering what the relativity of uncertainty means for the role of business lawyers in such transactions.

Part VI concludes.

I. BRAIDING THEORY AND EMPIRICAL RESEARCH

There is an emergent space between markets and hierarchies, between make and buy, and between formal and informal contracting.[14] This new class of contractual relationships has posed serious challenges

12. Uncertainty of bargaining power refers to the parties' inability ex ante to determine which party is least likely to defect when given an ex post decision right. In other words, it is not clear which party has the most to gain or most to lose in any future state of the world.

13. Positionally relative might mean several things and this article is only a first cut at clarifying the concept. Uncertainty can be relative to one's economic position, which would differentiate between the lender and the big collaborator, who each have very different economic transactions with the small collaborator and hence each have different concerns about uncertainty. The other possibility is that uncertainty is relative to legal position. The legal structure of the loan can be asset-based or cash-flow based and this structure might change how much uncertainty matters to the lender.

14. *See generally* Ronald J. Gilson et al., *Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration*, 109 COLUM. L. REV. 431 (2009) [hereinafter Gilson, *Contracting for Innovation*]; Gilson, *Braiding*, *supra* note 1; George S. Geis, *The Space Between Markets and Hierarchie*s, 95 VA. L. REV. 99 (2009).

to the traditional explanatory theories of firm behavior, organization, and contract design. Examples of such contracts have typically been found in research and development collaborations. The uncertainty inherent in radical technological innovation and in the search for the right partner for that work has necessitated a new type of contractual and organizational structure: the braiding contract.[15] Other settings with collaboration and informational uncertainty have also adopted this contractual structure, such as outsourcing transactions[16] and preliminary agreements to mergers and acquisition transactions.[17]

This contractual structure is not what traditional industrial organization and contract theory would predict. The traditional theory proceeds in three steps.

A. The Choice Between Formal and Informal Contracts

First, under the traditional theory, a firm can choose one of formal or informal (self-enforcing) contracts.[18] Formal contracts contain specific, hard terms that a third party can verify. For example, a court could verify whether the correct quantity of goods was delivered to the buyer by looking at various pieces of evidence. The availability of verification is an essential part of how formal contracts provide proper incentives and risk allocations between the parties.

Informal contracts do not contain such hard, specific terms, and instead rely on external constraints to enforce the agreement. For example, parties might be able to observe behavior within the relationship while being unable to verify that behavior to a third party. In this case, the parties' reputations, reciprocity, concerns about continued business with a repeat player, or other external factors provide the enforcement mechanisms behind the agreement to allocate risk and provide proper incentives.

A pure form of either of these types fails in the collaborative setting because neither verification nor observability can fully solve the uncertainty problem. The formal contract cannot adequately handle the uncertainty of technological innovation, and can, at best, come up with hard terms that crudely approximate success or soft terms that allow inefficient renegotiation.[19] Setting out specific terms ex ante can be

15. Gilson, *Braiding*, *supra* note 1, at 1383-84.

16. Geis, *supra* note 14, at 101-02, 121-26, 130-32 (describing hybrid governance mechanisms generally and outsourcing contracts specifically).

17. Gilson, *Braiding*, *supra* note 1, at 1431-39.

18. *Id*. at 1387-89 (describing the general theory of contract enforcement as a dichotomy between formal and informal mechanisms).

19. *Id*. at 1391-92.

done, but it would be done arbitrarily, rendering any risk allocation meaningless. The informal contract fails because its primary enforcement mechanism, reputational sanctions, cannot work when the uncertainty in the relationship makes fault impossible to assign.[20]

B. Crowding Out

Second, the traditional theory predicts that one cannot successfully blend informal and formal mechanisms in a contract.[21] The experimental economics literature in this area has found that formal mechanisms will crowd out the informal, damaging the trust between the parties.[22] In other words, the formal characteristic is like a dominant gene paired with a recessive gene: the dominant characteristic always shines through, excluding the recessive. In this way, a blending of contractual mechanisms yields a formal contract, which, as discussed above, cannot solve the uncertainty problems in the collaboration.[23]

C. Vertical Integration as Fallback to Contract

Third, where contract fails, one should see vertical integration.[24] Firms have the tools to police opportunism under uncertainty and can do so adequately both ex ante and ex post (after the uncertainty is resolved).[25] Yet, vertical integration has strategic costs, especially when it might hamper the ability to be nimble and change direction in an industry that is driven by innovation.[26] Thus, there is an increasing empirical trend of firms moving towards vertical disintegration in quickly innovating industries.[27]

Contract is now the mechanism of choice. Economists have proposed two theories to explain this unexpected use of contract:

20. *Id*. at 1397-98.

21. *Id*. at 1387-88.

22. *See, e.g.*, Iris Bohnet et al., *More Order with Less Law: On Contract Enforcement, Trust, and Crowding*, 95 AM. POL. SCI. REV. 131, 132 (2001).

23. See *infra* Part III.C for this article's contribution of the potential mechanisms of crowding out and how even high-powered formal elements may not crowd out informal elements.

24. *See generally* Francine Lafontaine & Margaret Slade, *Vertical Integration and Firm Boundaries: The Evidence*, 45 J. ECON. LITERATURE 629 (2007).

25. *See generally* ALFRED D. CHANDLER, THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS (1977) (describing the trend towards vertical integration in American industry and explaining that trend as a result of the value that skilled management can add to a business).

26. *See generally* Kathryn Rudie Harrigan, *Formulating Vertical Integration Strategies*, 9 ACAD. OF MGMT. REV. 638 (1984).

27. *See generally* Richard N. Langlois, *The Vanishing Hand: The Changing Dynamics of Industrial Capitalism*, 12 INDUS. & CORP. CHANGE 351 (2003).

modularity and relational contracting.

D. The Modularity Explanation

Richard Langlois is a major proponent of the modularity thesis as an explanation for the shift towards contracting in innovative industries.[28] Langlois is puzzled by the radical increase in vertical disintegration and questions what this phenomenon means for the theory of the firm.[29] To solve this puzzle, Langlois argues that "technology, organization[s] and institutions [] change at different rates."[30] The old era of vertical integration was a result of the imbalance in changes between technology and organizational structure—managerial oversight of several linked processes made it cheaper to produce industrial technology.[31] Vertical disintegration is occurring because markets and institutions have caught up to technology, decreasing the costs of coordination that previously gave rise to a glut of vertically-integrated firms.[32]

As this co-evolution of technology and organizational structure occurs, firms and markets develop buffers to reduce the uncertainty of that evolution.[33] Modularity is one such buffer.[34] Modularity is basically a "Lego" theory of design: there is a shared interface that enables individual components to interact and work together in complete systems, yet the developers of the individual component can innovate separately and use markets and contracts as mechanisms of exchange for those components.[35] Telecommunications, computers, and internet technology, for example, typically exhibit such characteristics.[36] For example, one can buy a computer processor from one manufacturer, a monitor from another, and so on with every other component, and then assemble them into a complete computer system.

But modularity alone cannot describe the radical technological

28. *See generally id.*

29. *Id.* at 352. The phenomenon that I refer to as "vertical disintegration," Langlois refers to as "de-verticalization." *See id.*

30. *Id.*

31. Langlois, *supra* note 27, at 352.

32. *Id.*

33. *Id.* at 354 (citing JAMES D. THOMPSON, ORGANIZATIONS IN ACTION 20 (1967)).

34. *Id.* at 355 (citing Daniel A. Levinthal & James G. March, *The Myopia of Learning*, 14 STRATEGIC MGMT. J. 95, 98 (1993)).

35. *Id.* at 375.

36. *See* Joseph Farrell & Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age*, 17 HARV. J.L. & TECH. 85, 90-96 (2003).

innovation and collaboration that we see in other industries.[37] When some organization or group of organizations must set a unified interface, there is some loss of innovative power. The standard-setter cannot foresee or predict cutting-edge innovation on every component of the system. The standard itself can become a force of inertia, with its network effects and established position shaping the scope and aim of innovation, much like a massive body's gravity bending the light that passes near it.

To escape this trap of constraining standards some firms have pursued a different process—collaboration. As discussed below in Part II.G on braiding, this process allows collaborating parties to engage in mutual learning and innovation by using contractual mechanisms designed to protect against uncertainty and opportunism. This phenomenon diverges greatly from modularity, but could be reconciled with Langlois' larger theory. Modular production, like the industrial phase preceding vertical integration, became overburdened with information costs: organizations could not keep up with the breakneck pace of technological innovation while retaining their original form. Organizations developed contractual mechanisms to solve these information problems and enable productive collaboration. In other words, these collaborations are just the next step in the co-evolution of technology, organizations, and institutions.

E. The Relational Contracting Explanation

Relational contracting predicts that networks of firms, informal cooperation, and reciprocity will suffice to constrain opportunism, and firms will be able to innovate together.[38] Lamoreaux et al., though careful to point out that circumstances may change in the future and undermine the descriptive power of their theory, rely heavily on long-term relationships among organizations and the informal costs and benefits associated with those relationships.[39] In order to explain the move away from vertical integration, this theory draws heavily on examples of localized industrial districts and more recent examples like Toyota's rise to power in automobile manufacturing.[40] Toyota, for example, developed long-term relationships with its network of

37. *See* Gilson, *Contracting for Innovation*, *supra* note 14, at 446-48 (criticizing the explanatory power of modularity and relational theories with regard to iterative collaborative processes).

38. Naomi R. Lamoreaux et al., *Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History*, 108 AM. HIST. REV. 404, 408-09 (2003).

39. *See generally id.*

40. *Id.* at 425-26.

suppliers.[41] Toyota made a significant reputational investment in its suppliers by giving them substantial independence in component design and operations, in addition to making other investments such as training and taking a financial stake in the companies.[42] As Lamoereuax et al. put it: this informal cooperation facilitated innovation and growth because problems could be solved by "voice rather than exit."[43] Informal cooperation and social relationships are experiencing a resurgence in business as advances in communications infrastructure have greatly decreased communications costs.

This theory fails to predict, however, that the contracts for innovation will have significant formal elements and complexities.[44] Although informal cooperation and exchange may be especially helpful in situations of uncertainty, and may have driven the movement towards vertical disintegration, Lamoreaux et al. do not describe a world where these informal collaborations are ensconced or even made possible by the mechanism of contract.[45] Perhaps industry clusters, like internet companies in Silicon Valley, or other tightly knit networks can solve uncertainty problems solely through the informal trust inherent in the fabric of those industries. But some industries use contract as a mechanism to create that kind of trust in a collaboration, allowing the formal side of contracting to facilitate instead of destroy informal cooperation.

F. Empirical Work on Collaborative R&D

There has also been empirical work that has directly assessed the characteristics and success of collaborative research and development (R&D) alliances. This work, even though it has focused on practical organizational realities, has failed to recognize the contractual braiding mechanism and hence relies heavily on the two theoretical frameworks discussed above: modularity and relational contracting. For example, one empirical study attempts to assess the cost of an organization incorrectly choosing either a contract mechanism or an equity joint-venture mechanism for a particular project.[46] In designing the empirical

41. *Id.* at 426.

42. *Id.*

43. Lamoreaux, *supra* note 38, at 426.

44. Gilson, *Contracting for Innovation*, *supra* note 14, at 446-48.

45. *Id.* at 445.

46. *See generally* Rachelle C. Sampson, *The Cost of Misaligned Governance in R&D Alliances*, 20 J.L. ECON. & ORG. 484 (2004). In this study, a choice is correct if the mechanism chosen maps onto the empirical facts about the transaction. *See id.* at 512-21. For example, an equity joint-venture structure would be the correct choice for a transaction

tests, the author assumed joint-ventures handle uncertainty better and that contract worked better if formal drafting can adequately police opportunism.[47] Other studies make the opposite assumption about contract, claiming that it operates informally and find results supporting a network or reputational theory of governance in R&D alliances.[48] In short, these studies make the false assumption that contract is binary: one can only have formal or informal contracts. They fail to account for the hybrid nature of braiding contracts.

Even if this argument does not undermine the results of these studies, it shows that they are incomplete. For example, evidence of the effectiveness of informal networks may be only part of the story; perhaps formal contract referee mechanisms are precisely what make the information spread to those networks trustworthy. That is, the process of unanimously consenting to a particular decision may signal its reliability, and a breakdown in that process can be interpreted from context. Less uniform or less observable decision procedures may not provide the same quality of information to the informal networks.

G. Braiding

Braiding theory provides a way out of the theory-practice disconnect outlined above, and it questions the generalizability and reliability of the empirical work done in this area. Collaborative innovation, as theorized by Gilson et al., typically suffers from two uncertainty-based problems: difficulties in the observation and verification of parties' performances.[49] In this article, I introduce a third problem: the possibility that bargaining power is uncertain ex ante.

laden with uncertainty, and a contract mechanism would be the incorrect choice. If opportunism is the primary problem, then contract would be the correct choice, and an equity joint-venture would be incorrect.

47. *Id.* at 494-97.

48. David T. Robinson & Toby E. Stuart, *Network Effects in the Governance of Strategic Alliances*, 23 J.L. ECON. & ORG. 242, 243 (2007).

49. Gilson, *Braiding*, *supra* note 1, at 1402. Formal contracting uses court (or arbitrator) verification of behavior to enforce specific outcomes and police opportunism. *Id.* at 1389. The formal obligations act as a mechanism by which the court can force the parties to provide information. *Id.* This contractual mechanism breaks down under uncertainty because the efficient outcomes are not predictable ex ante and any attempt to specify outcomes would be arbitrary. *Id.* at 1391-92. Informal contracting, on the other hand, depends on private observation of behavior to deter opportunism and achieve an efficient outcome. This mechanism is used when parties can mutually observe behavior and states of the world, but could not verify that information in court. *Id.* at 1392. "Enforcement" of informal contracts occurs through informal norms, such as reputation and reciprocity. Gilson, *Braiding*, *supra* note 1, at 1392-94. These informal norms break down under uncertainty: it becomes much more difficult to tell whether a party is following a norm, is making a mistake, acting opportunistically, etc. *Id.* at 1392-95.

When only one problem is present, a formal or an informal contract can solve the problem.[50] To solve all three problems, however, the contract must weave informal and formal elements together without falling prey to the crowding-out problem that makes the contract effectively formal. Crowding-out seems to occur only when high-powered formal mechanisms are used, but does not always occur when a high-powered formal mechanism is present.[51] Braiding avoids crowding-out by using low-powered formal mechanisms; namely, information exchange commitments and what Gilson et al. call the "contract referee mechanism."[52] Information exchange mechanisms create observable performance, allowing the parties to learn about each other and endogenizing trust in the contractual relationship.[53]

Braiding has some hallmark contractual features. First, braiding employs a "contract referee mechanism."[54] This mechanism is a formal governance structure that is used to resolve disputes, verify information, and direct research activities.[55] Employees from both collaborating firms are involved and there is typically a hierarchical structure.[56] Lower-level employees try to resolve disputes first, and they only pass on the disputes to management, and ultimately the executives, when the disputes cannot be resolved on the lower levels.[57] This gives employees strong incentives to resolve disputes because they want to keep that sort of work off of their boss's desk.

One aspect of the "contract referee mechanism" that has not been explored is how to prevent lower-level employees who have access to very sensitive information from conspiring and capitalizing on that information.[58] One can imagine a situation where two employees, one from each collaborator, make a discovery and want to reap the rewards for themselves. At the next formal meeting, these employees present

50. *Id.* at 1387-88.

51. *See id.* at 1399-1402 (arguing that high-powered formal mechanisms crowd out informal norms because such formal mechanisms crowd out information that leads to reciprocity and make the relationship seem exchange-based instead of norm-based). I argue in Part III that even some high-powered formal mechanisms, such as exclusivity and termination provisions, do not crowd out informal mechanisms related to switching costs.

52. *Id.* at 1403 (footnote omitted) (internal quotation marks omitted).

53. Gilson, *Braiding*, *supra* note 1, at 1402-03.

54. *Id.* at 1403 (footnote omitted) (internal quotation marks omitted) (describing the "contract referee mechanism" as a key feature of braiding), 1405, 1406 (examining the actual referee mechanism used in a prototypical contract).

55. *Id.* at 1403.

56. *Id.*

57. *Id.*

58. My thanks to Robert Jackson for this observation.

fabricated results and recommend a different direction for the research. If there is some deference to these employees on that particular research line, and no one audits the fabricated data, then the recommended change would likely receive unanimous approval.[59] The conspiring employees then hope to develop their discovery further and eventually start their own business, or perhaps sell that discovery in its nascent stage to a competitor. There are certainly informal checks against this type of behavior: the employees could be fired or their reputations in the technological community sullied. And criminal law and intellectual property law would provide some remedies against this type of behavior, but I suspect that the unverifiability of some types of information in this uncertain collaboration may make those formal legal checks ineffective.

Second, braiding has two hallmark characteristics that deal with the contractual end-game and prevent opportunism once the uncertainty is resolved. The contracts typically contain a nested options structure.[60] Once the innovation is developed, one party cannot just back out and keep the product himself: the other party has a right to purchase or license the rights to the product.[61] Also, as the relationship increases in duration and more relation-specific investments are made, the parties' switching costs rise.[62] Each party invests a great deal in learning about the other, developing trust, etc., and switching to a different partnership would forfeit that investment and reintroduce partner-based uncertainty into the research.

Although the practice of braiding and the theory behind it has been fleshed out in some detail, there is still much work to be done. Gilson, et al., at the end of their second article on braiding, pose the question:

> Could it be that braiding—the complementary use of formal and informal strategies—and the class of problems it addresses are fractal, repeating themselves from larger to smaller across a broad range of human interaction, and so providing a mechanism by which social cooperation too is endogenized and renewed even as the conditions of cooperation become more uncertain?[63]

If braiding is fundamentally tied to, and a solution for problems of,

59. These are strong assumptions and their strength suggests that this problem of fraud might not be so realistic in practice. If this type of fraud were a real risk, firms would ratchet up the intensity of their research committee meetings and ferret out this kind of behavior.

60. Gilson, *Braiding*, *supra* note 1, at 1408.

61. *Id.*

62. *See id.* at 1403.

63. *Id.* at 1447.

radical uncertainty, and that kind of uncertainty is growing ever more in the modern world, then the theoretical ambition would seem to be to develop a general theory of braiding in each micro-level relationship characterized by uncertainty and in macro-level problems of cooperation under uncertainty.

This article takes a step towards testing this general theory of braiding by looking beyond the original study of the direct collaboration relationship in the instant of contract. I examine how braiding works over time in a contractual relationship by analyzing a prototypical braiding contract that has gone through several amendments, produced a promising product, and continues to exist. I find several new phenomena that show the expanded reach of braiding theory and its adaptation to different contexts: the use of the "contract referee mechanism" to solve uncertainty of bargaining power and allocate power efficiently ex post, the formalization of switching costs in termination provisions, and the addition of informal mechanisms to solve the nested uncertainty that emerges after nested options are exercised.

II. MODIFICATIONS TO A BRAIDING CONTRACT

A. A Braiding Prototype—Shell and Codexis

The collaborative research agreement between Shell and Codexis, with its associated financing agreements and amendments, will be the prototypical transaction for this analysis.[64]

The Shell and Codexis agreement has many of the hallmarks of a braiding contract. Shell, a large multinational energy company,

64. *See generally* Amended and Restated Collaborative Research Agreement between Equilon Enterprises LLC dba Shell Oil Products US and Codexis, Inc., SEC. & EXCHANGE COMMISSION (Nov. 1, 2006), http://www.sec.gov/Archives/edgar/data/1200375/000119312510076663/dex103a.htm [hereinafter Amended and Restated Collaborative Research Agreement]; Ex-10.1A Loan and Security Agreement between General Electric Capital Corporation, Oxford Finance Corporation & Codexis, Inc., SEC. & EXCHANGE COMMISSION (Sept. 28, 2007), http://www.sec.gov/Archives/edgar/data/1200375/000119312510076663/dex101a.htm. By looking at recent collaborations with ongoing modifications, the analysis has an inherent risk of selection bias. I am essentially looking at the collaborations that survived and dealt with uncertainty in fruitful ways, instead of those collaborations that might have ended after just one iteration of the contract. Although studying these failures and comparing them to successful ventures would certainly be interesting, such a broad study is beyond the scope of this article. The analysis of a prototypical contract, even if not adequately representative, randomly chosen, or from an adequate sample, still provides much empirical fodder of theoretical interest. Even one contract can provide an impetus for questioning assumptions and refining theory.

partnered with Codexis, a small start-up specializing in biofuels. The stated purpose of this partnership was "to develop biocatalytic processes" for the conversion of biomass into fuels, lubricants, and fuel additives.[65] As a contract for collaborative technological innovation, in which the products to be developed were not clearly defined or subject to the type of expectations that lend themselves to being defined in contractual terms, this contract paired informal learning processes and obligations with a formal governance structure and dispute resolution mechanism.[66]

During the most uncertain period of the collaboration—the beginning—the obligations of the parties are determined solely as a function of the number of full-time employees (FTEs) dedicated to the project.[67] Codexis must dedicate a certain number of FTEs and Shell will pay fees based on that number of FTEs.[68] There are also some initial "fees" for use of Codexis' existing technology in developing the new products and for Codexis' exclusivity in this particular field of research.[69] At the outset, Shell also commits itself to paying Codexis for achieving certain milestones, but no details about the conditions for meeting a milestone or the calculation of payment are provided and the decision is left up to the research committee.[70] Shell also agreed to make an up-front ten percent equity investment in Codexis.[71]

The nested options structure typically found in braiding contracts is also present here. Recall that options are used to prevent opportunistic behavior once the uncertainty is resolved. For example, a party might have the option to purchase the innovative product and, if it does not, the other party retains full rights to that product. Here, the determination of research milestones acts as an option to continue researching and developing products.[72] Codexis also has the option of first negotiation if Shell wishes to outsource its manufacturing of any

65. Amended and Restated Collaborative Research Agreement, *supra* note 64, at recitals.

66. *See id.* §§ 2.2 (establishing research committee), 2.3 (establishing oversight committee), 2.8 (describing efforts of the parties, defined in terms of number of full-time employees and submission of various reports for benchmarks to be determined by research committee).

67. *Id.* § 2.6(b).

68. *Id.* §§ 2.6(b)(i), 3.3.

69. *Id.* §§ 3.1, 3.2 (technology access fee and exclusivity fee).

70. Amended and Restated Collaborative Research Agreement, *supra* note 64, §§ 2.8, 3.4 (outlining milestone payments).

71. *Id.* § 3.5(b) (equity payments).

72. *See id.* § 2.8.

products developed in this partnership.[73] Each party also has a complicated set of options related to termination of the agreement.[74] These options do not always contain the hard terms seen in Gilson et al.'s original braiding contracts which typically had, for example, fixed royalty prices for the purchase of IP.[75] Additional uncertainty seems to merit low-powered options.

The Shell-Codexis agreement also has the formal governance element that is typical of braiding contracts, but the structure of that governance mechanism in this contract is quite different from the structures previously examined. The essential element is still here: decisions about disputes and about the development of technology and research are made by a formal governance body composed of employees appointed by each party.[76] Typical braiding contracts would then include a process by which lower-level employees have to refer unresolved issues up the ladder to their superiors, and there would be some procedure to break a deadlock.[77]

B. Allocation of Power and Ex Post Shifts

This agreement, however, allocates power in a different way. Here, two separate formal committees are created, one to oversee research and one to determine milestones and resolve disputes.[78] For each committee, the first step is for the appointed employees of each party to resolve the issues by consensus.[79] If, however, there is a deadlock, then each committee has its own deadlock procedure. Codexis alone decides deadlocks for the research committee,[80] and

73. *Id.* § 2.4.

74. *See id.* §§ 11.2, 11.3, 11.4.

75. Gilson, *Braiding*, *supra* note 1, at 1407-08.

76. Amended and Restated Collaborative Research Agreement, *supra* note 64, §§ 2.2(b), 2.2(f)(i), 2.3(a), 2.3(f)(i).

77. Gilson, *Braiding*, *supra* note 1, at 1406 (describing the various stages of the dispute resolution process in a prototypical braiding contract from the pharmaceutical industry).

78. Amended and Restated Collaborative Research Agreement, *supra* note 64, §§ 2.2, 2.3.

79. *Id.* §§ 2.2(f)(i), 2.3(f)(i).

80. *Id.* § 2.2(f)(i) ("All decisions of the Research Committee shall be made by unanimous vote or written consent, as indicated by both co-chairpersons of the Research Committee signing the final written minutes thereof. Codexis representatives collectively shall have one (1) vote and Shell representatives collectively shall have one (1) vote; provided, however, that in the case of a deadlock where unanimity has not been reached, the final decision with respect to matters concerning technical aspects within the scope of an approved Research Plan shall be made by Codexis. . . .").

Shell alone decides deadlocks for the oversight committee.[81] If the tie is not broken in this manner, then the parties can refer the matter for a decision by the executives of each party.[82]

It is not clear what this bifurcated governance structure signifies, but there are at least two theoretical explanations. First, the governance structure could be the formalization of an estimated allocation of power. That is, bargaining power was uncertain ex ante, so the parties made the best allocation possible with the expectation that the allocation would change as more information became available. Second, one of the parties could have paid more for this additional discretion. Unfortunately, there is no reported financial data in the contracts from which one could glean whether there was a possibility that this discretion was paid for.

The development of the relationship between Shell and Codexis led to further rearrangement of the governance structure. In a 2009 amendment to the agreement, the research committee gained decision power over the milestones, leaving the oversight committee with just dispute resolution powers.[83] This change appears to give Codexis more power, as it can now break deadlocks on the approval of the very milestones which trigger Shell's payments under the original agreement.

If this is indeed a shift in power, then braiding contracts have an additional informational advantage. They not only solve the informational uncertainty problems related to trust in one's partner and the innovation of technology, but also the uncertainty of the relative power of the parties. The relative strength of the parties in this kind of collaborative context may not be so clear cut. Even if Shell is a much larger company with greater financial resources, Codexis might have (potential) IP or know-how that is so immensely valuable to its partner that it has an equal or stronger bargaining position than Shell. The value of that IP and knowledge, however, is not apparent ex ante and can only be discovered in the process of collaborative research and development. As the information about bargaining power is discovered informally, that power can be formally reallocated through this

81. *Id.* § 2.3(f)(i).

82. *Id.* §§ 2.2(f)(i), 2.3(f)(i).

83. Ex 10.3B Amendment to the Amended and Restated Collaborative Research Agreement between Equilon Enterprises LLC dba Shell Oil Products US and Codexis, Inc., SEC. & EXCHANGE COMMISSION §§ 2(c), 2(e) (Mar. 4, 2009), http://www.sec.gov/Archives/edgar/data/1200375/000119312510076663/dex103b.htm [hereinafter Amendment to the Amended and Restated Collaborative Research Agreement] (*compare* § 2(c) and §2(e) of this amendment *with* §2.2.(f)(i) and §2.3(f)(i) of the original agreement).

bifurcated governance structure.

A significant branch of theoretical economics literature disputes this argument and claims that the optimal governance structure for allocating decision rights under uncertainty is to allocate, ex ante, the decision right to the party least likely to defect.[84] Baker et al. apply their model to a prototypical braiding contract made between a large pharmaceutical company and a small biotech company, with specific focus on decision rights for whether the biotech firm will participate in the marketing of a drug that reaches that stage.[85] The analysis assumes that the biotech will always benefit from participation in marketing because it provides helpful learning to the biotech company, and that this learning is relatively constant across different states.[86] The pharmaceutical company, on the other hand, has widely varying costs of involving the biotech company.[87] The decision right should be assigned to the pharmaceutical company because its temptation to defect or renege will be lower, and the self-enforcing space of the contract (and efficiency) will be maximized.[88]

Baker et al.'s model can also explain the agreement and amendment in the Shell-Codexis relationship. Here, there are three decision rights: research, milestone achievement, and dispute resolution. In the first agreement, the parties thought that Codexis was least likely to defect for research and that Shell was least likely to defect for milestone achievement and dispute resolution. The parties thus allocated the rights that way. As the relationship progressed, perhaps the parties found out that they were mistaken about Shell being the least likely to defect for milestone achievement. Thus, the parties amended the agreement and reassigned that decision right to Codexis. This empirical counterexample is then reduced to an exercise in non-ideal theory: one just has to take account of some practical limitations and the model still works.

The Shell-Codexis agreement still presents some potential problems for the Baker model, however. First, the Baker model assumes two pieces of information that might not be true: that the defection spaces and preferences are known and that the small collaborator will always benefit from being involved in the marketing of

84. *See, e.g.*, George Baker et al., Contracting for Control 20-23 (Mar. 21, 2006) (unpublished manuscript), *available at* http://isites.harvard.edu/fs/docs/icb.topic66847.files/Robert_Gibbons.pdf.

85. *Id.* at 20.

86. *Id.* at 21.

87. *Id.*

88. *Id.* at 23.

a product. The costs and benefits to the small collaborator, however, might also be variable across states. If this is the case, there might not be a clear-cut choice of the party who is least likely to defect. The distribution of payoffs might itself be uncertain: the small collaborator could end up in a much better position if the collaboration produces a product far outside the expertise and market of the big collaborator and inside the expertise of the small collaborator. The solution under this kind of uncertainty might be the solution employed in the Shell-Codexis agreement: a somewhat arbitrary assignment of decision rights, with heavy reliance on the unanimity of the "contract referee mechanism" and informal norms to police that allocation, and a reallocation of decision rights once that uncertainty is resolved. That more decision rights went to the small collaborator is evidence that the payoff structure is not as clear as Baker et al. assume it to be.

Second, the Baker model assumes a single-stage game. When nested uncertainty is introduced, however, one must deal with a multi-stage game. The Baker model may well be able to handle this complication. Each stage of implementation has the same solution: assign decision rights to the party least likely to defect. The difference is that as one type of uncertainty is resolved and another is introduced, the defection payoffs of each party change. For example, the small collaborator, ex ante at stage one, might always benefit from participating in marketing. At stage two, after the small collaborator has grown in expertise and developed some new IP, the payoff might be different. Perhaps the small collaborator has specialized in early-stage development and faces a very high opportunity cost of dedicating resources to marketing. At this stage, the payoffs need to be reassessed, which might result in a reallocation of decision rights according to the Baker et al. recommendations.

C. Formalization of Switching Costs

This relationship certainly had informal switching costs that increased as the parties invested more time and effort in learning about each other, but there is something new here. The contract also imposed formal switching costs in its termination provision.[89] As of the third anniversary of the agreement's effective date, Shell had a right to

89. Amendment No. 2 to the Amended and Restated Collaborative Research Agreement between Equilon Enterprises LLC dba Shell Oil Products US and Codexis, Inc., SEC. & EXCHANGE COMMISSION § 3 (Feb. 23, 2010), http://www.sec.gov/Archives/edgar/data/1200375/000119312510076663/dex103c.htm [hereinafter Amendment No. 2 to the Amended and Restated Collaborative Research Agreement].

terminate at will if it provided six months' notice, unless the FTEs reached a certain threshold number, in which case Shell would have to provide twelve months' notice.[90] Codexis, on the other hand, could terminate with ninety days' notice only if the number of FTEs were reduced and Shell had not declared a milestone and was not "actively developing the Program Technology."[91]

This structure places the costly formal barrier of time on Shell's ability to exit opportunistically. Codexis could conceivably develop the technology significantly in that interim period and use Shell's resources to do it. The structure also makes it very difficult for Codexis to opportunistically pull out of the agreement if the collaboration succeeds, as Codexis has no at-will termination right if Shell goes forward with the project.

That amendment also included a formal exclusivity provision for the development of a particular fuel product created in the course of the collaboration.[92] By adding specific language about exclusivity with regard to a particular line of research, the contract formalizes a very high switching cost for Shell. If Shell were to seek another partner for that line of research, it would breach the contract with Codexis. One interpretation of this formal addition is that the informal switching costs were too low to deter opportunism with regard to a particularly valuable product, so the parties agreed to increase the switching costs formally. That this exclusivity was agreed upon in an ex post renegotiation makes sense because the parties would not want to lock themselves into a potentially inefficient relationship ex ante.

A subsequent amendment to the agreement, three years after the original agreement, updates the termination provision and increases the formalized switching costs.[93] The increase in formalized switching costs is the increase in time for Shell's pre-termination notice.[94] One might have expected that the switching costs would now be overwhelmed by the relationship-specific investment made over the past three years, such that additional measures need not be taken.

There are several possible interpretations of this action. First, this increase might just be a proportional increase in costs now that the

90. Amended and Restated Collaborative Research Agreement, *supra* note 64, § 11.2(a).

91. *Id.* § 11.2(b).

92. Amendment to the Amended and Restated Collaborative Research Agreement, *supra* note 83, § 2(k).

93. Amendment No. 2 to the Amended and Restated Collaborative Research Agreement, *supra* note 89, § 3.

94. *Id.* § 3(a).

stakes are higher and each party is investing more in what seems like a successful venture. That is, the net deterrent effect of this penalty might be the same as it previously was, adjusted for the parties' new investments in the relationship. For example, the informal switching costs of having learned about the partner and having some reputation at stake may peak at some point during the life of the transaction, or may start to experience diminishing marginal returns, just as the financial investment in the transaction is increasing at a higher rate. In such a case, the only way to calibrate switching costs to the increased investment is to add formal switching costs on top of the informal ones.

It is possible that these new formal costs may be a complete substitute for and crowd-out the informal costs. The mechanism for this crowding-out would be that the specified formal terms of the contract eliminate the need for trust or reciprocity between the parties, thus allowing whatever trust was built-up to wane. Additionally, reputational costs might be minimized because a breaching party could explain away the disagreement as an action within its contractual rights, which the other party bargained for at arms-length. This explanation would coincide with the empirical findings about formal terms crowding out informal deterrents, such as trust.

This crowding-out explanation fails to encompass several things about the braiding relationship that make the relationship resilient to such crowding-out. In a braiding relationship, there are several uncertain streams of information: technological, partner-related, bargaining power, and various types of market uncertainty that affect the future of the products created in the collaboration. The presence of a formal term related to one of those information streams may crowd out the informal there, but not in all other information streams. For example, formalizing the allocation of rights to a new invention may eliminate the reciprocity related to that particular product that previously existed in the relationship, but the informal trust and reputation attached to other elements of the collaboration seem likely to continue in the future. The crowding-out mechanism is not present there because that specific uncertainty has not been resolved and formally dealt with. One drop of formality does not poison the well of informal deterrents to opportunism.

Additionally, some informal aspects of the relationship seem to be resilient to crowding-out even within the same area of uncertainty that is being formalized. For example, this termination provision may eliminate reputational costs of breach, but it would not seem to eliminate the informal investment in having learned about one's partner in the collaboration. Finding a new partner would reintroduce the

uncertainty of the search for partners and their work style, reciprocity, etc. Perhaps even this uncertainty can be formally eliminated by identifying the proper approaches to respond to various contingencies in the collaboration, but such formalization of an uncertain collaboration ex ante is highly unlikely, unless a significant amount of that uncertainty is already resolved.[95] If such informal benefits remain after formal terms have been introduced, then instead of crowding-out the informal, formal terms complement or supplement the informal.

Second, Codexis may have learned that Shell was more likely to act opportunistically, in this case by seeking other partners, and so Codexis demanded and received additional protection in the form of higher formalized switching costs. The crowding-out analysis would be the same here, since the addition of a formal term is supplementing the informal costs of switching. The only difference between this interpretation and the first one offered is the motivation. Instead of ratcheting up switching costs to line up with increased investment, this interpretation suggests new external information that might induce Shell to leave the collaboration. Perhaps a competitor has reached a benchmark earlier than Codexis and Shell would rather partner with them, or a management change at Shell decreased the effectiveness of the informal switching costs. New management might have a different work style and preference for reciprocity, and formalizing switching costs could account for the decreased effectiveness of informal switching costs.

Third, it is possible that the parties formalized the exclusivity and switching cost terms because the relevant uncertainty has been resolved. When the uncertainty is resolved, the parties may be able to return to the traditional theory's binary choice of formal or informal contracting, depending on whether the resolution of uncertainty resulted in verifiable or observable behavior. In one sense, this interpretation is clearly right—some uncertainty has been resolved, such as the uncertainty of searching for a reliable partner, and there are verifiable pieces of information that lend themselves to formal contracting solutions. For example, a court could easily verify whether a party stayed true to its

95. For an example of a formal approach to shared responsibility and other partner characteristics, *see* Ex-10.67 Statement of Work Under the Technical Collaboration Agreement between Microsoft and Novell, SEC. & EXCHANGE COMMISSION (Nov. 2, 2006), http://www.sec.gov/Archives/edgar/data/758004/000119312510279391/dex1067.htm. This plan came into being after the parties had collaborated for four years, and the Work Plan refers to specific products that were developed in the course of that collaboration. I am not aware of any examples of contracts formally allocating responsibilities ex ante in an uncertain collaboration.

exclusivity obligation. Formalization may be a way to cordon off those parts of the collaborative relationship that have resolved uncertainty, such as a specific product line. The braiding mechanism remains, however, to deal with the residual uncertainty.

D. Nested Options and Dealing with Nested Uncertainty

Modifications to the Shell-Codexis agreement also reveal an interesting staging of options and uncertainty. At the time of the first amendment, it appears that some product was successfully developed in the course of the collaboration. The next step was to commercialize the product, and the amendment included a preliminary agreement to negotiate in good faith about that commercialization.[96] One can infer from this that Shell exercised its option on the IP produced, entering the relationship into the next stage. This introduces a new stage of uncertainty: collaboration with regard to commercialization. In a later amendment, the pattern of unfolding uncertainty and nested options was repeated: Codexis received an option of first negotiation for the manufacturing of this product.[97]

Even though the commercialization stage could be anticipated ex ante, and partially dealt with through mechanisms like milestone specifications and nested options, the agreement on commercialization was only specified after the development of a viable product. The terms are formal, but also low-powered, suggesting that even with a viable product, it did not make sense to fully articulate terms.

This failure to include a heavily fleshed-out nested options structure for each stage might be a function of drafting costs or of the parties' oversight,[98] but there is also another explanation. The nested options structure might only work for the types of uncertainty that can be known ex ante and might fail to prevent opportunism under any uncertainty that was not previously foreseeable. I name this unforeseeable uncertainty "nested uncertainty," because it appears to arise at stages after some uncertainty has resolved and the parties have exercised a round of nested options.

For example, the future of some products might be so uncertain

96. Amendment to the Amended and Restated Collaborative Research Agreement, *supra* note 83, § 2(k).

97. Amendment No. 2 to the Amended and Restated Collaborative Research Agreement, *supra* note 89, § 11.2(b).

98. *See, e.g.*, Oliver Hart & John Moore, *Incomplete Contracts and Renegotiation*, 56 ECONOMETRICA 755, 755 (1988) (describing parties' failure to negotiate complete contingent contracts—contracts that plan for every possible contingency—because of the complexity and drafting costs incurred in doing so).

that specifying future rights, even in option form, would be arbitrary. The research and development might produce a product solely for Shell's internal research use, for use in several commercial operations, or for broad retail use. Codexis' role as partner might also be uncertain under each of these scenarios. As a small start-up at the beginning of the agreement, it might not have the capacity to commercialize or manufacture any resulting products, but it may develop that capacity during the collaboration. If these things are uncertain, then trying to specify even a formal informational exchange ex ante would be difficult. Perhaps the parties could use general terms like options to good faith negotiation, but it might be impossible to specify the right trigger for such an option if the relation-specific investments at that stage are also uncertain.

Nested uncertainty might also be a function of uncertainty's positional relativity, discussed below in Part V. As the parties resolve uncertainty and gradually change their economic positions, new types of uncertainty might become relevant. For example, an innovation might end up catching on in an unexpected market after failing in the target market. This development might add uncertainty to the search for partners because the parties might have no prior experience with each other's behavior in that particular market. This kind of uncertainty, produced by the changing economic positions of the parties, might help explain why the nested options in the Shell-Codexis agreement seem to be low-powered. Instead of buying IP at a fixed price, the agreement here allows for an option to good faith negotiation about a particular purchase or involvement in a particular stage. The endgame solution depends on the parties' evolving relationships to uncertainty, and is not always susceptible to a formal solution like nested options with high-powered formal obligations.

III. FINANCING CONTRACTS FOR INNOVATION

A. Theoretical Predictions: Secured Credit and Contractual Structure

Before turning to the examination of the actual financing mechanism in this kind of collaborative partnership, I will discuss the standard theoretical frameworks for thinking about commercial financing and what those theories would predict in this situation. This way, it will be easier to see how the financing structure in this partnership deviates from the standard accounts. In this discussion of theory, I will focus primarily on the financing of the small collaborator. Although the financing of the big collaborator might be interesting in its own right, it is much harder to isolate the collaborative partnership from

the big collaborator's general financing, e.g. a mixture of public equity and debt, and perhaps a cash-flow based term-loan that covers all of the company's business operations, of which the collaboration may only be a small part.

The "puzzle of secured debt" provided the theoretical impetus for the theories that attempt to explain the operation of secured debt, and this puzzle remains a vexing thorn in the side of these theories.[99] The basic insight of the puzzle is that if secured credit is an efficient means of lending money, it should be ubiquitous.[100] Empirically, however, this is not the case, as unsecured credit is the preferred lending form in many sectors of the economy.[101]

The traditional theories each offer a partial solution to the puzzle. No theory has been able to offer a generalized solution based on the efficiency of secured credit, but bottom-up theories have offered compelling reasons for some context-specific uses of secured and unsecured debt.[102]

The uncertainty of an innovative collaboration presents a unique context in which to test these theories and examine the puzzle of secured debt. Although the theoretical implications that I draw from this context must be taken with a grain of salt, as they are potentially limited to this special context and inapposite when applied to theory more broadly, the special circumstances of uncertain collaboration allow for a theoretical distance that can help question some assumptions

99. *See* Alan Schwartz, *Security Interests and Bankruptcy Priorities: A Review of Current Theories*, 10 J. LEGAL STUD. 1, 1-2 (1981) [hereinafter Schwartz, *Security Interests and Bankruptcy Priorities*]; Alan Schwartz, *The Continuing Puzzle of Secured Debt*, 37 VAND. L. REV. 1051, 1052-53 (1984) [hereinafter Schwartz, *Continuing Puzzle*]; Alan Schwartz, *A Theory of Loan Priorities*, 18 J. LEGAL STUD. 209, 213, 243-47 (1989); *see also generally* Alan Schwartz, *Taking the Analysis of Security Seriously*, 80 VA. L. REV. 2073 (1994).

100. The formal argument behind this insight is basically an argument by analogy from the Modigliani-Miller Irrelevance Theorem with regard to capital structure. That is, in the absence of certain transaction costs like bankruptcy and tax, the capital structure of a firm has no effect on its efficiency. In the real world, those assumptions do not hold and so capital structure does matter. The argument about the form of financing, whether secured or unsecured, is much the same, except that it is very hard to defeat the irrelevance argument because the traditional justifications offered for security, like lowering the risk of default, can be directly offset in an unsecured loan by changing the interest rate. *See* Schwartz, *Continuing Puzzle*, *supra* note 99, at 1052-55.

101. *See, e.g.*, Lynn M. Lopucki, *The Unsecured Creditor's Bargain*, 80 VA. L. REV. 1887, 1920-24 (1994); Ronald J. Mann, *Explaining the Pattern of Secured Credit*, 110 HARV. L. REV. 625 (1997) [hereinafter Mann, *Explaining the Pattern*].

102. Mann, *Explaining the Pattern*, *supra* note 101, at 628-30 (using a decision-based model based on interviews with bankers and lenders in various industries and why they choose the type of financing that they do).

in the traditional theories.

The example of Codexis' financing agreement, as discussed below, undermines some of these theories' central assumptions.[103] The attributes of "secured lending" are severable, such that it makes little sense to speak of a monolithic concept of "secured lending" that includes collateral, remedies against that collateral, monitoring of debtor behavior and collateral, and other common features of security. Here, the secured lender does almost no monitoring and has almost no worthwhile collateral, relying instead on the other collaborating party to police opportunism and manage risk. This secured lender acts much more like an unsecured creditor, freeriding on the substitute monitoring of the collaborator, much like trade creditors do with a secured creditor under the traditional theory. Conversely, an unsecured creditor could theoretically act more like a secured creditor by having some monitoring role or having the power to call a default and cripple the debtor. Whether a creditor has a security interest does not appear to be the right categorization for an investigation of efficiency. Instead, one should ask the efficiency question of each severable component of lending and understand how they interact, perhaps as an endogenous function of technology and organization.[104]

Traditional corporate finance and secured credit theory offer a few predictive hypotheses about what kind of financing we would find for the small collaborator in this type of partnership. I discuss each hypothesis in turn.

1. Monitoring and Bonding

First, creditors are worried about, and will require protection against, debtor opportunism as a condition to lending. The canonical forms of debtor opportunism are asset substitution,[105] adverse

103. This Part discusses only the challenges to secured credit theory. Part V discusses the challenges to assumptions about uncertainty.

104. Ronald J. Gilson, *Locating Innovation: The Endogeneity of Technology, Organizational Structure, and Financial Contracting*, 110 COLUM. L. REV. 885, 888 (2010) [hereinafter Gilson, *Locating Innovation*].

105. Asset substitution occurs when a debtor enters the agreement, apparently engaged in a low-risk business, who switches to a high-risk business activity once the financing has been obtained. For example, a simple retail business might obtain financing and then switch to speculative day-trading. Without preventing this activity or otherwise adjusting terms of the loan for such a switch, the lender would be undercompensated for the risk taken on this loan. *See* George G. Triantis, *Secured Debt Under Conditions of Imperfect Information*, 21 J. LEGAL STUD. 225, 234 (1992) (describing various "wealth-redistribution" actions, including shifting the risk of a particular venture); *see also* David Gray Carlson, *On the Efficiency of Secured Lending*, 80 VA. L. REV. 2179, 2187 & n.21 (1994).

selection,[106] and moral hazard.[107] The creditor will likely require some form of monitoring or bonding, or both, in order to police these forms of debtor opportunism.[108]

Monitoring includes activities like valuing and tracking the collateral, such as inventory, to make sure that there is an adequate amount of collateral to recover if the debtor should default.[109] Monitoring also includes observing the debtor's behavior to make sure that no covenants are being breached.[110] For example, the lender will look for additional unpermitted indebtedness on the debtor's balance sheet or for entry into a riskier area of business.

Bonding includes giving the creditor a hostage, such as a piece of equipment necessary to run a factory, which the creditor can render unusable.[111] Other bonding mechanisms include negative loan covenants, unilateral termination rights, performance bonds, and other self-imposed restrictions.[112] By giving the lender the ability to cripple the debtor or go after the debtor's personal assets, the debtor has obviated the need for monitoring and substituted bonding.

106. Adverse selection is a hidden information problem. For example, the lender may think that a financially healthy debtor is on the other side of the bargaining table when that debtor knows that several judgment liens are about to be obtained on his assets. These liens would severely undermine the lender's ability to recover the amount of the loan based on the collateral. *See* Triantis, *supra* note 105, at 234 (discussing types of actions that redistribute wealth from creditors to debtors, including issuance of dilutive indebtedness).

107. Moral hazard is a hidden action problem. For example, after the loan has been obtained, the debtor may suffer financially and reach the brink of insolvency. Upon reaching that brink, it is in the debtor's interest to take on very risky projects with high returns because the lender bears most of the downside risk. *See id.* at 234 (discussing the risk of projects, the return to creditors and debtor, and the resulting incentives); Carlson, *supra* note 105, at 2186-87.

108. The discussion that follows draws heavily on Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 J. FIN. ECON. 305 (1976). Contractual covenants are another tool used in conjunction with monitoring and bonding to prevent opportunistic behavior, but I set these aside for the purposes of this analysis.

109. Schwartz, *Security Interests and Bankruptcy Priorities*, *supra* note 99, at 7 (describing the primary benefit of security as the ability to obtain and resell encumbered property to reduce debt); *see also* Mann, *Explaining the Pattern*, *supra* note 101, at 639 (stating that the direct advantage of secured lending is the ability to enforce repayment).

110. Mann, *Explaining the Pattern*, *supra* note 101, at 651-55 (arguing that collateral provides a means of focused monitoring by which the lender can more cheaply observe the debtor's behavior and minimize agency costs).

111. Other commentators refer to this concept as "creditor power," which serves as a deterrent to any debtor misbehavior. *See* Carlson, *supra* note 105, at 2188 ("When a debtor has the potential to misbehave, creditors are better off if they have [the] power to punish the debtor . . . creditor power intimidates the debtor into behaving better.").

112. Robert E. Scott, *A Relational Theory of Secured Financing*, 86 COLUM. L. REV. 901, 921 (1986).

In the specific example of Codexis, it is not readily apparent what specific forms of monitoring or bonding would be expected, but there are a few options. One might expect to see monitoring of the collaborative effort to ensure that valuable IP assets are not squandered or somehow secreted away from the lender's reach. If monitoring is too costly, especially where the direction of the collaboration is so uncertain and the very assets to be created cannot be specified ex ante, then a bonding mechanism would make sense. Codexis executives could offer personal guarantees or offer some piece of collateral which, if foreclosed upon or disabled, would cripple Codexis' operations. Where no physical assets are available and the IP is too uncertain to use as a hostage, this could perhaps be done by taking control of Codexis' cash flows, enabling the lender to starve Codexis of working capital if things go poorly.

2. The Secured Lender as "Cop on the Beat"

Second, the secured lender will usually engage in significant monitoring and act as the "cop on the beat,"[113] providing an informational public good that opens up space for unsecured creditors.[114] That is, it is usually the secured lender who has the greatest incentive and ability to monitor the debtor because the secured lender looks after the collateral, which may depreciate or disappear, and has to look to that collateral for recovery.[115] Unsecured creditors trust the secured lender's monitoring for these reasons and can provide lower-priced credit on trade accounts, inventory, equipment, etc.[116] In other words, there is some fixed amount of monitoring that must be done to lend money to a debtor efficiently, and that fixed amount can be borne by the least-cost monitor, resulting in the most efficient transaction. Duplicative monitoring is not necessary, but that monitoring cost can be split up among monitors, e.g. a manufacturer monitors its purchase-money goods while the general secured lender monitors other collateral.

Here, the secured lender does not have the luxury of being

113. Carlson, *supra* note 105, at 2189. Monitoring is not just as good because it provides information about the debtor, instead, "monitoring is advertising, threat, and intimidation. A monitor is like a cop on the beat, whose very presence deters crime." *Id*.

114. *See id.* at 2195 (describing the symbiotic relationship between secured and unsecured credit, and also noting how the risk of time with regard to repayment is better borne by the secured lender, also benefitting the unsecured lender).

115. *See* Levmore, *supra* note 7, at 57.

116. *See id.* at 50-59 (but also recognizing that under some circumstances, it may be most efficient to allow talented unsecured monitors to monitor the debtor because they will have the greatest incentive to monitor and deter debtor misbehavior).

oversecured or having a single asset to concentrate on. Instead, the primary assets of the debtor are IP rights that are still in development, which would seem to require a tremendous amount of monitoring. The secured lender, typically skilled in looking at financials and dealing with the common types of collateral within an industry, would seem to have an advantage in doing this intensive monitoring. Unsecured lenders then would trust the secured lender's monitoring and extend credit for other purposes, such as liquidity. In the collaborative setting, one might also expect the secured lender to do some monitoring of the collaborator because that collaborator is essential to the lender's successful repayment.

Alternatively, the nature of collaboration might severely resist granting a creditor leverage because that gives the creditor an incentive to push for more conservative business decisions instead of potentially valuable but riskier decisions.[117] In this situation, the debtor would rather have unsecured credit with a high interest rate, so that the debtor can better maintain control over its business decisions. In a transaction designed to produce a technological innovation amid risk and uncertainty, the conservatism and control which accompany granting great power to a secured lender seem inapposite.

3. A Relational Theory of Secured Lending

Third, under a relational theory of secured finance, security and collateral may be a way to deal with relational complexities that contract could not otherwise solve.[118] Generally, "[a] contract is relational to the extent that the parties are incapable of reducing important terms of the arrangement to well-defined obligations[,]" typically when contingencies cannot be foreseen or, even if foreseen, are too complex to manage ex ante.[119]

In the context of secured financing, this relational theory rejects the standard monitoring theory as too simplistic and instead argues that optimal development of projects and growth opportunities often requires an exclusive control relationship.[120] Creating such a relationship solely from formal contractual covenants would be very difficult, so the debtor sends a signal of credible commitment: he gives the creditor leverage by means of a secured loan on all assets, typically

117. *See* Mann, *Explaining the Pattern*, *supra* note 101, at 664-65.

118. *See generally* Scott, *supra* note 112.

119. *See* Charles J. Goetz & Robert E. Scott, *Principles of Relational Contracts*, 67 VA. L. REV. 1089, 1090-91 (1981).

120. Scott, *supra* note 112, at 951.

in the form of a "floating lien" which will automatically attach to after-acquired property in addition to all current assets.[121] The creditor then provides financial coordination and discipline, along with financing for the project and influence over the decisions for that project.[122] In short, secured credit is efficient because it gives both debtor and creditor an incentive equivalent to total ownership and control.[123]

Here, one might expect a "floating lien" on all of Codexis' assets and significant influence over the investment project by the lender. This relational mechanism of secured financing would be necessary because the underlying uncertainty of the transaction prevents the parties from articulating well-defined obligations ex ante.

4. A Bottom-Up Theory of Secured Lending

Fourth, a bottom-up theory would suggest that secured lending would be present as a way to avoid differentiation of incentives with regard to practical leverage in the relationship, concentrated monitoring, and the role of control and restrictive covenants.[124] The core insight of this theory is that different contexts require different methods of aligning the lender's and debtor's incentives, because having misaligned incentives can be quite costly.[125] Practical leverage is one such method used in secured credit: the borrower grants collateral to lower the risk of nonpayment by increasing the lender's ability to coerce payment.[126] Concentrated monitoring is another mechanism.[127] The lender focuses monitoring on one specific key asset so that it has an effective means to cripple the debtor without adding the transaction costs of monitoring all other assets.[128] Parties also have different incentives with regard to control: lenders want a stable debtor who can repay the loan, but debtors want growth and dislike supervision by a party who does not necessarily want the same result.[129] Where this differentiation is particularly stark, debtors will not choose secured credit.[130]

This theory prefers a contextualist analysis that is sensitive to the

121. *Id.* at 903.
122. *Id.* at 904.
123. *Id.* at 956.
124. Mann, *Explaining the Pattern*, *supra* note 101, at 630.
125. *See id.*
126. *Id.* at 639.
127. *See id.* at 650.
128. *Id.* at 650-51.
129. Mann, *Explaining the Pattern*, *supra* note 101, at 633-34.
130. *Id.* at 634.

significant transaction costs of secured credit.[131] It rejects the explanatory theories of exclusive relationship, signaling, and simple monitoring theories based on day-to-day financials.[132] Here, one would have to do a contextual analysis of the factors present in financing technological innovation. Technological innovation seems to be analogous to the software development context: secured lenders may have little interest in the actual assets, but they want some remedy that can cripple the debtor.[133] Further research into the various industries would be needed to confirm this hypothesis.

5. Endogeneity of Technology, Organization, and Financing

Fifth, a new theory tries to carve out a special understanding for the financing of technological innovation.[134] It eschews these traditional predictions and methods of thinking about financing solely in terms of a small set of variables, like opportunism and information costs. Ronald Gilson, in a recent essay, argues that financing, organizational structure, and technology are endogenous.[135] In trying to pin down the location of technological innovation, Gilson argues that there is a dynamic "three-dimensional" space with an endogeneity underlying those three dimensions.[136] That is, changing one feature of the model—technology, organizational structure, or financial contracting—changes the other features of the model.[137] For example, Gilson points to different sets of transaction costs and incentives to explain why some industries follow a joint-venture structure for innovation as opposed to in-house R&D or allowing a start-up to break off.[138] This understanding will require a more complicated function to explain secured credit than the functional relationships described by the other theories given above. The results under this theory are too

131. *Id.* at 682.

132. *Id.*

133. *See generally* Ronald J. Mann, *Secured Credit and Software Financing*, 85 CORNELL L. REV. 134 (1999) hereinafter Mann, *Secured Credit*].

134. *See id.* at 136-37.

135. Gilson, *Locating Innovation*, *supra* note 104, at 890.

136. *Id.*

137. *See id.*

Technology influences informational asymmetries and transaction costs, which in turn—theory tells us—influence organizational form. A fully formulated account should therefore be able to predict which forms of innovation generally will take place, for example, within startup companies financed by venture capital, within the research labs of existing large companies, or through cooperation among separate entities.

Id.

138. *See id*. at 894-95.

preliminary to make any strong predictions, and this article hopes to add another data point with the Shell-Codexis relationship.

B. The GECC-Codexis Loan Agreement: Opportunism Analysis

Codexis, the small collaborator in our prototypical contract, is a public company with three sources of financing: public equity, internal funds, and private secured debt.[139] From the financials and management discussion in the most recent 10-K, one can see that the collaborative relationship with Shell accounts for approximately two-thirds of Codexis' annual revenue.[140] The other third comes from product sales and a license agreement with another company, Maxygen.[141] When the secured loan was originally made, this data about revenue streams was not available, as the Shell-Codexis collaboration was just beginning. For now, I will assume away the uncertainty of the collaboration that characterized the situation ex ante. Instead, I will focus solely on the risk of debtor opportunism. After dealing with opportunism, I will return to the more complicated problem of lending into such a collaboration under uncertainty.

Given that the arrangement with Shell seems so essential to Codexis' success, one would predict that the secured lender would take great care in monitoring that relationship or otherwise ensuring its continued viability. At the very least, the secured lender would have a collateral-based exit strategy if the partnership fell apart, but prior literature on innovation has suggested that when IP is the primary asset of a company, particularly a company specializing in technological innovation, such collateral exit strategies are unavailable because the lender cannot easily liquidate the IP or support its income-generating operations.[142] Alternatively, the secured lender would have some option to drive a stake through the debtor's operations and shut them down, such as control agreements on all accounts with any debtor cash flow.

The secured lending agreement between Codexis and General Electric Capital Corporation (GECC) exhibits none of these characteristics and at first glance, is quite puzzling.[143] There is some

139. *See* Annual Report on Form 10-K for Codexis, Inc., SEC. & EXCHANGE COMMISSION (Feb. 10, 2011), http://www.sec.gov/Archives/edgar/data/1200375/000119312511030827/d10k.htm#tx148586_10.

140. *Id.* at 59.

141. *Id.* at 62.

142. *See* Mann, *Explaining the Pattern*, *supra* note 101, at 137-38.

143. *See generally* Loan and Security Agreement between General Electric Capital Corporation, Oxford Finance Corporation, and Codexis, Inc., SEC. & EXCHANGE

minimal amount of monitoring and use of collateral here: the lender requests regular financial statements and has a security interest in everything except the intellectual property.[144] There are also some standard covenants against debtor opportunism, such as limiting other indebtedness and prohibiting mergers and acquisitions without prior consent.[145] But the lender's only rights with regard to the critical asset, the IP, are a security interest in any monetary proceeds that come to Codexis from the partnership and a non-exclusive license in the IP that is subordinated to Shell's exclusive license.[146] The lender also appears to have no monitoring mechanism for the collaboration with Shell, and no additional bonding mechanism, like a personal guarantee from a primary owner or the ability to destroy the collaboration. How is the lender protected here? There seems to be no policing of a dynamic, uncertain partnership that is the primary means of paying back the lender, and it is not as if there is some safe, valuable asset lying around that does not need close monitoring, like a huge swath of real estate. Without monitoring, the lender cannot determine whether the debtor is misbehaving, transferring away wealth or adding on dilutive debt, or otherwise wasting away the collateral that could provide the lender some recovery. In the case of default, this lender could end up receiving no additional protection from the security interest and end up in the unenviable position of a general unsecured creditor struggling to recover anything.

One means of explaining this lending structure is that Codexis (or Shell) was not willing to grant any control or monitoring over the collaboration, so GECC offered this loan at a very high interest rate to account for the risk when there is no monitoring, no collateral exit strategy, and no certainty of cash flow. If the collaboration fails, the lender is left with almost no recourse, but the lender will have been compensated for that risk ex ante by the higher interest rate. If the collaboration succeeds, the lender will get paid off from the IP proceeds.

The interest rate in the Loan Agreement is redacted as confidential, so I do not know if this was the attempted solution, but theory suggests that this solution is not optimal. Even a higher interest rate will not be sufficient to police moral hazard without additional covenants

COMMISSION (Sept. 28, 2007), http://www.sec.gov/Archives/edgar/data/1200375/000119312510076663/dex101a.htm.

144. *Id.* at 7, 16.

145. *Id.* at 20-21, 22.

146. *Id.* at 9, 28.

preventing opportunism within the collaboration.[147] From the option perspective, the debtor will have incentives to bet on increasingly risky projects as insolvency and failure loom closer. Here, Codexis could take a particularly daring direction in research, effectively "gambling on resurrection,"[148] with GECC bearing the downside costs.

The key to understanding this Loan Agreement is to look beyond the traditional model of the secured lender as primary monitor. The big collaborator, Shell, is the one doing all the monitoring and policing of the collaboration. Shell has the right incentives for this and has all of the tools it needs to police opportunism. Shell's equity investments, time investment in the project, opportunity cost of working with other potential partners, and the FTE payments to Codexis all point to Shell wanting this collaboration to succeed. Shell monitors the relationship by necessity: it works side by side with Codexis on the research every day. There is also credible force behind this monitoring: the milestone and nested option structure gives Codexis strong incentives to succeed, and disputes can be taken to committee. The switching costs, increasing as the partnership develops, also point to a greater investment by Codexis in this relationship and hence less incentive to destroy it with opportunistic behavior.

Here, the secured lender relies on that monitoring, just as unsecured creditors rely on secured lenders in traditional transactions. Given the structure of the relationship between the big and small collaborators, the secured lender can trust the big collaborator's monitoring. As long as there is a "cop on the beat" with adequate power to back up his monitoring, then the primary risk of debtor misbehavior will be eliminated.[149] David Gray Carlson, in defending the efficiency of secured credit, described the relationship between the monitoring secured lender and unsecured creditors as symbiotic:

> To be sure, unsecured creditors may exist within this model. They are

147. *See* Credit Lyonnais Bank Nederland, N.V. v. Pathe Commc'ns Corp., No. 12150, 1991 WL 277613, at *34 n.55 (Del. Ch. Dec. 30, 1991) (reprinted in 17 Del. J. Corp. L. 1099, 1155 n.55) (using the option perspective to show that the corporation's incentives do not align with the creditor's incentives when the corporation is in the zone of insolvency).

148. "Gambling on resurrection" is a common description of the incentive for extreme risk-taking that a debtor faces on the eve of insolvency. *See, e.g.*, Joseph E. Stiglitz, *Bankruptcy Laws: Basic Economic Principles*, *in* RESOLUTION OF FINANCIAL DISTRESS: AN INTERNATIONAL PERSPECTIVE ON THE DESIGN OF BANKRUPTCY LAWS 1, 9 (Stijn Claessens et al. eds., 2001). From an option perspective, the debtor has much to reap from the upside of such a gamble and the creditors, absent bankruptcy law protections, would be left bearing the downside. *Id.*

149. Carlson, *supra* note 105, at 2188, 2192-95.

> the suppliers of inputs. But the security interest just described does not increase the risk these suppliers face. On the contrary, the secured creditor is supplying the working capital that gets these suppliers paid. These unsecured creditors are not in conflict with the secured creditor. Rather, these creditors have an entirely symbiotic relation. So conceived, unsecured credit has more to do with convenience of payment than with the formation of productive capacity.[150]

The relationship between the big collaborator and the secured lender here is much the same. The big collaborator is the "cop on the beat" who eliminates the risk of debtor misbehavior, allowing the secured lender to infuse working capital into the collaboration.

C. Implications of the Substitute Monitoring Hypothesis

This hypothesis that a collaborating partner will take on the brunt of the monitoring responsibility and the secured lender will rely on that monitoring has significant implications for the traditional theories of secured credit and for a recent normative theory recommending symmetry in creditors' rights, which primarily concerns incentives with regard to monitoring.[151] I will refer to this hypothesis as the "Substitute Monitoring Hypothesis."

Richard Squire's normative theory of symmetry in creditors' rights provides a useful starting point for understanding how the Substitute Monitoring Hypothesis affects traditional monitoring theory. Squire posits that secured lending has two effects which often work at cross-purposes: an insulating effect and a focusing effect.[152] The insulating effect is the shifting of nonpayment risk onto unsecured creditors, because the secured creditor now has collateral to look to for recovery.[153] The unsecured creditor then has greater incentive to monitor because the size of the secured creditor's deficiency claim affects the unsecured creditor more than the secured.[154] The focusing effect is the secured lender's bargain of monitoring collateral in exchange for a priority claim, by which the secured lender's recovery is determined to a greater extent by the value of a particular asset pool.[155]

---

150. *Id.* at 2194.

151. *See generally* Richard Squire, *The Case for Symmetry in Creditors' Rights*, 118 YALE L.J. 806 (2009). I will discuss below Squire's normative suggestions for secured lending and evaluate them in the context of substitute monitoring.

152. *Id.* at 850.

153. *Id.* (citing Thomas H. Jackson & Anthony T. Kronman, *Secured Financing and Priorities Among Creditors*, 88 YALE L.J. 1143, 1143 (1979)).

154. Squire, *supra* note 151, at 850.

155. *Id.* at 819, 850; *see also* Levmore, *supra* note 7, at 56-57.

Because the grant of a security interest typically contains both of these effects, Squire argues that the secured lender's deficiency claim should be subordinated so that the effects no longer work at cross-purposes and monitoring is optimal.[156]

The Substitute Monitoring Hypothesis provides further evidence of the severable effects of security and monitoring. Traditional monitoring theory mistakenly assumed that secured credit had only a few, inflexible packages to offer: various degrees of monitoring by the secured lender or unsecured lender, or if monitoring was too costly, a higher interest rate or bonding. Squire insightfully severed the two different monitoring incentives that a security interest creates and suggested a way for the law to change and align those incentives for the secured lender.

Squire does not go far enough: in recognizing the severability of monitoring incentives, he limits his analysis to the incentives of a single party.[157] Those incentives, however, can be optimally allocated among different parties. In the example of this collaboration case study, Shell takes the role of focused monitor—its success is directly tied to Codexis' success. GECC, as secured lender, takes on the insulating effect, if any exists here, by having its recovery tied to the cash flows from the collaboration.[158] Here, where there is no definite separation of recovery based on a pool of assets and both parties are relying on the success of the whole for recovery, monitoring incentives for Shell are optimized and the secured lender can rely on a substitute monitor.[159]

156. Squire, *supra* note 151, at 852.

157. Squire considers the possibility of substitute monitoring by contractual agreement, but argues that this would increase monitoring costs and might suffer from collective action problems, especially with groups of unsecured creditors that have small individual claims. *Id.* at 824 n.48. Also, the creditors who are not doing the monitoring have to deal with the added agency costs of the appointed monitor, who presents another risk of opportunism and misbehavior. *Id.* While this argument is theoretically correct for a one-off transaction, it ignores the practical reality of loan syndicates that typically appoint one lender as an administrative agent or collateral agent in an asset-based lending facility. The increased agency costs that Squire identifies become much less important in the context of a group of repeat-players, where information costs related to learning about a lender's creditworthiness are amortized over time and reinforced by informal reputational sanctions for misbehavior. Additionally, loan syndication provides an element of diversification that can eliminate some of the specific risks associated with individual misbehavior.

158. It is possible that GECC's recovery does not come from any privileged pool of assets, such as the FTE payments or royalty cash flows, as those cash flows are byproducts of the pool of assets that determines Shell's recovery.

159. Squire might object here that GECC now has to worry about the agency costs of Shell and Shell's misbehavior. It is certainly possible that a collaborator may loot the venture or otherwise misbehave and harm the lender's recovery. But here, the braiding mechanism in the contract between the collaborators solves this problem. Basically, the

This example opens the theoretical possibility that other severable attributes could be taken on by different parties. For example, one could have substitute bonding, which would substitute the effect of a "cop on the beat" for the effect of a hostage in plain view. If the debtor gives over a hostage and the taker of that hostage has the power to execute the hostage, then it does not matter much who the hostage-taker is. Any hostage will provide the debtor with incentive to behave properly, and if the hostage situation is readily accessible or reliable for others, then they can treat the debtor accordingly.

The important lesson for traditional monitoring theory is that the superficial labels of "secured," "unsecured," or even "creditor" do not necessarily indicate which party is responsible for which severable part of monitoring or bonding. The better analysis looks at the underlying information streams and incentives of each party. This analysis provides additional support for insights previously made in the literature, such as the effectiveness of the public equity and debt markets in monitoring corporate misbehavior, and the consequent prevalence of unsecured debt at public companies.[160]

The Substitute Monitoring Hypothesis can also help refine relational financing theory. The original theory focused only on the relationship between debtor and creditor, and it was this relationship that had elements of contractual incompleteness and exclusivity. But where there is a contractual incompleteness problem, as there is with uncertainty, that problem may be avoided by reconfiguring the deal. Instead of the secured lender entering into a relational contract with the debtor, the collaborative partner can do so. The secured lender can then lend against a different kind of risk—the exogenous success of the collaboration—and specify obligations, such as traditional lending covenants, to seal the deal. This point is closely linked to the argument below about the relativity of uncertainty and how positional changes can affect the substance of a transaction.

Ronald Mann's bottom-up theory is generally supported, but also expanded by the Substitute Monitoring Hypothesis. The focus on contextual analysis leaves the door open for instances such as this. Mann separated out the benefits and costs of security, and his theory can be extended, much like Squire's, to include third parties that may take on some of those costs and benefits. In other words, the contextual

small collaborator is also monitoring the big collaborator and has some contractual protections to prevent opportunism. If the collaborators keep each other in check, the third-party lender has nothing to worry about, except perhaps some remote risk of the collaborators colluding to defraud the lender.

160. Mann, *Explaining the Pattern*, *supra* note 101, at 673.

analysis should not be limited merely to the secured and unsecured creditors, but also to other parties who may take on concentrated monitoring or other roles traditionally reserved for the secured creditor.

As for the effect of this Hypothesis on Gilson's endogeneity theory and the puzzle of secured debt, it is too early to tell. The Substitute Monitoring Hypothesis contributes another data point and some understanding of the information costs involved in a big company-small company collaboration, which helps shade in a tiny corner of the map of innovation that Gilson challenges scholars to complete. The puzzle of secured debt has not been solved, as there is still no general theory of the efficiency of security; but refining the analysis by severing monitoring and recovery may pave the way for some progress on this front.

IV. SECURED LENDING INTO COLLABORATION AND THE RELATIVITY OF UNCERTAINTY

Even after the monitoring problem is solved, however, another problem remains. If we strip away the assumption that we know the revenues that come from the collaboration, we face an ex ante situation of lending against an uncertain partnership. That is, the development of the technology and the combination of partners in this collaboration are both characterized by Knightian uncertainty instead of by risk.[161] Risk is quantifiable and can be rationally allocated, but allocation of uncertainty is inherently arbitrary.

This problem of uncertainty is why braiding contracts pair informal and formal methods of contracting. One would predict a similar braiding structure between the collaborator and the secured lender. The lender might use low-powered formal mechanisms to set up information exchanges and monitor the borrower. There might be nested options to take security interests or IP licenses in assets as they are developed in the collaboration. In other words, the hypothesis is that the uncertainty inherent in braiding collaborations is fractal and every transaction that touches the underlying uncertainty of innovation is expected to mirror the braiding solution to that uncertainty.

A. The Puzzling Absence of Braiding in Secured Loans

But, in practice, there does not seem to be any braiding mechanism between the secured lender and the small collaborator. There are no contract referee mechanisms and nested options, nor informal terms

161. *See generally* KNIGHT, *supra* note 9.

about the parties' obligations. The loan agreement is a formal secured-lending agreement with clear rights, obligations, and remedies for each party. This kind of agreement cannot solve the uncertainty problem.[162] Any interest rate or similar attempt at rational calibration would fall prey to the same arbitrariness that plagues any risk-allocation effort under Knightian uncertainty. Ex post reallocation would seem to be a natural remedy for this problem,[163] and renegotiation is certainly possible, but this formal contract clearly puts the renegotiation power in the hands of the lender. The secured lender has the power to foreclose on the collateral, inflict pain on the debtor,[164] and, here, has little if any relation-specific investment, since the big collaborator is the one doing the monitoring. The debtor has almost no power, except the spectral threat of lender liability if the lender refuses to provide funds.[165] If the parties planned on ex post reallocation as a solution, it seems strange that the contract would be constructed ex ante in a way that rigs the odds in the lender's favor.

Another potential solution to this puzzle is that the big collaborator not only eliminates risk, but also eliminates uncertainty. If the braiding contract acts as a solution for the collaborating parties, perhaps it somehow eliminates the uncertainty for other parties. Such a solution would be nice, but I cannot imagine a mechanism that solves this fundamentally uncertain event.[166] This braiding relationship will not

162. A formal agreement cannot solve the uncertainty problem in this contract because formal solutions require verifiability of behavior and some way to specify that behavior and verification ex ante. This contractual specification is not possible in the context of an uncertain innovation.

163. *See, e.g.*, Charles F. Sabel & William H. Simon, *Minimalism and Experimentalism in the Administrative State*, Columbia Law Sch. Pub. Law & Legal Theory Working Paper Grp., Paper No. 10-238 (2011), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1600898 (arguing for experimentalism's virtues in dealing with regulation under uncertainty).

164. *See* Mann, *Explaining the Pattern*, *supra* note 101, at 177 (discussing how secured lenders who finance software companies use a termination remedy to cripple debtors who default).

165. *See, e.g.*, K.M.C. Co. v. Irving Trust Co., 757 F.2d 752 (6th Cir. 1985).

166. Some uncertainty problems can be solved by finding a way to access the information that would enable a risk calculation. One example, in the military context, is the use of military intelligence to plug informational gaps. Hugh Jones, *How the U.S. Army Analyzes and Copes with Uncertainty and Risk*, 23 J. APPLIED CORP. FIN. 34 (2011). Some uncertainty problems, however, cannot be solved because the necessary information is unavailable and the only option here is to use an "action-focused solution" that enables the relevant actors to plan for and adapt to uncertainty as it arises in real time. *Id.* Here, technological innovation and the other uncertain elements of the braiding relationship seem insusceptible to further information-gathering ex ante, so the contractual mechanisms of braiding focus on guiding actions to deal with uncertainty as it is gradually resolved.

produce the information necessary to allay the uncertainty until further along in the relationship. The collaborators themselves are still operating under radical uncertainty, perhaps for years, until the technology starts to take shape and the collaborators learn about each other. The uncertainty, however, does not need to be eliminated to solve the secured lender's problem.

If uncertainty is relative to the party perceiving it, then the solution to the puzzle might be that there is no uncertainty problem at all for the secured lender. Although uncertainty is typically defined as a fundamental state with regard to a particular event, an uncertain event might be re-characterized as a risk-based event when seen from a different perspective. The collaborators are dealing with the uncertainty of technological innovation and its direction. The secured lender, however, is dealing primarily with a different event. The salient risk for the secured lender is the exogenous risk of a successful technological innovation, whatever that innovation turns out to be. This risk is the kind of thing that one can rationally lend against.[167]

The actual economics of the loan are a bit more complicated than the simplistic bet on success discussed above.[168] The exogenous risk of success is probably the key risk for repayment of the loan, but there are other factors that play into the risk of payment default. The collaboration is producing periodic payments to Codexis for its dedication of FTEs, which might alone be sufficient to handle repayments in the early stages of the loan.[169] There is also a time constraint on the success of the venture: it must succeed within the term

Perhaps the relativity analysis suggested in this article is itself an informational solution, but it strikes me as being merely a different objective that requires different information.

167. As an analogy, consider how insurance companies price their policies based on actuarial tables. An individual's cause of death is in one sense uncertain and determined by innumerable variables. But insurance companies do not bet that a particular individual will die in an automobile accident instead of from heart disease. The insurance company has changed the terms of the bet to time of death, not manner, and so avoids the uncertainty of the manner of death, even if the manner of death plays a role in the risk-calculus (e.g. a smoker dying of a related illness).

168. In the discussion of the loan that follows, I focus exclusively on repayment and cash flow. The lender will also care about policing debtor misbehavior, and the loan agreement includes standard covenants against debtor opportunism. The collateral under the loan agreement might also suffice as a means of repayment, but I have suggested above that the collateral in this deal probably does not provide such a repayment exit strategy.

169. *See* Amended and Restated Collaborative Research Agreement, *supra* note 64, § 3.3 (requiring periodic FTE payments by Shell to Codexis). Unfortunately, the financial information about the payments and the loan structure is redacted, so the importance of such payments to the loan is unclear.

of the loan, and not after.[170] This time constraint is likely to be practically defeasible—the big collaborator might make payments to keep the lender on board if success is not too far off, or the lender and small collaborator could renegotiate to extend the term. In any event, the loan lies somewhere on the spectrum of a cash-flow deal based on FTE payments to a pure bet on the success of the collaboration within a specific timeframe.

Let me try to illustrate this informational relativity with a simple example of betting on a baseball game. One bettor might want to bet on a series of events, such as whether a certain player hits for the cycle or how many pitches the starting pitcher will throw. Another bettor bets simply on the over/under score of the game. The first bettor cares about a slew of uncertain events that are all internal to the game and work together to produce the circumstances that determine the things he bets on. Those same events might affect the overall score, but the second bettor need not worry himself about those details and can rely on a few salient details in assessing whether he has made a good bet. The baseball game has some uncertain elements to it and some risk-based elements to it. By filtering out or otherwise not focusing on the uncertain information streams, one can make a risk-based bet on the game. In this way, Knightian uncertainty is relative.

The relativity of uncertainty does not mean that there is no objective framework for determining how risk and uncertainty are perceived from different positions. On the contrary, understanding this positional relativity helps to provide an objective explanation of these transactions.[171] It is not merely some subjective feeling that determines whether one is dealing with a risky or an uncertain event. Rather, the party's economic position and the information that he needs to act on that position determine whether the party perceives risk or uncertainty with regard to a particular event. Further research in information economics or industrial organization might be able to determine what characteristics of information streams and economic positions determine the positional switch from uncertainty to risk (and perhaps risk to uncertainty). It is also not clear whether one in a particular economic

170. That is, if the venture is not successful early enough to keep pace with its debt repayment schedule, then the lender, in order to recoup its losses, will have to either modify the agreement or seek to collect on the defaulted debt.

171. Einstein's theory of relativity, for example, was an attempt to create an objective theory of physics that could reconcile apparently divergent and relative experiences of simultaneity, such as the divergent perceptions of two observers of a lightning strike when one observer is stationary and the other aboard a moving train. *See generally* ALBERT EINSTEIN, RELATIVITY: THE SPECIAL AND GENERAL THEORY (1920).

position has a fixed or mutable perception. That is, can one re-characterize a particular uncertain event as a risky one, thereby avoiding the problems associated with acting under uncertainty? This perceptual pivot is what may have occurred here: the secured lender might have seen the uncertainty problem with having an asset-based loan facility and so switched to a cash-flow structure based on the overall risk of the collaboration's success.

B. A Portfolio Theory Explanation of the Relativity of Uncertainty

Although the intuitive explanations given above about the relativity of uncertainty give some foundation to the intuition, portfolio theory can provide a more rigorous explanation of this phenomenon. [172] Portfolio theory is a tool of financial economists used to analyze risk and decision-making by investors holding a variety of investments.[173] For example, one of the normative dogmas of portfolio theory is that an investor should hold a diversified portfolio.[174] Diversification, or holding many different investments that are imperfectly or negatively correlated, nearly eliminates the specific risk of the individual investments, leaving the investor with the systematic risk of the market.[175]

The analogy in this context is that the secured lender may hold a diversified portfolio of risks and uncertainties, such that specific uncertainties are eliminated and only systematic risk and uncertainty remain.[176] For example, the big collaborator cares about the outcomes

172. My thanks to Richard Squire for the suggestion of portfolio theory as an explanation for the relativity of uncertainty.

173. Harry Markowitz, *Portfolio Selection*, 7 J. FIN. 77, 77 (1952) (inventing portfolio theory and describing basic principles of portfolio construction).

174. RICHARD A. BREALEY, STEWART C. MYERS, & FRANKLIN ALLEN, PRINCIPLES OF CORPORATE FINANCE 185-90 (2011).

175. *Id.* at 185-87.

176. Financial economists have focused on questions of portfolio choice when some systematic uncertainty (also called ambiguity) remains. *See, e.g.*, Larry G. Epstein & Martin Schneider, *Ambiguity, Information Quality, and Asset Pricing*, 63 J. FIN. 197, 197 (2008). Epstein and Schneider find that systematic ambiguities in information remain after diversification and ambiguity-averse investors discount expected returns accordingly. *See id*. This remaining systematic uncertainty can also be a product of uncertain information about specific risk of a firm's fundamentals, suggesting that even specific risks or uncertainties do not fully disappear in the process of diversification. *See id.* This argument, however, does not impugn the portfolio explanation of uncertainty's relativity and diversification. My argument also recognizes that specific uncertainties will determine the states which govern the set of contingent payouts for the lender, and that this set of payouts may require additional compensation compared to a set of payouts without such specific uncertainties. As discussed below, the point is that the diversified lender cares *only* about that resulting systematic risk or uncertainty and not the details of the specific risk or

of specific uncertainties, such as which type of technology is produced in the collaboration. The specific technology might have added value if there is some synergy with the big collaborator's business, and it might have less value if the big collaborator merely co-invented a new product that has no such synergy with its business.

The secured lender does not care about those specific uncertainties if they wash out in the larger scheme of things. The lender has a set of future payout scenarios. This set of payouts has an upside cap—the lender will only be repaid the amount of the loan and any interest on that loan. In this sense, the lender does not care in which manner the collaboration is successful or, beyond a certain point, how successful it is. The lender cares only about the risk of that full payout, as opposed to various scenarios of default or suboptimal recovery on the loan. Although the contingent states that determine the various payouts and the probabilities associated with those states are necessarily determined by specific uncertainties, the portfolio of uncertainties within a specific transaction may wash out the specific uncertainties and allow a general risk assessment without regard to them. As a crude example, the secured lender might know that ten percent of these kinds of collaborations produce a successful product and lend on terms in accord with that risk assessment.[177]

In some deals, there is insufficient diversification of risks and uncertainties within the individual borrower-lender relationship. One could see lenders take on the specific risk and uncertainty of such borrowers and be compensated accordingly, but the lending market, as is the case with stock market investors, has found diversification at the lender or investor level to be cheaper than compensation for specific risk. For example, in asset-based financings of risky, private, small businesses, lenders group together in syndicates to diversify away the risk of individual borrowers. The set of payouts on these loans is highly contingent on the borrower's specific risks, evidenced by the customization of these loans and the tying of revolving loan amounts to specific future events and benchmarks.[178] By spreading that specific risk

uncertainty. The collaborators, on the other hand, must deal with the details of specific risk and uncertainty.

177. A related point is that the specific uncertainties might be such outliers that no statistically significant or salient information is historically available about them. As such, folding them into the risk analysis is distortive or arbitrary. The problem with the lack of attention to outliers is that some uncertainties have fat-tailed distributions and do, in fact, tip the scales significantly in one direction.

178. *See generally* Elliott Asarnow, *Corporate Loans as an Asset Class*, 22 J. PORTFOLIO MGMT. 92 (1996) (describing revolving loans and loan syndication with regard

across many lenders in a syndicate, lenders with portfolios of such loans minimize their exposure to that specific risk.

C. Implications for the Role of the Business Lawyer

Ronald Gilson, in a seminal article on the role of business lawyers, argued that business lawyers create value in transactions by acting as "transaction cost engineers."[179] A "transaction cost engineer" is one who, through structuring the deal, reduces the deviation of practical reality from capital asset pricing theory.[180] This reduction of variance and risk adds value to the transaction and justifies the use of business lawyers to save on that transaction cost.[181]

The deviation from the capital asset pricing model arises because the assumptions of that model do not hold in the real world and the deal must be adjusted accordingly. For example, the assumption of investors' homogeneous expectations does not hold in the typical case of an acquisition agreement because the buyer and seller do not share the same outlook on the risk of the business being transferred.[182] The transactional lawyer can fix this problem and reduce the deviation from the pricing model by using a particular contractual mechanism: an "earnout" provision, which allows the buyer and seller to determine the price of a particular asset by its performance after the sale, thus avoiding the disagreement about the risk of the business's future.[183]

Uncertainty is another deviation from the assumptions of the capital asset pricing model, and so provides an opportunity for transactional lawyers to add value by closing the gap between theory and practice. The contractual mechanisms of braiding are one way to accomplish this for collaborating parties. The contract referee mechanism, nested options, switching costs, and bargaining power mechanisms all allow parties to avoid ex ante specification of uncertain contingent states. Instead of arguing about innumerable contingencies inherent in the innovative process, parties can agree to certain mechanisms that will settle these disputes when the information necessary to settle them is available.

The relativity of uncertainty offers new ground for transactional

to borrower risk, but only discussing portfolio theory and diversification by comparing corporate loans to other asset classes, like stocks and bonds).

179. Ronald J. Gilson, *Value Creation by Business Lawyers: Legal Skills and Asset Pricing*, 94 YALE L.J. 239, 255 (1984).

180. *Id.*

181. *See id.* at 253-55.

182. *Id.* at 262.

183. *Id.* at 263.

lawyers and businesspeople alike to reduce transaction costs and avoid intractable informational problems. The lawyer can avoid casting a lending agreement in terms of the uncertain assets to be created in the collaboration, and can instead structure the deal as a cash-flow loan with the superstructure of a collateral-based secured loan. By relying on a substitute monitor, the lender can avoid the monitoring costs it would incur on a collateral-based deal. The legal construction of "full-time employees" as a determinant metric of cash payments is what enables the collaboration between Shell and Codexis to be financed as a cash-flow deal through a security interest in those payments.

Where lawyers are faced with an uncertainty problem, they should look to legal tools like those involved in the braiding collaboration and its financing to avoid the informational transaction costs associated with that uncertainty. By using creative constructions like "full-time employees" or low-powered formal mechanisms, lawyers can move beyond the traditional task of minimizing risk deviation to minimizing the impact of uncertainty. Additionally, lawyers should use the insight from portfolio theory that there may be specific uncertainties or risks that may be diversified away.[184]

Lawyers might also be able to come up with transactional solutions to a set of uncertainty problems that has received tremendous attention after the financial crisis and in other areas, such as environmental regulation.[185] A fundamental regulatory problem is how to deal with thin-tailed and fat-tailed catastrophic uncertainties, and how to tell which type of tail the uncertain problem has. This insight holds also in transactional uncertainty—a certain contingency might have a thin- or fat-tailed distribution. The drafting and other transaction costs might or might not be justified by which distribution the parties are facing. For example, the parties would likely not spend money on lawyers negotiating how to allocate risk as to thin-tailed catastrophes, such as who gets the IP rights to an innovation spurred by the transfer of technology from extraterrestrials. They might, however, want to deal with various fat-tailed uncertainties related to the development and commercialization of an innovative product. Or they might not know which distribution they are facing and use a low-powered formal

184. Businesspeople in a particular industry have probably already developed best practices for diversifying risk, such as through loan syndication or the lender's own portfolio of borrowers. It is possible, however, that in the negotiation of the deal, there may be *legal* specific risks or uncertainties that arise and should be brought to the attention of the businesspeople. Lawyers might also be able to solve such legal specific risks and uncertainties through creative transactional structuring.

185. *See generally* Daniel A. Farber, *Uncertainty*, 99 GEO. L.J. 901 (2011).

mechanism that allows the parties to determine that information and deal with it accordingly, through subsequent modifications or informal measures. Such contracting solutions might be especially valuable in financial innovation transactions, such as collateralized debt obligations, which had unforeseen fat-tailed distributions upon the occurrence of a drastic drop in housing-market prices.[186]

The lawyer's ability to use legal tools like contractual mechanisms to deal with uncertainty also opens up the possibility for opportunism related to these tools. In the context of the financial crisis, this was seen in the newly apparent form of debtor opportunism called "correlation-seeking."[187] One can also conceive of braiding opportunism: somehow rigging the low-powered formal mechanisms to favor one side. For example, an experienced venture capital firm might use nested options to acquire uncertain IP rights from a poorly represented entrepreneur at an extremely cheap price. The business lawyer will also be tasked with minimizing the costs of this new avenue for opportunism.

CONCLUSION

This initial foray into relationships beyond the core braiding relationships seems to suggest that braiding is not fractal and ubiquitous where there is uncertainty. Instead, it is the party's position with regard to specific uncertainty problems that will determine the solution. This discovery can help us be more careful when discussing uncertainty by separating out specific uncertainty problems and understanding how they interact. Further research into the application of portfolio theory to this problem might help us predict when positional relativity will occur, and, possibly, when pivoting from an uncertain position to a risk-based position is possible.

186. *Id.* at 955.

187. Richard Squire, *Shareholder Opportunism in a World of Risky Debt*, 123 HARV. L. REV. 1151, 1152, 1153 (2010).