

**INFORMATION EXPLOITATION
AND INTERORGANIZATIONAL SYSTEMS OWNERSHIP**

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ABSTRACT

We develop a model based on the theory of incomplete contracts for how ownership structure of interorganizational systems (**IOS**) can affect information exploitation and adoption. Our model yields several propositions that suggest the appropriate strategic actions that a firm may take when there is potential for IOS adopters to question whether adopting the IOS will be value maximizing. We analyze and illustrate the related strategic thinking in a real world context involving a financial risk management IOS. We present a case study of the ownership and spin-off of RiskMetrics, developed by New York City-based investment bank, J. P. Morgan, in the late 1980s. The firm first gave RiskMetrics to its correspondent banking, treasury and investment clients for free, in the context of its clearing account relationship services. Later, the bank spun off the product to an independent company which offered fee-based services. We model the bank's clients in terms of their heterogeneous portfolio risks, and their effects on the value a client can gain from adopting the technology. We also examine the value they may lose if their private portfolio risk information is exploited. A key roadblock to the adoption of the free service may have been the potential for strategic information exploitation by the service provider. When Morgan spun off RiskMetrics with multi-party ownership, wider adoption occurred. Our theory interprets this strategic move as an appropriate means to maximize long-term profits when information exploitation may occur.

KEYWORDS: Economic theory, financial risk management, incomplete contracts, information sharing, information systems, interorganizational systems, ownership, value-at-risk.

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INTRODUCTION

Interorganizational systems (**IOS**) play a central role in today's business environment, facilitating interfirm transactions in various industries [1]. Especially, information sharing through IOS is very important in ensuring proper execution of the transactions. However, there often exist risks of a firm's information getting exploited by its business partners [5] because such information exploitation is not easily observable or verifiable by a third party (e.g., a court). The risk of information exploitation can sometimes impede adoption of IOS. IOS ownership structure (i.e., who owns the IOS) is important because it affects the owner firm's incentives for IOS-related efforts [12] including information exploitation. In this paper, we develop a model based on the theory of incomplete contracts for how ownership structure of IOS can affect information exploitation and adoption in the context of financial risk management.

Over the past decade, financial risk management has become increasingly important in the financial industry, due to financial disasters in the mid-1990s, such as the bankruptcies of Barings Bank and Orange County [10]. Poor financial controls and risk management have been blamed for these disasters. Among a number of different risk management methodologies that were introduced in the past two decades, "Value-at-Risk" (**VaR**), developed by New York-based J. P. Morgan Bank in the late 1980s for its own internal purposes, has been the most widely accepted by various kinds of financial and non-financial institutions. VaR provides a summary measure of portfolio risk expressed in a probabilistic statement that can bundle together the individual risks of many different kinds of financial instruments and risk positions observed in financial operations.

Morgan provided a free risk management service, which it called “RiskMetrics,” to promote VaR among its clients. RiskMetrics is an IOS that receives data on a financial services firm’s portfolio of risk positions (e.g., credit risks for loan borrowers, credit risks for letter of credit holders, overnight risks related to changing currency rates and derivative securities prices). It generates a measure of portfolio risk in terms of possible loss of value. In 1998, Morgan spun off RiskMetrics by founding an independent software and consulting firm called the RiskMetrics Group, with participation from several other financial services firms, and the international news organization and digital financial quote vendor, Reuters.

Despite the initial impact and interest in the underlying technological innovation and the new financial risk management concepts, RiskMetrics was not adopted by a majority of Morgan’s clients, even when the service was free. How the service would be owned played a critical role in creating inertia with its adoption. Because Morgan was the owner, its clients and potential clients expressed concerns about the possibility that their private information (e.g., the details of their firm-wide risk positions, the overall nature of their portfolios, and specific risks related to individual borrowers, financial instruments or industry sectors) might be exploited or “poached” [5] by Morgan, which could be detrimental to their financial performance. Also, after the spin-off, though the RiskMetrics service was no longer free, more firms adopted it. They perceived that there was less risk—and possibly even no risk of information exploitation by the service provider. Thus, the spin-off was a move by Morgan to increase adoption, recognizing the risks that its clients perceived and increasing their willingness-to-pay for RiskMetrics.

Prior research in Economics and Information Systems (IS) offers a number of potential paths for bringing the appropriate theoretical insights to bear in order to shed light on how senior managers should think about technology adoption strategies for IOS in the presence of possible

information exploitation by an IOS vendor or related product or service provider in an IOS context. We develop a game theoretic model to explain how changes in the ownership of a leading strategic IOS affected the observed behavior of the clients of the IOS and vendor. To accomplish this, we will build on the theory of incomplete contracts, principal-agent theory, and perspectives on strategic information sharing. We address the following questions:

- ❑ What theoretical perspectives are effective in helping us to understand the managerial issues associated with maximizing the value of IOS ownership when the potential IOS adopters perceive risk of information exploitation?
- ❑ How can the different theories aid us in explaining what happened with technological innovations and their ownership in the financial risk management arena? More specifically, can the theories we employ justify the rationale behind Morgan's decision to spin off RiskMetrics, beyond other arguments of increasing equity prices in a burgeoning stock market, or a desire to cash out on a new technological innovation? Can we show that spinning off RiskMetrics was value maximizing?
- ❑ What is the mechanism by which the spin-off positively affected clients' adoption? What can we learn about the underlying dynamics of the market for the financial risk management technology innovation?

The analysis that we develop in the remainder of this paper is intended to address these high-level questions, so we can provide guidance to senior managers about the various settings in which IOS adoption takes place, but that are subject to inertia based on the possibility of information exploitation.

THEORETICAL BACKGROUND

We next look at the theory of incomplete contracts to examine the role of ownership structure,

principal-agent theory to analyze the basis for opportunistic behavior and information exploitation, and the various perspectives in the literature on strategic information sharing. These three areas of the literature help us to identify the multiple bases for the formulation of a new theoretical model that will support value-maximizing strategic decision making in the technology adoption contexts that we have described.

Incomplete Contracts and Bargaining

Based on the general observation that contracts are incomplete and should be revised and renegotiated [27], Grossman, Hart, and Moore (in [11] and [13]) proposed the *theory of incomplete contracts*, which underscores the importance of making appropriate decisions about asset ownership to ensure profit maximization for the firm. One important concept is that of “observable but non-verifiable” variables. Hart and Moore [13] argue that some variables (e.g., quality, investments, and benefits) are not verifiable by a third “party” (e.g., court), even though they may be observable by the parties involved in the contract. These variables are said to be “non-contractible” from the point of view of the parties (or the firms) involved. This means that the parties cannot enter into a contract based on the outcomes that are related to these variables. As a result, they must divide the value that is produced through their use of the assets based on their relative bargaining power.

A popular solution concept for distributing surplus when competing firms are involved is the *Nash bargaining solution*. This involves splitting the incremental value 50:50 between the two firms involved in a bilateral relationship. For example, Hart et al. [14] examined public and private ownership for prison services using the Nash bargaining solution for division of the surplus between the service provider and the customers. In a similar vein, Clemons and Kleindorfer [6] applied Nash bargaining in a model of firms’ investments in IOS and value

sharing among the participants. We will use the generalized Nash bargaining solution for the division of surplus between the service provider of the IOS (i.e., Morgan Bank and the RiskMetrics Group) and each client that agrees to use it.

The theory of incomplete contracts focuses on how ownership structure affects the firm's incentives for making non-contractible investments. This determines the total value that can be created. The theory is relevant in the financial risk management IOS service context that we will discuss. This is because there are non-contractible variables, such as the quality of the VaR service, the related technology investments, and the resulting benefits. Also, who owns the service (i.e., Morgan or RiskMetrics Group, in this case) will affect the service provider's incentive to engage in information exploitation, and this, we believe, can be detrimental to the customers of the service, and ultimately, to the effect organization of such services in the industry.

Principal-Agent Theory

Principal-agent theory is concerned with the presence of asymmetric information between the principal and agent. The agent usually has private information that the principal does not know [24]. In a standard principal-agent problem, the principal does not know the action or have the ability to observe the effort of the agent. This is the moral hazard problem: the principal's utility depends on the agent's action. But the principal cannot induce the agent to make the first-best (i.e., socially optimal) level of effort. Instead, the principal can only observe some results or outcomes that relate to the agent's action. The clients of a financial risk management system's services can be regarded as the principals and the service provider as the agent. In addition, we expect that asymmetric information regarding the actions or efforts of the service provider will exist. In our case study context, the customers of RiskMetrics were concerned about the

possibility that their private portfolio and position risk information might be exploited by the provider of the RiskMetrics service because Morgan's actions were not perfectly observable.

Information Sharing and Misappropriation

Information sharing has been an important research topic (e.g., [17]), and a number of studies have shown that information sharing between firms can create significant value. For example, by sharing buyers' sales and inventory information, a supplier can improve demand forecasting and production planning [26]. At the same time, the risk of misappropriation of information or "poaching" has been an important area of research because shared information can be used by one party to the detriment of the other beyond a contractual relationship [5, 7, 8]. For example, Clemons and Hitt [5] suggest that there are increasing risks of poaching in such areas as outsourcing information systems development or information technology-intensive service operation (e.g., call centers, data processors) that involve a substantial amount of the client firm's private information shared to the third party. In the finance literature, Pagano and Jappelli [23] examined the factors that affect lenders' incentives to share information about borrowers.

Information sharing is the essence of financial risk management methodologies like VaR, and financial risk management IOS like RiskMetrics. As more firms share information about their portfolio, the financial risk management tools can provide better benchmarking data for risk measurement which, in turn, enhances the quality of the VaR measures that the system generates. The IOS networking capabilities make it possible to do this nearly in real-time. Therefore, it is important for the firms that participate to have the proper incentives to share their information. However, as we mentioned earlier, their incentives can be significantly reduced if they perceive a risk of their information being exploited by the service provider.

FINANCIAL RISK MANAGEMENT AND RISKMETRICS

We now turn our efforts toward developing case study insights on innovations in technology and analysis methods for effective financial risk management that occurred in the 1990s. This will set the stage for our modeling-based analysis of information exploitation and value-maximizing IOS ownership structure in the case of RiskMetrics. We will explain why financial risk management has become important, what led to the innovations that occurred, how RiskMetrics came into existence, and how the ownership structure of RiskMetrics has changed over time. We also briefly explain how financial risk management systems work by describing major elements of a VaR-based risk management system. This will aid the reader in understanding where the potential arises for information exploitation.

Financial Risk Management

Financial risk management is defined as “the process by which various risk exposures are identified, measured, and controlled” [18]. There are various kinds of risks (e.g., business risks and non-business risks), and in this research we focus on financial risks that are related to possible losses in financial markets (especially losses due to interest rate changes that affect the value of financial instruments and foreign currency, as well as the value of lending portfolios). Financial risk management became important due to the increased volatility of financial markets over the past few decades, beginning with the Black Monday crash in 1987 of the New York Stock Exchange and the NASDAQ Stock Exchange. More recently, financial risk management concerns arose amidst the financial turmoil in Asian economics in 1997. In addition, the deregulation of financial markets and globalization drastically increased competition among financial institutions, which made them—and more importantly, their regulators—realize the importance of managing financial risks to ensure the health of their institutions and the broader

global financial economy.

The importance of effective financial risk management also was underscored by several financial disasters in 1990s. Some of them include the infamous names of firms and municipal governments—Barings Bank of the Netherlands, Orange County in California, and Daiwa Securities of Japan—which inflicted more than a billion dollars of losses upon unfortunate investors and shareholders. One of common causes identified in later reports, analyses and regulatory announcements was poor financial risk management policies and systems. The series of losses led to an industry-wide realization of the need to properly measure and manage financial risks.

Value-at-Risk and RiskMetrics

Fortunately, however, innovations in financial analysis capabilities for risk management and IT were already in process. During the early 1990s Value-at-Risk (**VaR**), the proprietary financial risk measurement methodology of J. P. Morgan, became widely recognized as a new and effective method to quantify a portfolio's risk. VaR was developed internally in the late 1980s by the bank for the purpose of improving its own internal risk controls. This was in line with Morgan's longstanding reputation for effective risk controls, careful lending practices, and attractive returns on its financial assets.

VaR is defined as “the worst expected loss over a given horizon under normal market conditions at a given level of confidence” [18]. It provides a single numeric measure of portfolio risk across multiple financial instruments and portfolios. For example, suppose that the “daily VaR” of a trading portfolio of derivative securities is US\$20 million at the 95% confidence level. This means that there is 5% chance, under normal market conditions, for a loss of \$20 million to occur. In contrast to nominal risk measures (which measure the amount of money that is loaned,

or the amount of foreign currency whose value is subject to change), VaR provides an aggregate view of a portfolio's risk that accounts for leverage, cross-instrument correlations for value changes when markets experience shocks, and a firm's current positions. VaR is viewed as a forward-looking way to measure risk, since it offers senior managers a means to interpret the extent to which losses may accrue from future shocks to their business.

One of the key factors that prompted the widespread adoption of VaR by firms during the mid-1990s was the offering of a product called "RiskMetrics"—a financial risk management service that J. P. Morgan offered free of charge to its clients from 1994 on to promote VaR as a risk management tool.¹ At the time, VaR was used by some leading financial services firms (especially large foreign banks in New York City), but mostly unheard of among the less sophisticated players and non-financial firms. The launch of the RiskMetrics service was successful especially because of the timing: firms were gravely concerned about financial risks after witnessing the financial disasters.

RiskMetrics has three basic components: market risk measurement methodologies, volatility and correlation data sets used in the computation of market risk, and software systems that implement the methodologies [16]. Morgan provided clients with a technical document which could serve as a reference for the statistical estimation methodology for market risk, as well as detailed documentation about the analytics that generate the data sets. These were published

¹ We recognize that characterizing RiskMetrics as being offered totally "free of charge" fails to recognize that large money center banks have a relationship management practice in support of their wholesale clearing account business which may "bundle" together elements of the services offered. Typically, the "all-in" bundle will be made more attractive to the clearing account or investment services client because high volume services are specifically priced out (e.g., funds transfer, check clearing, lines of credits, end-of-day investments of idle funds), while low volume or new services are not. We think it is appropriate to view RiskMetrics as being "free" in the sense that it was typically introduced into existing relationships, with no requirement that the client explicitly pay a fee. Still it required the typical kinds of supporting IT investments that you might see in IOSs for supply chain management or financial reporting. We thank Rajiv Dewan for pointing out this distinction to us.

daily on Morgan's Web site. The quality of the RiskMetrics service also was improved by Morgan's R&D investments. For example, the technical document explaining the details of how VaR worked was revised several times to provide better information for the clients, and the methods used were expanded from interest rate-sensitive financial instruments and market risk to the evaluation of different kinds of risks involving credit and loan quality. (This innovation would later be released separately as "CreditMetrics," initiating the offering of a family of high-powered IOS-based tools for financial risk management.)

In October 1998, Morgan spun off its risk products group as an independent software development and consulting firm. The resulting firm is called the RiskMetrics Group (www.riskmetrics.com). The quality of the service improved substantially under the ownership of the RiskMetrics Group, and the scope has expanded from market risk and credit risk to include wealth management. Also, the RiskMetrics Group provides even more comprehensive market data, with over 50,000 historical time series. Today, over 450 financial institutions all over the world are using the service. The current shareholders of the company include American Express, DB Capital Venture Partners, the Intel 64 Fund, J.P. Morgan Chase, Procter & Gamble, Reuters, and Sony. The company's market risk solutions have the three main components as did its predecessor, the free RiskMetrics service. (See Figure 1.)

Figure 1. RiskMetrics' Market Risk Solutions



Source: Overview material from the RiskMetrics Web site, www.riskmetrics.com/market_risk.html. Accessed on April 16, 2004.

When Morgan wholly owned RiskMetrics, its clients were concerned about potential exploitation of their private financial information. The following excerpt from a Harvard Business School case on RiskMetrics provides strong evidence of market perceptions of this risk of information exploitation:

"[T]he [RiskMetrics] group could benefit from an independent relationship to Morgan for several reasons. The financial software business would have more room to grow because clients (i.e., other financial firms) would feel more secure in their transactions; as a subsidiary of Morgan, Morgan's own competitors were not likely to confide sensitive financial data to the risk management group [at Morgan]." [22, pp. 2-3]

How would exploitation of information occur in this setting? As an example, Morgan might use its clients'—who are also very large-scale borrowers of loaned funds in the interbank capital market—portfolio information to adjust the lending rate made available to them for overnight loans. Morgan would have the incentive to raise the interest rate it charges if the borrower's portfolio appears to have become riskier. Morgan might also share its clients' private information with other lenders, creating additional impetus for changing the borrower's cost of

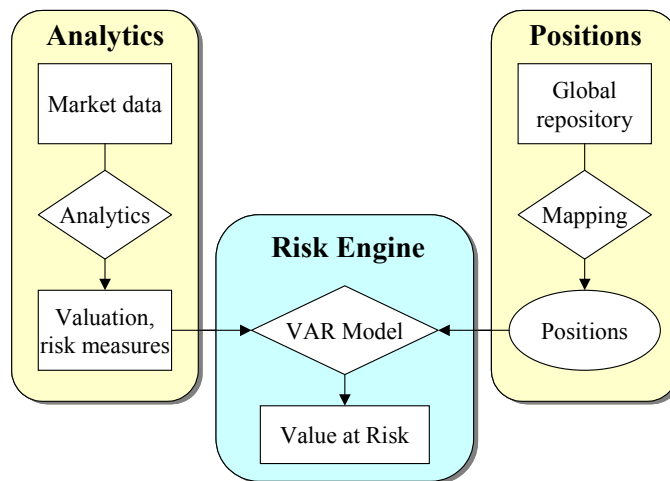
capital.² In addition, access to competitors' portfolio information would put Morgan at a significant advantage over its competition in formulating strategies. The clients' and competitors' concerns were substantially reduced when RiskMetrics was spun off. When that happened, the service provider was the lender no longer. As a result of the third-party ownership of RiskMetrics by the new RiskMetrics Group, market-wide perceptions have shifted. No longer was information exploitation a matter for serious concern. This is because under third party ownership with multiple shareholders, even if one of the shareholders had an incentive to exploit the clients' information, other shareholders would not have allowed it to happen.

Financial Risk Management Systems

Recently, enterprise-wide risk management systems have become a key area for strategic IT investments. They enable firms to take a portfolio approach to risk, which can produce diversification benefits and lead to the more efficient allocation of capital. A typical VaR-based risk management system consists of three parts: the *analytic platform* that collects and filters market data, the *positions platform* that serves as a global repository for all trades, and a *risk measurement engine* that integrates analytics and positions with a VaR model to create a measure of market or credit risk or both [18]. (See Figure 2.)

² Long-used *relationship-based methods* for sharing information about middle-market corporate and correspondent banking accounts involve indications in telephone calls or face-to-face meetings of actual outstanding loans or a willingness to lend in general terms (for example, "OK to lend, high-seven figures, long-term and low-seven figures 180-days revolving credit") to a firm. Lack of a reciprocal response from the other party is often a signal that triggers additional fact-finding and investigation to establish whether credit problems may be occurring. RiskMetrics provides information of much greater precision in the context of market risk, and makes it possible for information about changing risk levels to be brought to the attention of a relationship manager, who may change the willingness of the bank to provide as much support for risky transactions (or charge more for the same level of support as before). Once this happens, it is only a matter of time before the information is transmitted to the marketplace, and other lenders shift their approach and loan pricing to the now-riskier firm. In this sense, the use of an IOS like RiskMetrics makes the market much more efficient in terms of the discovery and transmission of risk-related information. This helps to make the market more resistant to failure, however, the riskier firm may face greater pressures due to the use the technology, compared to the days when all of information transmission about these issues occurred over "bankers luncheons."

Figure 2. Components of a VaR-Based System



Source: Adapted from Jorion [18].

After deciding to implement a risk management system, institutions must decide whether to develop the system in-house or to purchase an off-the-shelf system from an outside vendor. Although in-house development can offer more flexibility and integration with existing systems, outside systems are preferred by most institutions because of the immediate functionality that the systems offer, lower costs, and the vendors' expertise. However, some institutions that view risk as a strategic aspect of their business or that need a high level of customization resort to in-house development.

A MODEL FOR EXPLAINING OWNERSHIP STRUCTURE CHANGE

We next define our notation and the assumptions for a model to explain what drive the ownership structure changes in IOS for non-contractible services and how the changes might affect the behavior of a service provider and its clients, when there is the possibility of information exploitation. Then, we analyze the service provider's optimal investment levels and the clients' adoption decision in a free service case and fee-based case. This analysis is intended to address some of the issues that arise in the J. P. Morgan RiskMetrics case, which involves

alternative ownership structures of the financial risk management IOS and their impact on the information exploitation by the service provider and the adoption by its clients—clearing account customers and also lending clients, subject to the risks of transitorily higher lending rates when private portfolio risk information is exploited.

Basic Setup and Modeling Notation

We use the theoretical perspective of governance structure for non-contractible services, suggested by Hart, et al. [14], to develop a game-theoretic model for the service provider's investment decision and the borrowers' adoption decisions. We will refer to J. P. Morgan or the RiskMetrics Group as “the service provider,” and the financial services clients who adopt the financial risk management service as “the borrowers.” In our model, there is a single service provider of the risk management system, denoted by s , and multiple borrowers, indexed by b . The parameter b represents the relative “riskiness” of a borrower's portfolio, which is uniformly distributed in the interval $[0,1]$. Larger values of b represent riskier borrowers.

To understand the impact of the ownership structure change for RiskMetrics, we consider two cases: *free service* and *fee-based service*. In the former, the financial institution (i.e., Morgan) is the service provider and offers the service free of charge. In the latter, a third party (i.e., the RiskMetrics Group) is the service provider; it charges a fee for the service.

There are two kinds of non-contractible investments that the service provider can make: e and i . Investment $e \in [0, \bar{e}]$ corresponds to the service provider exploiting the borrowers' private information for the service provider's own benefit. This information exploitation occurs because the borrowers' portfolios exhibit different levels of risk. We call this an *information exploitation investment*. This investment gives the service provider a benefit, $u(e) \geq 0$. This benefit is increasing at a decreasing rate in e and satisfies $u(0) = 0, u'(0) = \infty, u'(\bar{e}) = 0$. For simplicity, we

assume that the cost of investment is the investment itself, e . This investment has an adverse effect on borrowers, $a(e)$, which is increasing at an increasing rate and there is no effect when there is no investment, $a(0) = 0$. The function $a(e)$ plays a critical role because it measures how much borrowers get hurt by the service provider exploiting their private portfolio information.

As we mentioned earlier, information exploitation by Morgan might hurt the borrowers through the repricing of short-term capital available to them. When Morgan learns about the increased risk of its clients' portfolio, it may increase the overnight lending rate available to them, for example. Also, this is likely to be a signal to the rest of the market, which will follow suit in increasing their lending rates to the borrower. This will increase the borrowers' cost of capital. On the other hand, Morgan can gain by making its loan pricing more efficient based on the updated risk information about its clients. This benefit to Morgan is reflected in $u(e)$. In addition, Morgan may be able to benefit more from the repricing of its overnight loans relative to other lenders because it could act before the rest of the market did based on the private risk information about its borrowers.

Investment $i \in [0, \bar{i}]$, which we call a *quality enhancement investment*, increases the quality of RiskMetrics service by $q(i) \geq 0$ at the cost of i . $q(i)$ is increasing at a decreasing rate and satisfies $q(0) = 0, q'(0) = \infty, q'(\bar{i}) = 0$. The cost i includes the monetary cost and intangible costs associated with quality enhancement of the financial risk management service. For example, the service provider may change its internal processes or train employees to provide better service in addition to investing in the software. So investment i can be viewed as an R&D investment.

$V^* b$ denotes the value a borrower b gets from the “basic” service without quality improvement. This means that as a borrower's portfolio becomes riskier, the borrower can gain more from the service. This value is assumed to be the same whether the service is free or fee-

based. For example, V^*b might be the borrower's benefit from allocating its capital more efficiently and effectively, based on VaR measures that RiskMetrics provides. C is the one-time cost of adoption, which is assumed to be identical for all the borrowers and can be viewed as the net present value of the costs that borrowers incur over time, including the costs of integrating their internal systems with the RiskMetrics system. P denotes the price of the basic service in the fee-based service case, which is the same for all borrowers. We assume, without loss of generality, that the service provider's cost of providing the basic service to each adopter is zero. Π_b and Π_s represent borrower b 's net benefit and the service provider's profit from a single adopting borrower respectively. We use superscripts f and p to represent the free service case and the fee-based service case. (See Appendix A for summary of notation.)

Timing and Assumptions

Our model consists of three periods. (See Appendix B.) At Date 0, each borrower decides whether to adopt the service based on the expected benefit, and if a borrower chooses to adopt, it writes a contract with the service provider (Morgan or the RiskMetrics Group). As we mentioned earlier, this contract can only be an incomplete one; it is not possible for the firms to write down contractual provisions that deal with every contingency. At Date 1, the service provider chooses the levels of the two types of investments. Finally, at Date 2, the value is shared through bilateral bargaining between the service provider and each borrower. Therefore, there are n bargaining pairs. These bargaining pairs are assumed to be totally independent: the service provider's investment decision and the borrower's adoption decision in each pair do not affect the decisions in other pairs. We adopt the generalized Nash bargaining solution, in which the surplus distribution can be asymmetric [2], for surplus distribution in each pair. In the fee-based service case, we assume that the price has already been determined by the service provider

before Date 0, and so we do not analyze its pricing decision.³

We make the following assumptions.

- **ASSUMPTION 1 (BARGAINING OVER QUALITY ENHANCEMENT BENEFITS):** *Only the benefits of the quality enhancement investments, $q(i)$, are subject to bargaining at Date 2, and the borrower's share of $q(i)$ in bargaining relative to the service provider is greater in the free service case.*

This means that Date 1 investments are sunk, and $u(e)$ and $a(e)$ affect only a single party, the service provider and a borrower in each case. The borrower's share of $q(i)$ is assumed to be greater in the free service case because when the service was offered free of charge, the borrowers might not suffer as much loss as in the fee-based case if bargaining breaks down, which would reduce the service provider's hold-up power. Another important reason is that the RiskMetrics service was bundled as a value-added feature to its clearing account and treasury advisory service, the Morgan's main services.

The consequences of information exploitation, $a(e)$ and $u(e)$, are not subject to bargaining, however. Why? Information exploitation will be implemented by the service provider (i.e., Morgan) even in the absence of *ex post* renegotiation, because the benefit accrues solely to Morgan. However, quality enhancement will not be implemented, because no payment from the borrower will be forthcoming. Only the additional surplus (i.e., quality enhancement) from the renegotiation is subject to bargaining. In other words, $a(e)$ and $u(e)$ will be part of the default payoffs of the borrower and the service provider respectively. (Hart et al. [14] use a similar modeling setup. The interested reader should see that paper for additional details.)

- **ASSUMPTION 2 (INFORMATION EXPLOITATION EFFECTS):** *The effects of information exploitation investment are proportional to the relative risk of the borrower, b , from the point of view of the service provider.*

This assumption implies that the riskier a borrower is, the greater the adverse effect of the

³ Treating price as given is common in the incomplete contracting literature. We do this because we primarily are interested in the impact of ownership structure on investment incentives.

service provider exploiting the portfolio information (e.g., adjusting the overnight lending rate or sharing information with other lenders), and the greater the service provider's gain from the exploitation. For the sake of simplicity, we multiply $a(e)$ and $u(e)$ by b .

- **ASSUMPTION 3 (NO INFORMATION EXPLOITATION CASE):** *There is no information exploitation problem in the fee-based service case.*

This is because in the fee-based service case, the owner of the service is no longer the lender, but a third party (in this case, the RiskMetrics Group) with multiple shareholders.

Assumption 3 is central to our model and we provide the following justification. Under third party ownership with multiple shareholders, even if one of the owners (e.g., Morgan) has an incentive to exploit or resell the clients' risk information, other owners (e.g., Reuters) would not allow it to happen. This is because that kind of practice would significantly degrade the value of the service and impede adoption of the service, which, in turn, will substantially reduce the value that the owners can extract from the third party's operation of RiskMetrics. Under third party ownership, there still may have been some risk perceived by the borrowers. However, we believe the risk was much smaller compared with the perceived information exploitation risk under the sole ownership of Morgan. It also turns out that including information exploitation in the fee-based case does not affect our qualitative results, so long as the risk under third party ownership is smaller than that under Morgan's sole ownership. We further assume that both the service provider and the borrowers are risk neutral.

We evaluate the model backward from Date 1 in both cases. We first analyze the service provider's investment decision, and then the borrowers' adoption decisions. We look at the first-best (e.g., socially optimal) situation, where everything is contractible as a benchmark. This might be a situation where the service provider and each borrower can write a complete contract on each other's actions and consequences, and then share the gains based on the contractual

terms. In this case, for each relationship pair, the service provider and the borrower together would choose e and i to maximize the total net surplus from their relationship:

$$\max_{e,i} \Pi(e,i) = V \cdot b - C - a(e) \cdot b + u(e) \cdot b + q(i) - i - e \quad (1)$$

With standard assumptions of convexity, concavity and monotonicity of the benefit and cost functions for each relationship pair, there exists a unique solution (e^*, i^*) that satisfies the following two first-order conditions:

$$b[-a'(e^*) + u'(e^*)] = 1 \quad \text{and} \quad q'(i^*) = 1 \quad \forall b \quad (2)$$

Because $b \in [0,1]$, we need a technical assumption, $u'(e) - a'(e) \geq 1$, to ensure that Equation (2) always has a solution.

Analysis of the Free Service Case (Before Spin-Off)

Service Provider's Investment Decision. Assuming generalized Nash bargaining over the benefit from quality improvement in each relationship pair, the borrower and the service provider's profits are:

$$\Pi_b^f = V \cdot b - a(e) \cdot b - C + \alpha \cdot q(i) \quad \forall b \quad (3a)$$

$$\Pi_s^f = u(e) \cdot b - e + (1 - \alpha)q(i) - i \quad \forall b \quad (3b)$$

where α represents the borrower's share of the surplus from bargaining relative to the service provider (i.e., Morgan), and $0 < \alpha < 1$. The service provider chooses e and i to maximize its profit Π_s^f . With the unique solution (e^f, i^f) , the corresponding two first-order conditions are:

$$u'(e^f) \cdot b = 1 \quad \text{and} \quad (1 - \alpha)q'(i^f) = 1 \quad \forall b \quad (4)$$

Because the borrowers' riskiness affects the service provider's equilibrium investment in information exploitation effort, we write $e^f(b)$. Due to the concavity of $u(e)$, the riskier a

borrower is, the higher the service provider's information exploitation investment, and therefore,

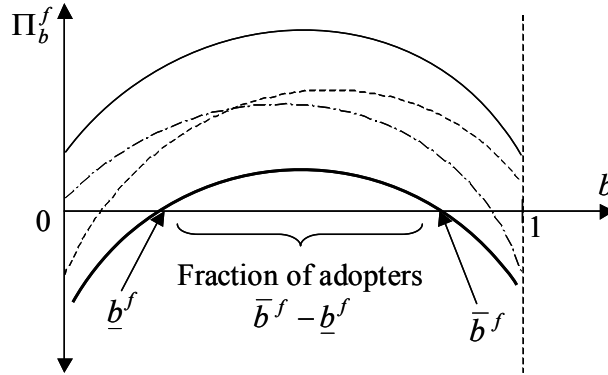
$$\frac{\partial e^f(b)}{\partial b} > 0.$$

Borrowers' Adoption Decisions. Because the borrowers' relative riskiness affects the equilibrium level of e , a borrower's net benefit function becomes:

$$\Pi_b^f = V \cdot b - a(e^f(b)) \cdot b - C + \alpha \cdot q(i^f). \quad (5)$$

Because $a(e)$ is convex and e^f is an increasing function of b as discussed above, the benefit function is concave under a mild assumption. (See Appendix D for the proof of this assertion.) Given the concavity of the benefit function, there are four possible cases in terms of where the function assumes zero values. (See Figure 4.)

Figure 4. Possible Adoption Patterns for Free Service



Note: There are four possible cases in terms of where the function assumes zero values due to concavity.

We focus on the case where no adoption occurs at both extremes of riskiness, that is,

$\Pi_b^f(b=0) < 0$ and $\Pi_b^f(b=1) < 0$ will be true. Using Equation (5) and rearranging the terms, we get

$$C > \alpha \cdot q(i^f) \quad \text{and} \quad a(e^f)|_{b=1} > V - C + \alpha \cdot q(i^f). \quad (6)$$

Let us represent the two marginal borrowers who are indifferent between adopting and not adopting RiskMetrics as $\bar{b}^f$ and $\underline{b}^f$, where $\underline{b}^f < \bar{b}^f$. Equation (6) states that borrowers who are

less risky than $\underline{b}^f$ will not adopt RiskMetrics even though it is free. This is because the value they get from the service is too small to offset the adoption costs. Those borrowers who are riskier than $\bar{b}^f$ also do not adopt. This is because the risk of their information being exploited (i.e., $a(e)$) is so large that the net benefit becomes negative. So the fraction of borrowers who adopt RiskMetrics will be $\bar{b}^f - \underline{b}^f$.

Analysis of Fee-Based Service Case (After Spin-Off)

Service Provider's Investment Decision. There are two important distinctions from the free service case: there is a price, P , charged for the basic service; because now a third party with multiple shareholders owns it, the service provider does not make information exploitation investment e . So, assuming generalized Nash bargaining over the gains, the parties' profits are:

$$\Pi_b^P = V \cdot b - P - C + \beta \cdot q(i) \quad \forall b \quad (7a)$$

$$\Pi_s^P = P + (1 - \beta)q(i) - i \quad (7b)$$

where β represents the borrower's share of the surplus from bargaining relative to the service provider (i.e., RiskMetrics Group), and $0 < \beta < 1$ and $\alpha > \beta$. (See Assumption 1.) The service provider will choose i to maximize its profit, Π_s^P . Denote the unique solution i^P , and the corresponding first-order condition is:

$$(1 - \beta)q'(i^P) = 1 \quad (8)$$

Borrowers' Adoption Decisions. We look at the marginal borrower, b^P , who is indifferent between adopting and not adopting the RiskMetrics service in the fee-based service case.

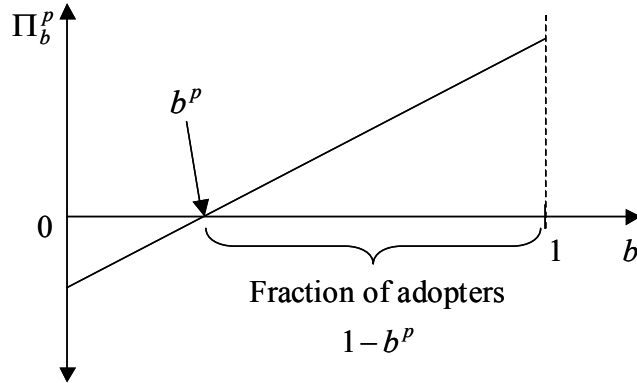
Borrower b^P may be risky enough to gain value that just offsets the price and the costs of adoption. Setting the marginal borrower's benefit to zero, we get $0 = V \cdot b^P - P - C + \beta \cdot q(i^P)$.

Solving for b^P yields

$$b^p = \frac{P + C - \beta \cdot q(i^p)}{V} \quad (9)$$

Then, as shown in Figure 5, $(1 - b^p)$ is the fraction of borrowers adopting RiskMetrics because any borrower who is riskier than b^p will adopt the service. This is due to the linearity of Π_b^p in b .

Figure 5. Adoption Pattern for Fee-Based Service



MAIN RESULTS AND INTERPRETATION

We now provide four propositions based on our model to explain why Morgan had to change the ownership structure of RiskMetrics and how it affected borrowers' behavior and the owner's investment incentives.

When Morgan was the service provider, the borrowers were concerned that it would adjust their lending rates based on their portfolio risk information submitted to the RiskMetrics system or share this information with others. This concern was substantially reduced when RiskMetrics was spun off. Additionally, the quality of the service has significantly improved after spin-off.

This leads to our Proposition 1:

- **PROPOSITION 1 (SERVICE PROVIDER'S EQUILIBRIUM INVESTMENTS):** *In the free service case, the service provider overinvests in information exploitation effort, and underinvests in quality enhancement effort relative to the first-best levels. That is,*

$e^f > e^$, $i^f < i^*$. In the fee-based service case, the service provider still underinvests in quality enhancement effort, but the investment level is greater than in the free service case. That is, $i^f < i^p < i^*$. More importantly, the riskier the borrower, the greater the service provider's information exploitation investment is.*

Proof: Comparing Equations (2), (4) and (8) yields the result. (Q.E.D.)

Morgan's overinvestment in e is due to the fact that it reaps the full benefit from the investment (i.e., $u(e)$), while it does not have to bear the adverse effects of the investment (i.e., $a(e)$). However, Morgan underinvests in the quality enhancement (i.e., R&D for RiskMetrics) because it has to split the benefit from the investment with the adopters while bearing the entire cost of quality enhancement. After the spin-off, the risk of information exploitation was substantially reduced or disappeared due to the multi-party ownership; now Morgan cannot utilize the clients' risk information for its own benefit because it is not the sole owner. Further, the quality enhancement investment increased after the spin-off because now the RiskMetrics Group can capture a greater share of the benefit from quality enhancement. Here, as mentioned earlier, the quality enhancement investments may include training customer support staff, expanding the market database, and improving the functionality of the risk engine.

The positive relationship between the borrowers' riskiness and the service provider's incentive for information exploitation is straightforward. The riskier a borrower is, the greater the benefit from utilizing the borrower's risk information. For example, if Morgan found out that a borrower has become riskier, it might want to raise the lending rate or stop lending to the borrower to avoid potential loss.

As we mentioned above, despite the potential benefit of the free RiskMetrics service, the adoption by Morgan's clients stalled. We believe this was caused by two factors: the adoption costs and the potential damage by Morgan exploiting borrowers' risk information. This leads to our Proposition 2:

- **PROPOSITION 2 (ADOPTION STALLING BEFORE SPIN-OFF):** *When the adoption costs are relatively high, that is, $C > \alpha \cdot q(i^f)$, or the potential adverse effect of the information exploitation by the service provider is large, $a(e^f)|_{b=1} > V - C + \alpha \cdot q(i^f)$, full adoption does not take place in the free service case. Those borrowers who have too much or very little portfolio risk do not adopt the free RiskMetrics service.*

Proof: Examining Equation (6) yields the result. (Q.E.D.)

This result is interesting in that no adoption will occur around both extremes of riskiness.

Borrowers who have very safe risks in their portfolios will benefit little from the service. So if the adoption costs are too high (e.g., it requires a lot of integration with their internal systems), their net benefit will become negative. And others whose portfolio is very risky can benefit a lot from keeping track of their market risk through RiskMetrics. However, the service provider's incentive for exploiting their information also increases. If the potential damage becomes too large, they cannot adopt the service despite the large potential benefit. This explains why adoption of RiskMetrics was limited when Morgan owned the service; only those borrowers who were moderately risky and could afford the adoption costs—and the adverse effects—actually adopted the service.

Providing a detailed technical document for its clients can be viewed as Morgan's effort to help those at the “lower tail” to adopt its service by reducing their adoption costs. Likewise, we believe that changing the ownership structure by spinning off RiskMetrics Group was an effort to create incentives for those at the “upper tail” to adopt, by eliminating their concern about potential information exploitation.⁴ As a result, we believe more borrowers adopted the RiskMetrics service after spin-off. This leads to Proposition 3:

- **PROPOSITION 3 (FULL ADOPTION AFTER SPIN-OFF):** *When the price charged by the service provider is lower than a certain level, $P \leq \beta \cdot q(i^p) - C$, full adoption occurs in the*

⁴ Another way for Morgan to address its clients' concerns about information exploitation would have been to hire an outside auditing firm, as Optimark [9] and Aucnet Japan [19] did. However, we could not find any evidence that Morgan tried this.

fee-based service case. Therefore, more borrowers adopt the service in the fee-based case than in the free service case.

Proof: See Appendix C.

It may sound counterintuitive that more borrowers adopt the service when the service becomes fee-based. But this can happen due to two factors: the quality is higher in the fee-based case because the service provider's incentive for quality enhancement effort is greater, and the adverse effect from the service provider's information exploitation, $a(e)$, disappears in the fee-based case.⁵ As a result, the borrowers' willingness-to-pay increases, and if the price is less than a certain level, then more borrowers will adopt with fees.

We showed that under certain conditions more borrowers will adopt the RiskMetrics service after the spin-off. Now what about the profit of the service provider? Was it profit-maximizing for Morgan to spin off RiskMetrics in the way we have analyzed the situation? This leads to our final proposition:

- **PROPOSITION 4 (SERVICE PROVIDER'S PROFIT BEFORE AND AFTER SPIN-OFF):** *Given the conditions in Proposition 2 (Adoption Stalling Before Spin-Off) and 3 (Full Adoption After Spin-Off), the service provider's total profit is higher in the fee-based service case than in the free service case, if the price is greater than a certain level.*

Proof: See Appendix C.

The service provider's profit may be greater in the fee-based service case because it charges a positive fee for the service and captures a greater share in bargaining with a larger number of adopters even though it loses the benefit of exploiting the borrowers' risk information.

Our last proposition partially explains why Morgan decided to spin off RiskMetrics. Even though Morgan reduced its ownership share in RiskMetrics after spin-off, it still might have

⁵ The higher quality of the service after spin-off may be due to more accurate and timely market data, a better user interface and flexible platform (Web-based systems and platforms with open architecture), and more sophisticated analytics and reporting (including simulation-based VaR, stress testing with predictive scenario generation, and dynamic risk decomposition).

earned a greater profit because the borrower adoption level increased. Another key factor that does not show up in our model but can justify Morgan's decision is the one-time gain that Morgan must have enjoyed by selling ownership shares to such companies as American Express and Reuters.

INFORMATION EXPLOITATION AND OWNERSHIP: BEYOND RISKMETRICS

We next will generalize our findings beyond the case of RiskMetrics related to the relationship between IT asset ownership and information exploitation. The two cases that we will discuss involve the owners of technologies for gathering, sharing, or distributing information allegedly engaged in exploiting others' private information.

Computerized Reservations Systems in the Airline Industry

A computerized reservation system (**CRS**) is an IOS that provides travel agencies (or travelers) with information on airline schedules, fares and seat availability, and allows agents to book seats and issue tickets [3]. CRSs were a major technological innovation in the airline industry in the 1970s. They substantially improved the efficiency of airline reservation process compared with the previous methods that were available. No longer was it necessary for a travel agent to telephone various airlines, requesting flight information, relaying that information to the customer, and then requesting tickets.

The earliest entrants in the CRS market were American Airlines' Sabre and United Airlines' Apollo, which were introduced in the mid-1970s. By the early 1980s, these two CRSs dominated the market, accounting for more than 50% of all travel agency sales [20]. Competing airlines had to get their flights listed on these systems; otherwise they would lose significant sales opportunities. The CRSs not only created technical efficiency for travel agents and airlines, but also built new opportunities for the airline-owners—specifically American and United—to

leverage the systems as competitive weapons in several ways. For example, the CRS owners were accused of limiting other airlines' access to the reservation system both directly (e.g., through a boycott) and indirectly (e.g., via price discrimination) [21]. The owners were also indicted for having programmed their systems to display their own flights ahead of competitors' more convenient or lower-priced flights between the same cities. This so-called *screen bias* had a considerable impact on agents' bookings and created a significant advantage for the owner airlines.

Most importantly, the CRSs gave the owners exclusive access to real-time information regarding the bookings of all flight segments by each agent on all airlines in the systems. In contrast, each subscriber airline only received a monthly report of its own bookings [20]. This "information asymmetry" put the CRS owners at a substantial advantage over the non-owners in marketing and product planning. The owners could also access sensitive information regarding how and when their competition would change a product line because they received advance notice from the subscriber airlines. This information allowed the CRS owners to adjust their own product strategies prior to posting subscribers' adjustments on the system, thus preempting subscriber airlines' marketing initiatives. Again, this competitive information was available only to the owners, not to subscriber airlines.

From the perspective of our model, the CRS owners had strong incentives for information exploitation because they captured the full benefit from information exploitation while letting the subscribers bear the adverse effect. As suggested by our model, one of the solutions to the information exploitation problem was for the owners to divest their CRS ownership interests just as Morgan did in the RiskMetrics case. Divestiture would reduce or eliminate the owner airlines' ability to exploit the confidential information for anti-competitive purposes because

they would no longer be the sole owners of the CRSs. It is possible that an independent service provider still had some incentive to sell confidential subscriber information after divestiture, but we believe the incentive was quite small due to the multiparty ownership structure. Interestingly, this is actually what happened in the early 1990s. As a result, today the CRSs are not controlled by any single airline. Rather, each of the four existing CRSs—Sabre (www.sabre.com), Galileo (www.galileo.com), Worldspan (www.worldspan.com), and Amadeus (www.amadeus.com)—is an independent service provider owned by multiple airlines.

DoubleClick in Online Advertising

As the industry leader in Internet advertising services, DoubleClick (www.doubleclick.com) is able to track Internet users' click stream data by placing a "cookie" on a user's hard drive to target advertisements to Internet users' interests. A cookie is a small text file that contains an identification number associated with the user's computer. The cookies allow advertising and other content to be targeted by ID number. Because an ID number is associated with a computer, not a user, and DoubleClick hold no information on who has owned or used a computer, the information collected should remain anonymous. However, the story doesn't stop here.

Abacus Direct (www.abacusdirect.com) is known as a leader in targeted marketing. By 1999, it had five-year buying profiles on 88 million households in the United States, including name, address, telephone number, credit card numbers, income, and purchases. Abacus Direct was acquired by DoubleClick in 1999, and it remains a division of that firm today. After the acquisition, DoubleClick tried to integrate its user data collected online from the Internet with Abacus Direct's database of household purchase information. Such integration would substantially increase the value of targeted online advertising by linking information from consumers' online browsing activities with their purchase activities [25]. DoubleClick argued

that the integration of the databases would benefit consumers because advertisements would be tailored to their interests and purchasing behaviors, just as Amazon.com sends messages about books that might be of interest based on their purchase history. However, DoubleClick had to suspend its plan to merge the databases after the plan was disclosed by a magazine in February 2000. Consumers were gravely concerned about the potential exploitation of their private information by DoubleClick and the resulting damage to their privacy.

In view of our model, as the owner of both the technology for collecting Internet users' online click-stream data and the database of their offline purchase history, DoubleClick had strong incentives to exploit the users' information without their knowledge to maximize its profits. Again, it was the users who would suffer the damage to their privacy. Meanwhile, DoubleClick would capture the entire benefits from the information exploitation. This explains why some privacy activists were vehemently against DoubleClick's acquisition of Abacus Direct when the acquisition was underway [4].

ALTERNATIVE EXPLANATIONS AND LIMITATIONS

We used the theory of incomplete contracts to explain the impact of an ownership change for RiskMetrics. The incomplete contracts-motivated theory that we developed in this paper is useful to explain the impact of ownership on firms' investment incentives. We also believe that the contract between the service provider and the clients was highly incomplete due to the non-contractible investments and benefits involved. However, there may be other theoretical perspectives that are relevant in this context. For example, the multitask principal-agent perspective [15] can be useful for analyzing the incentives of the agent (i.e., the service provider, Morgan), whose task is multidimensional. The multitask principal-agent theory assumes that agent's investments are interrelated in such a way that increasing the agent's incentive for one

type of investment reduces its incentive for the other type of investment—in other words, the investments are substitutes—whereas our model assumes that the two types of investments are independent of each other. Depending on the context, such interrelationship between multiple types of investments may help to better portray the reality and provide richer insights.

Another possible explanation for the spin-off is much simpler: that the spin-off was Morgan's opportunity to cash out at a time when the market value of RiskMetrics was high. It is also possible (and likely) that Morgan realized that there existed a greater demand for the RiskMetrics service than could be met with its own internal risk management resources, and so it spun off a non-core business unit, realizing value by capturing residual demand for the service and selling ownership share to other firms.

To facilitate our analysis, we made some simplifying assumptions. More realistic models might enable us to provide additional insights, but this will require relaxing some of the assumptions that drove our present results. For example, we imposed an assumption that in the fee-based service case there is no information exploitation (i.e., e). The model can be extended by making the choice of e endogenous in the fee-based service case. Also, the service provider's profit-maximizing pricing decision can be analyzed in addition to its investment decision.

Another important extension is to incorporate externalities into the model, which may be useful to characterize the borrowers' and service provider's behavior during different stages of diffusion of RiskMetrics. Finally, it will be interesting to analyze a situation where not only the service provider but also the borrowers make non-contractible investments (e.g., integration with their internal systems), as suggested in Clemons and Kleindorfer [6].

CONCLUSIONS

As firms share greater amount of information with their customers and business partners, there

exist increasing risks of the information being exploited to their detriment. When there is potential for information exploitation associated with an IOS, the value that the owner can capture is undermined because potential adopters would not adopt the IOS due to the risks. Although the problem of information exploitation or poaching has been an important topic in the Economics and IS literature, there is little guidance offered regarding how firms should strategically deal with the problem. Building on the theory of incomplete contracts, we contribute to this area by developing a model for how ownership structure of IOS can affect information exploitation and adoption. Our model yields several propositions that suggest the appropriate strategic actions that a firm may take when there is potential for IOS adopters to question whether adopting the IOS will be value maximizing. We analyze and illustrate the related strategic thinking in a real world context involving a financial risk management IOS.

We used the theory of incomplete contracts and other related theories to understand and explain why the RiskMetrics service, one of the most important innovations in the financial risk management arena during the last decade, was spun off and how the change in ownership structure affected borrowers' adoption behaviors and the service provider's profit. We analyzed two cases: free service and fee-based service. The former case corresponds to Morgan's ownership of RiskMetrics, and the latter case corresponds to RiskMetrics Group providing the service after spin-off from Morgan. One of the most important aspects of our model is borrowers' differential riskiness. We assumed that how risky a borrower is affects the value from the service through the impact of the service provider's information exploitation. Assuming generalized Nash bargaining over the surplus from the non-contractible investments, we analyzed the service provider's investment decision and the borrowers' service adoption decision and found the following.

In the free service case where the service provider make two types of non-contractible investments, quality enhancement and information exploitation, we have shown that the service provider overinvests in information exploitation and underinvests in quality enhancement relative to the first-best levels. We have also shown that in the fee-based service case where it is assumed that there is no information exploitation, the service provider's equilibrium investment in quality enhancement is higher than in the free service case. In addition, we have shown that the service provider's information exploitation is more severe for riskier borrowers.

Our result suggests that if the risk management service is free, adoption may stall because borrowers who have extreme values of riskiness do not adopt. Too risky borrowers may not adopt because of the high potential risk of information exploitation by the service provider (Morgan). On the other hand, the safe ones may not adopt the service because the value they get from the service does not offset the adoption costs. The risk of information exploitation existed because Morgan was a lender as well as the service provider; it had an incentive to utilize its clients' private risk information for its lending operation. When a third party (RiskMetrics Group) owned the service, however, this risk disappeared because the service provider was no longer the lender, and therefore more—and possibly all if the price is not so high—borrowers adopted the service despite the fee charged for the service. Also, our model shows that the third-party has a greater incentive for enhancing the quality of the service, and we believe that this also contributed to increased adoption of the RiskMetrics service after the spin-off.

We have shown that within a certain price range (i.e., high enough to compensate for the decrease in the net benefit when the service becomes fee-based, but low enough for more borrowers to adopt) the service provider's profit is greater in the fee-based service case compared with the free service case. We believe this result justifies Morgan's decision to

spin off RiskMetrics in 1998. Although Morgan reduced its ownership share in RiskMetrics, it might have earned greater profit after spin-off not only because the size of the “pie” got larger but also because it earned a large one-time profit by selling its ownership share to the other current shareholders of RiskMetrics Group. We believe the spin-off was a strategic move by Morgan to maximize its long-term profit from RiskMetrics.

Finally, we have shown that our findings from the RiskMetrics case generalize to other situations where the owners of IT assets for gathering, sharing or distributing information can engage in exploiting others’ private information for its own benefits. We analyzed two such cases: American and United Airlines’ CRSs and DoubleClick/Abacus Direct. These cases illustrate that the kind of strategic thinking we provide may apply to both IOS and non-IOS settings.

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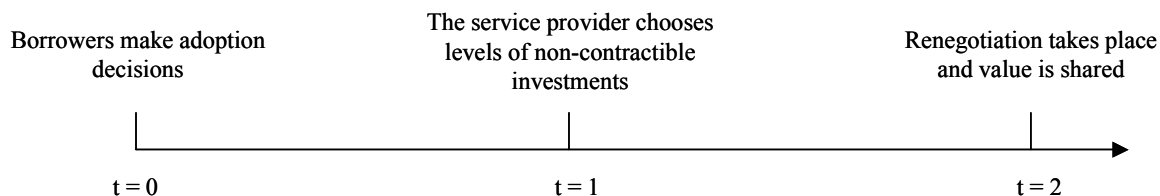
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Appendix A. Model Elements

ELEMENT	DESCRIPTION
b	Index of borrower risk, $b \in [0,1]$
e	Service provider's non-contractible investment to exploit borrowers' private information $e \in [0, \bar{e}]$
i	Service provider's non-contractible investment to improve the quality of the service, $i \in [0, \bar{i}]$
V_*b	Value of the basic service to borrower, b
$u(e)$	Service provider's benefit from, e , with $u(0) = 0, u'(0) = \infty, u' > 0, u'' < 0, u'(\bar{e}) = 0$
$a(e)$	Adverse effect of e , with $a(0) = 0, a' \geq 0, a'' \geq 0$
$q(i)$	Benefit from the quality enhancement effort i , with $q(0) = 0, q'(0) = \infty, q' > 0, q'' < 0, q'(\bar{i}) = 0$
C	Borrower's one-time cost of adoption
P	Price of the basic service
Π_b	Borrower's net benefit
Π_s	Service provider's profit from one adopter

Appendix B. Timing of Actions in the Model



Note: We assume that the price has already been determined before Date 0.

Appendix C. Proof of Propositions

Proof of Proposition 3: Full adoption is possible if the least risky borrower's ($b=0$) net benefit is non-negative, that is, $\Pi_b^P(b=0) = V \cdot 0 - P - C + \beta \cdot q(i^P) \geq 0$. Rearranging terms, we get the above inequality. (Q.E.D.)

Proof of Proposition 4: Assume the conditions in Proposition 2 and 3 hold true (i.e., partial adoption before spin-off and full adoption after spin-off) and let F be the cumulative distribution

function (uniform) for b . Then, based on Equations (3b) and (7b), the service provider's total profit in each case is given in Equations (10a) and (10b) below:

$$\begin{aligned}\int_{\underline{b}^f}^{\bar{b}^f} \Pi_s^f(b) dF &= \int_{\underline{b}^f}^{\bar{b}^f} [u(e^f) \cdot b - e^f + (1 - \alpha)q(i^f)] dF \\ &= \int_{\underline{b}^f}^{\bar{b}^f} [u(e^f) \cdot b - e^f] dF + (\bar{b}^f - \underline{b}^f)(1 - \alpha)q(i^f)\end{aligned}\quad (10a)$$

$$\begin{aligned}\int_0^1 \Pi_s^p(b) dF &= \int_0^1 [P + (1 - \beta)q(i^p)] dF \\ &= P + (1 - \beta)q(i^p)\end{aligned}\quad (10b)$$

Setting (10b) $\geq$ (10a) yields:

$$\begin{aligned}P &\geq \int_{\underline{b}^f}^{\bar{b}^f} [u(e^f) \cdot b - e^f] dF + (\bar{b}^f - \underline{b}^f)(1 - \alpha)q(i^f) \\ &\quad - (1 - \beta)q(i^p)\end{aligned}\quad (11)$$

(Q.E.D.)

The right hand side represents the decrease in the net benefit to the service provider when the service becomes fee-based. The inequality means that RiskMetrics Group could earn more profit than Morgan did as long as the price charged for the RiskMetrics service at least covered the decrease in the benefit.

Appendix D. Proof of Concavity of Π_b^f

For Π_b^f to be concave in b , its second derivative must be negative. The first and second order conditions are:

$$\frac{\partial \Pi_b^f}{\partial b} = V - a(e^f(b)) - b \frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial e^f(b)}{\partial b}$$

$$\begin{aligned}
\frac{\partial^2 \Pi_b^f}{\partial b^2} &= -\frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial e^f(b)}{\partial b} - \frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial e^f(b)}{\partial b} \\
&\quad - b \frac{\partial^2 a(e^f(b))}{\partial [e^f(b)]^2} \left[\frac{\partial e^f(b)}{\partial b} \right]^2 - b \frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial^2 e^f(b)}{\partial b^2} \\
&= -2 \frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial e^f(b)}{\partial b} - b \frac{\partial^2 a(e^f(b))}{\partial [e^f(b)]^2} \left[\frac{\partial e^f(b)}{\partial b} \right]^2 - b \frac{\partial a(e^f(b))}{\partial e^f(b)} \frac{\partial^2 e^f(b)}{\partial b^2}
\end{aligned}$$

For this to be negative, the following must hold:

$$\frac{\partial^2 e^f(b)}{\partial b^2} > -\frac{2}{b} \frac{\partial e^f(b)}{\partial b} - \frac{\frac{\partial^2 a(e^f(b))}{\partial [e^f(b)]^2} \left[\frac{\partial e^f(b)}{\partial b} \right]^2}{\frac{\partial a(e^f(b))}{\partial e^f(b)}}$$

The right hand side is always negative because $a(\cdot)$ is convex in e and $e^f(b)$ is increasing in b , that

is, $\frac{\partial a(e^f(b))}{\partial e^f(b)} > 0$, $\frac{\partial^2 a(e^f(b))}{\partial [e^f(b)]^2} > 0$, $\frac{\partial e^f(b)}{\partial b} > 0$. This means that as long as the second derivative of

$e^f(b)$ is not strongly negative (i.e., if $e^f(b)$ is not strongly concave in b), the inequality will hold.

This is a mild assumption because there is no reason to believe that the supplier's incentives for information exploitation will increase at a (strongly) decreasing rate as the borrower's portfolio becomes riskier. (Q.E.D.)