INFORMATION TECHNOLOGY INVESTMENT AND PRICE RECOVERY EFFECTS IN INTERNATIONAL BANKING

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ABSTRACT

Firms invest in information technology (**IT**) to create various kinds of leverage on firm profitability and performance. However, IT researchers have concentrated their efforts on the productivity impacts of technology, at the employee, process, firm, industry, and economy levels of analysis, to the exclusion of other business value impacts. Not captured by productivity metrics are the significant benefits that may accrue to the firm as product quality improves, managerial assessment of risk is enhanced, time to market and other cycle time reductions are made, and new ways to control firm input and output prices become available to management. These kinds of impacts reflect *price recovery* improvements – the ratio of the prices of a firm's outputs (of goods and services) to the prices of the inputs it consumes in production – and they are rarely measured or understood in a systematic way. In this paper, we argue that it is appropriate to reconsider the current measurement and research agenda that aims to discover and document the payoffs that accrue from corporate investments in IT. We illustrate the extent to which IT investment may be motivated by management's understanding of the potential price recovery payoffs (even if they fail to carefully measure or report them) in the context of trading and treasury operations in international banking. We find that price recovery captures a previously unmeasured dimension of the business value of IT.

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1. INTRODUCTION

Since 1960, senior managers in the manufacturing and services sectors have invested over $4 trillion in information technology (**IT**), and currently invest about 10% of U.S. GNP each year in technology capital (Landau, 1995). Major efforts have been undertaken by industry experts, most notably Stephen Roach, the chief economist of Morgan Stanley (Roach, 1987, 1989, 1991 and 1993), and academic researchers to examine the payoffs. However, academic researchers have found conflicting results (Banker, Kauffman, and Morey, 1990; Berndt, Morrison and Rosenblum, 1992; Brynjolfsson and Hitt, 1993; Loveman, 1994; Weill, 1992). The term "productivity paradox," coined by Roach and others in the business literature and industry interviews, has been used to describe the seeming lack of evidence of a causal relationship between productivity and IT. In the 1980s, some of Morgan Stanley's economic analyses demonstrated that IT investment was associated with a *negative* impact on productivity at the level of the economy, further obscuring the issue (Roach, 1989).

Yet, today firms and IT senior managers recognize that IT can pay off in a variety of ways. Some firms invest in IT to reduce costs, others to improve product quality, and still others to increase customer satisfaction. IT is also capable of shortening new product development, reducing cycle time, and improving organizational responsiveness. The financial services industry, among others, provides a range of examples of these potential gains. The New York Stock Exchange is investing heavily in IT, specifically wireless technology, to reduce transaction cycle time in its floor trading operations.[1] Chase Bank and its pre-merger predecessor, Chemical Bank, invested in object-oriented technology so new products can be brought to market more rapidly.[2] In addition, Richard Matteis, previously senior vice president of the former Chemical Bank, noted that his business unit "has seen a saving of $80 million since the merger [of Chemical Bank with Manufacturer's Hanover] from a combination of reducing head count, integrating systems, and closing data centers."[3] Even though deploying IT to reduce costs was important, deploying IT to create and support attractive new products and services was equally important to increase the business value of the merged bank. Although these examples show that there are multiple economic payoffs from IT investment, it is interesting that the main focus of debate among researchers continues to be on productivity as the *key* payoff. Perhaps the real paradox here may be why the academic community has not sought to shift the emphasis of IT value research away from productivity outcomes to other broader metrics of investment value.

This paper illustrates the application of a framework that places equal emphasis on the productivity and price recovery effects of IT. Just as *productivity* is described by a ratio (Y/X) of the quantity of outputs (Y) to the quantity of inputs (X), so *price recovery* is the ratio (P_X / P_Y) of the prices of the outputs (P_X) to the prices of the inputs (P_Y). The price recovery measure captures the net effect on profits of a decrease in input costs or an increase in sales prices, an outcome that may result from a variety of beneficial changes in the production process. Although these beneficial changes will influence firm performance, the productivity metric may remain unchanged, because prices, not quantities, were affected.

Our illustration of these ideas relies on exploratory case study research that we have conducted in international commercial banking. This industry invests substantially in IT. Citibank and Bank of America, for example, each invest over $1 billion annually. Yet, senior banking managers are perplexed as to why the measurable payoffs are not larger. For

[1] Moeller, M. "NYSE Takes Stock of Its IT portfolio," *PC Week*, July 31, 1995.
[2] Spinner, K. "Chemical Banks on Object Middleware for Global Trading," *Wall Street & Technology*, August, 1995.
[3] Strachman, D. "Chemical's Geoserve Serves Up Profits," *American Banker*, September 30, 1994.

example, in a recent survey released by CWB, the London-based financial technology consultancy, 61% of City of London financial technology managers believe that IT costs are not being accurately measured against the benefits that are produced.[4]

In this paper, we develop our argument about the importance of price recovery in the banking industry in the following way. Section 2 discusses the basis for the assessment of the price recovery effects of IT investment through changes in quality and cycle time, and contrasts this approach with more traditional methods for productivity assessment. Sections 3 provides relevant background on the international commercial banking industry, its core business processes, and how its use of information technology can create significant leverage on firm performance. From this foundation we discuss some of the ways that price recovery gains may be discovered and measured in this industry. Section 4 presents a series of mini-case results that develop these ideas further, and points towards a typology of price recovery effects that illustrate the importance of developing a broader perspective of IT value measurement that captures the relevant performance increases. The mini-case studies also highlight the key conceptual and measurement issues. Section 5 interprets our findings in the light of the productivity paradox of IT, suggests new reasons to explain why it may exist, and discusses other business contexts in which price recovery assessment is expected to be valuable. Section 6 offers managerial guidelines for implementing price recovery metrics within the firm, and Section 7 concludes with thoughts on future research.

2. PRODUCTIVITY, QUALITY AND CYCLE TIME IN IT VALUE RESEARCH

Prior research on productivity, quality and cycle time gains from IT investment offer natural starting points for the investigation of how price recovery concepts can be applied to discover new sources of business value in empirical research. We conclude that there is ample opportunity to contribute to and build upon the field's understanding of how investment in IT creates value, in two ways. First, price recovery has not been widely studied outside of managerial accounting and operation management circles, so creating a greater awareness of how price recovery can be tied to IT-driven performance will add to the critical mass of research results that emphasize the importance of measuring value in multiple relevant portions of the value chain of a firm's business process. Second, we can offer advice about future research directions that will be likely to yield significant new insights into how IT value can best be measured.

2.1. Productivity

A number of researchers have modeled business value by measuring business process, firm level and industry level productivity gains. Productivity, as we stated earlier, is defined as the ratio of the quantities of outputs produced to the quantities of the inputs consumed in production. We review research that illustrates the extent of the discrepant findings: some researchers have found a positive relationship between investment and IT, while others have found a negative relationship. We also the lack of analysis of financial inputs: most previous research has focused on physical, rather than financial, production.

Various studies point to significant and positive impacts of IT investment on production. For example, in a quasi-experimental study of the introduction of order coordination technology in fast food restaurant production involving physical inputs, Banker, Kauffman and Morey (1990) found that investment in IT was associated with conditional improvements in input productivity. Benefits were only realized when the technology did not duplicate the efforts of a

[4] "Survey Reports 'Inadequate Control' of Financial Technology Expenses," *Risk Management Operations*, May 20, 1996.

human order coordinator in a restaurant. Weill (1992), examining physical inputs in the valve manufacturing process, found that some types of investment in IT in manufacturing firms were positively associated with productivity, while others were not. He defined three kinds of IT: transactional, strategic and informational IT. *Transactional IT* is responsible for carrying out the routine business transaction processing of the firm. *Strategic IT*, by contrast, is deployed to assist a firm in gaining a specific kind of competitive advantage, such as a particular customer base, product or service. Finally, *informational IT* investments reflect departmental, business process and firm-wide investments in traditional management information systems and decision technologies. Although Weill's categorization is not definitive, he was nevertheless able to show that valve manufacturers' investments in transactional IT were associated with increased firm performance. Using a broad range of industries, Brynjolfsson and Hitt (1993) found that the return on investment for computer capital was 54% for the manufacturing sector in the U.S. economy, and 68% for the combined manufacturing and service sectors. In a follow-up study (Hitt and Brynjolfsson, 1994), they presented more refined results: IT was associated with increases in net output and consumer surplus, but it had no association with business performance, as measured by total shareholder return, return on equity, and return on assets. They, also, measured physical inputs and not financial ones.

In contrast to these and other positive results, other researchers who focused on the productivity effects of IT capital investment have failed to find such supportive evidence. For example, a multi-industry study conducted by Berndt, Morrison, and Rosenblum (1992) found a negative relationship between IT investment and labor productivity. Loveman (1994) found that IT investment had a negligible impact on productivity. The most widely publicized study of this group was done by Roach (1987), whose research has focused on business cycle trends in technology investment and how productivity gains in the economy change over time. A later study by Roach (1993) reported just the opposite result, however: that IT-led gains in labor productivity occurred as the economy came out of a minor recession earlier in the 1990s.

Mixed results are also evident when the focus shifts to the financial services industry. Alpar and Kim (1990), in a study that applied multi-factor productivity assessment methods from microeconomics to IT investment and retail banking firm performance, found that IT investments were associated with increases in some outputs, but decreases in others. Using regulatory and performance data that banks must provide to the Federal Reserve Bank, the authors found that IT investments were correlated with increases in commercial loans; bigger investors in IT, however, tended to have smaller amounts of demand deposits and installment loans. Their study, unlike the previous ones, did measure financial capital. A second study found that IT investment in bank branches contributed to only 20% of the growth in productivity, while scale economies and output growth contributed to the remaining 80% (Kim and Weiss, 1989).

In summary, there is mixed evidence to support the claim that information technology increases productivity.[5] Even if the IT manager makes a valuable IT investment decision, it still may be difficult to discern a productivity gain. Researchers have argued that there may be many reasons why this is so, including poor data quality, inadequate measures, failure to measure at the proper locus of value, or a beneficial effect from technology that is small relative to many of the outcomes of managerial action and involvement. For example, Brynjolfsson (1993) stated that the lack of "IT productivity is as much due to deficiencies in our measurement and methodological tool kit as to mismanagement by developers and

[5] For additional information on IT and productivity, see the following useful surveys of research: three mainstream IS publications (Bakos and Kemerer, 1992; Brynjolfsson, 1993; Kauffman and Weill, 1989), two books commissioned by two different panels under the National Research Council (National Research Council, 1994a and 1994b), and a third book written by a university professor (Landau, 1995).

users of IT (p. 67)." We concur with this assessment for two reasons. First, productivity is only one dimension of business value, and senior managers may invest in IT for reasons other than to achieve productivity gains. A richer approach to business value measurement is needed, one which bridges the value gap. We examine two additional value dimensions, quality (Section 2.2) and cycle time (Section 2.3). Second, the locus of value at which measurements are made may be incorrectly specified, resulting in incorrectly specified inputs. Very often, physical inputs and physical outputs are measured, because such measurement most closely parallels the kinds of analysis that the available theory will support, while economic capital has been excluded. We now turn to other dimensions of business value.

2.2. Quality

Quality is an important dimension of business value, and has been an important source of competitive advantage for firms who build their corporate strategy so they can consistently deliver quality services. Grant, Shani and Krishnan (1994) observed that "companies such as Xerox and Hewlett Packard ... made fundamental changes in their management practices and philosophies and improved product quality and company performance (p. 25)." One study which examines the impact of IT on quality was conducted by Barua, Kriebel, and Mukhopadhyay (1995). They found that investment in IT had a positive impact on firm level performance through intermediate variables at the process level. An increase in IT investment was associated with increased quality, one of the intermediate variables, which was then associated with increased market share and return on assets. A second study by Caron, Jarvenpaa, and Stoddard (1994) found that quality improved as much as 75% after an investment in IT for a business process reengineering effort at Cigna, the international insurance firm.

Researchers investigating issues at the intersection of IT and operations research have also found IT associated with quality, which, in turn, was associated with business value. For example, May, Spangler, Chen and Donohue (1993) found that an insurance firm which invested in IT increased the quality of the claims process. The software detected errors in the insurance claims by performing various edits. The edits included automated error analysis, historical analysis, problem identification, and performance comparisons. The IT investment decreased the error level from 10% of the dollar value of the claims to 4.5% of the dollar value. Another study, this one by Labe (1994), found evidence that automating a portion of the process for identifying new customers, by investing in data mining software, improved performance. He examined three database mining strategies: a priority strategy which identified potential customers similar to the firm's existing profitable customers, a geographical location analysis strategy that targeted the neighbors of current customers, and a demographic "lifestyle cluster" strategy that forecasted the kinds of family characteristics conducive to obtaining new clients. These three strategies were compared to the existing strategy of obtaining new customers. The priority and lifestyle cluster strategies both resulted in a 50% increase in customer identification, thus greatly improving the quality of the process.

2.3. Reduced Cycle Time

Investments in IT are also made to significantly reduce cycle time in service operations and in product development, a dimension that American firms have increasingly come to recognize as a strategic and competitive concern.[6] The specialization of labor and hierarchical management, two well-known organizing principles from Taylor's scientific management approach, have led to the fragmentation of work, which has led to unacceptably long cycle times. Taylor believed that an employee would be the most efficient and productive if work was organized into as many small and

[6] For a useful typology of the potential cycle time impacts that can be gained through business process engineering, the interested reader should see Wetherbe (1995).

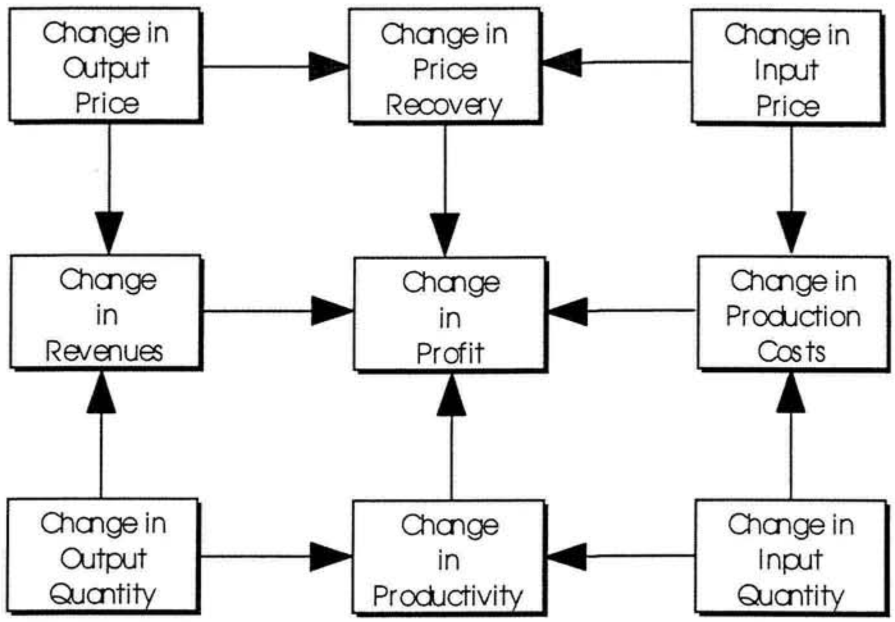
different tasks as possible. The tasks were then to be coordinated in a hierarchy, which was intended to enable the firm to be efficient and productive, too. Unfortunately, however, this organization of work maximizes the number of *handoffs*, lengthening start-to-finish service times, increasing coordination costs and reducing customer responsiveness. For example, IBM Credit Corporation found that the process of analyzing credit and making financing commitments took two weeks on average from start to finish. Yet, the actual work totaled only 90 minutes (Hammer and Champy, 1993, p. 36).

Case study research suggests that a range of efforts are underway to utilize IT to rationalize workflow processes and decrease cycle times. For example, Caron, Jarvenpaa, and Stoddard (1994), in addition to the quality effects we mentioned earlier, also found that investment in IT was associated with a 100% improvement in the cycle time of the insurance underwriting process. May, Spangler, Chen and Donohue (1993) found that error processing time decreased from seven days to one hour after investing in IT. Mehring's (1995) study of loan processing found that significant reductions in processing time were achieved through modifications to the existing workflow. After changes were made, the average response time was reduced to less than half of the previous response time. Similarly, Bowers and Agarwal (1995) reported that a firm that was able to reduce cycle time, leading to improved customer service and hence business value, when an automated costing and garment information system was implemented. Prior to the deployment of the system, only 74% of the deliveries were on time; afterwards, 90% of the deliveries were on time. As Nichols, Frolick and Wetherbe (1995) point out, IT should be recognized for its ability to link intraorganizational and interorganizational elements of the value chain to improve coordination and yield cycle time gains for the firm.

2.4. Synthesis

A useful synthesis of these dimensions of IT value is found in a framework called the *profit variance matrix*, attributed to the American Productivity Center (**APC**), and shown in Figure 1. This framework has been used to analyze firm performance gains, and to assist managers in decomposing changes in profitability that result from changes to input and output productivity, and to input and output prices (Banker, Chang and Majumdar, 1993; Datar and Kaplan, 1989; and Miller and Rao, 1989). The framework emphasizes input quantities and prices, and output quantities and prices, as managerially controllable variables. Relevant managerial actions can take many forms, and some of the most important and high payoff actions involve the deployment of IT. Moreover, this framework helps us to understand the manner in which quality and cycle time impacts lead to changes in firm performance. Quality impacts on performance, for example, can be traced back as business process improvements leading to productivity gains, as less work needs to be redone, fewer errors need to be corrected, or less input waste reduces operating costs. Quality can also positively impact price recovery, as a firm's customers exhibit a greater willingness-to-pay for a higher quality, more reliable product or service. Cycle time improvements can also lead to significant gains in input and output productivity, as more work is completed in a shorter time and labor costs are controlled through the reduction in handoffs and workflow streamlining. In fact, however, cycle time reduction has a potentially greater impact on management's ability to increase output prices, again, as firms indicate their willingness-to-pay for more timely services.

Figure 1: American Productivity Center (APC) Profit Variance Matrix



We next describe the context for our illustration and how some of these profit variance gains are obtained by international commercial banking firms engaged in financial market, and trading and treasury operations. This is an especially interesting context, because the gains that firms in this industry have made through IT investments frequently seem to appear as price recovery effects.

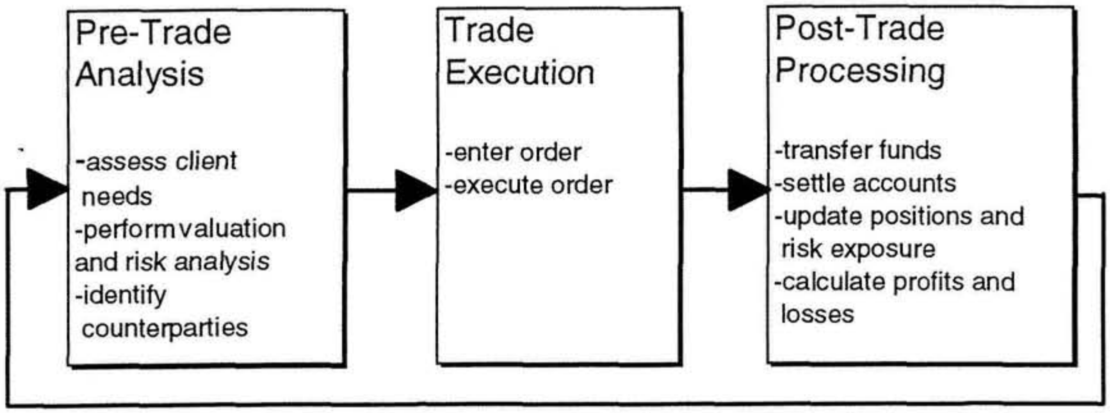
3. IT AND THE FINANCIAL MARKET OPERATIONS OF INTERNATIONAL COMMERCIAL BANKS

Information technology is critical to the financial market operations of international commercial banks. Joel Kurtzman, author of a book on technology, financial markets and economic policymaking called *The Death of Money* (Kurtzman, 1993), refers to the markets of the 1990s as "cybermarkets," reflecting the unprecedented influence of IT in transforming the process of financial intermediation. Indeed, traders at the major financial institutions, irrespective of their locations in London, Frankfurt, Hong Kong, Tokyo or New York, interact daily in a global marketplace whose efficiency increases day by day, largely due to changes made possible by IT and telecommunication. In this environment, inadequate information, control systems and procedures can lead to unexpected and large losses, and even the bankruptcy of well-established firms.

3.1. The Trading Value Chain

IT's role in transforming financial market trading and risk management operations can be understood in the context of Porter's (1985) value chain. The trading and risk management value chain consists of three distinct areas: pre-trade analysis, trade execution, and post-trade processing, as shown in Figure 2.

Figure 2: The Trading Process Value Chain



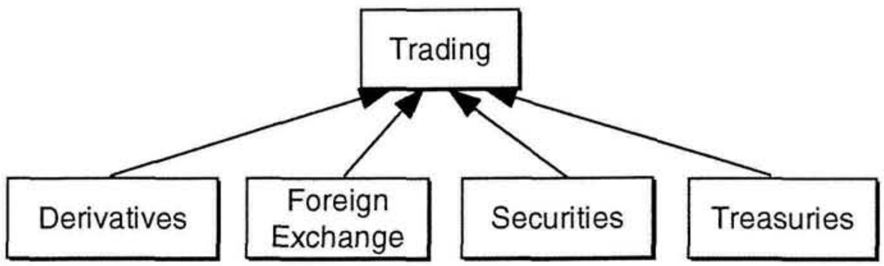
Pre-Trade. The primary activity in the pre-trade analysis phase is analysis of potential deals or trades in support of customer banking relationships and the firm's own proprietary trading strategies. The activities consist of hedging risky portfolios, putting together interest rate and foreign exchange swap deals, identifying counterparty risk and performing credit analysis, doing valuation and other kinds of analysis for specific financial instruments, assessing funding strategies in a changing market, and gauging the performance of the bank's trading activities on behalf of its customers and in its interactions with other financial institutions. Traders obtain data from market data feed vendors, such as Reuters and Bloomberg, through a digital "ticker plant" that makes telecommunication and data distribution across a trading platform into a smooth, seamless and transparent process. This enables traders to conduct proprietary analyses on data that relate to the business areas in which they make trades, for example, using "what if" analysis to examine the potential impacts of changing foreign exchange spot rates, and doing convexity and duration analysis for fixed income securities and other derivatives. Equally important in this phase is decision making about the allocation of scarce capital to finance trades on behalf of correspondent banking and corporate customers.

Trade Execution. The major function in the trade execution phase is the order entry and submission process. The value chain activities consist of traders taking or creating orders, entering them into a system that pulls together relevant information for subsequent downstream activities in clearing and settlement, and then executing trades. Until the last few years, the trade entry process was largely manual. However, today trade entry is increasingly "ticketless": traders are using real-time trade entry and execution to make trades, with resulting increases in efficiency, accuracy and reaction speed, and improvements in the process of capturing trade-related data for risk management and control purposes.

Post-Trade. In the post-trade processing phase, the main activities involve settlement and accounting. These operations require various activities to occur: positions and risk exposure in currency, counterparty and customer terms are updated; profits and losses are analyzed in terms of market, customer, and trade profitability; and trades are cleared, funds are transferred, confirmations and compliance documents are distributed, and accounts are settled. In the post-trade phase, trading transactions are posted to the general ledger, thereby enabling updates to be made to the firm's on and off-balance sheet accounts. General ledger posting also enables customers who may have operating and reconcilement questions to have them answered on the basis of data stored in these databases. This way, discrepancies can be ironed out, trades that don't match can be resolved, and accurate, customer statements can be prepared for end-of-day transmission.[7]

These phases of value chain activities occur for every financial product. Some of the more basic financial products include foreign exchange, banker's acceptances and government debt securities. More complex financial products include derivatives, such as options on stock, foreign exchange and financial market indices, futures, and mortgage and asset-backed securities. A group of financial products, such as derivatives, is usually organized into its own department, as shown in Figure 3. The similarity of the trading value chain for each financial instrument and department, and the fact that each business often developed with its own operational infrastructure, has made it very common for these activities to be vertically integrated, yet horizontally fragmented, as shown in Figure 4. Risk management and trading controls, however, place a high premium on horizontal integration: to support data collection and data analysis for multiple financial instruments and the departments that trade them, to accomplish high yield capital allocation, and to create a basis for firm-wide implementation of trading strategies.

Figure 3: The Organization of Trading Products



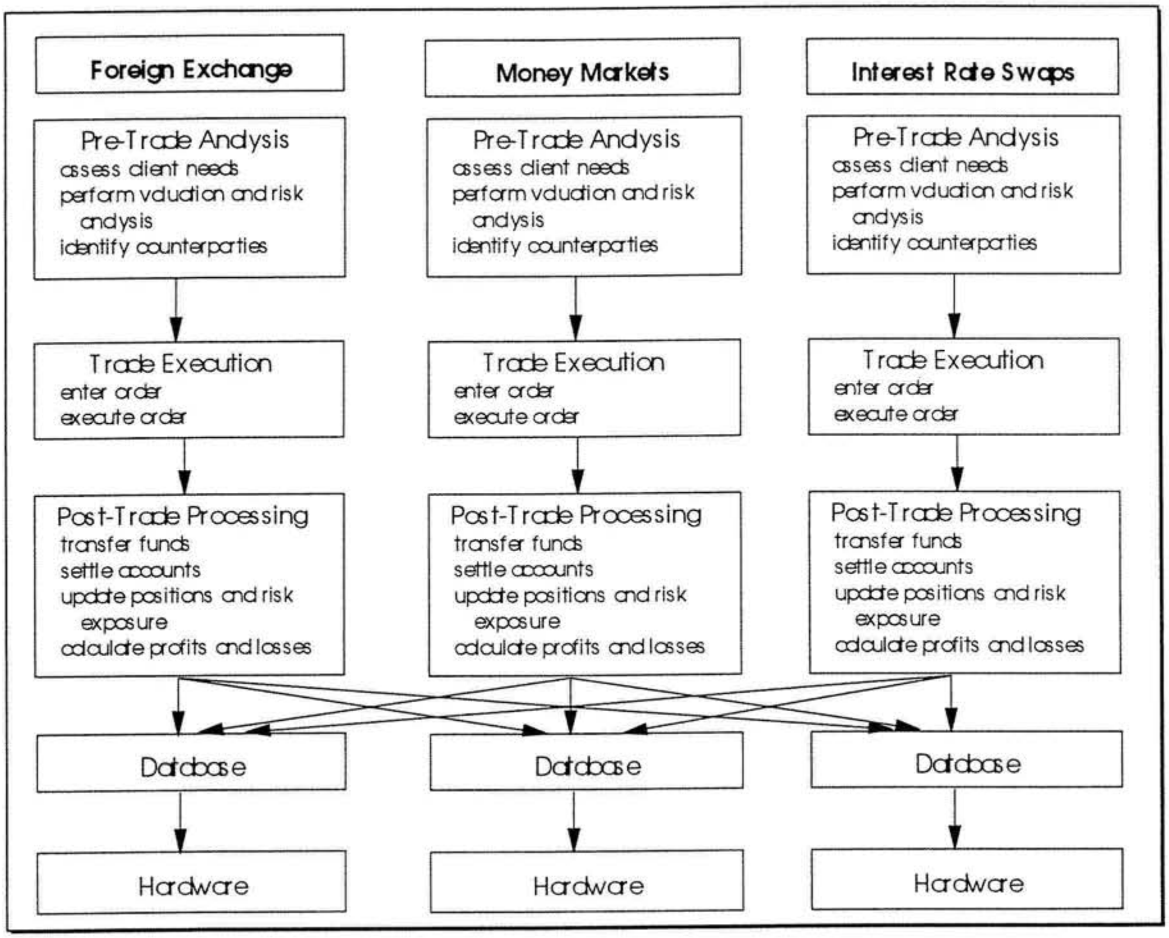
3.2. Risk Management and Profitability Assessment

Barings PLC, a large, London-based bank with a 200-year operating history, was forced to declare bankruptcy in March 1995 due to trading losses in excess of $1 billion. The losses apparently were due to the activities of a single trader in Singapore, who was able to circumvent the firm's primary control procedures for money market trading. This dramatic failure, and the fear of inadequately controlled trading, has led many banks to invest in IT to enable firm-wide, and, for some businesses, real-time risk management. Risk management systems measure, monitor, and control risk from movements in interest and foreign exchange rates and the market prices of financial products that influence lending, investment, trading and funding policies and the market value of a banking firm. They recognize that exposure to risk requires accurate measurement before it can be managed. Just as yield management systems have transformed business processes in the rental car, hotel and airline industries, so have risk management systems led to significant changes in how

[7] In spite of our earlier critical remarks about how workflow process designs based on Taylor's scientific management approach can be dysfunctional for some firms, the reader should recognize that there may be reasons besides the traditional ones that motivate this kind of organization of work. For example, in the trading and treasury value chain, it is important that there is an organizational separation of duties for many of the activities conducted in the three value chain phases. No single person should be able to analyze counterparty risk, then decide that a particular trade should be made with that counterparty, and finally take steps to clear the trade and update account information. In the absence of separation of duties, a banking firm exposes itself to significant risks from fraudulent trading. Barings PLC is a good example: Nick Leeson, the trader reputed to have done the fraudulent trading was apparently able to get involved in all three groups of activities.

international commercial banks operate in the areas of capital allocation and funding and intraday exposure controls, and the coordination of branch office

Figure 4: A Generic Trading and Treasury IT Architecture



operations, and in trading counterparty credit risk assessment. The sentiment in industry is that the "main culprit [for failures like Barings] was often not derivatives but lax internal controls or a failure to price risk properly."[8]

A recent and interesting development reflected by the efforts of an American international commercial bank, J. P. Morgan, provides an apt illustration. J. P. Morgan has developed and deployed RiskMetrics, a risk management system that consists of a risk assessment methodology and detailed data sets that enable risk assessments to be conducted on a daily basis. On October 11, 1994, Morgan made RiskMetrics available over the Internet and the World Wide Web.[9] In so doing, it became the industry's de facto standard for risk management. RiskMetrics estimates market risk based on the "value-at-risk" approach. Value-at-risk measures the potential overnight loss in the market value of a portfolio, based on its sensitivity to a variety of market risk factors. Morgan's approach involves the estimation of future movements in key market indicators in terms of volatility, representing the historical price variance of a financial instrument, and correlation, which measures the extent of co-movement or correlation of two or more financial instruments. Assessed together,

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[8] "Dangerous Driving," in Special Section -- A Survey of International Banking, *The Economist*, April 27, 1996.

[9] Sesit, M. "Morgan Unveils the Way It Measures Market Risk," *Wall Street Journal*, October 11, 1994, p. C1, C20.

volatility and correlation enable a manager to predict the potential dollar losses in a portfolio when a key market indicator moves up or down.[10] Morgan's ability to develop application solutions like RiskMetrics is based on its understanding of the financial markets, its success in utilizing theory from financial economics to specify a risk assessment methodology, and its prowess as a leading investor in IT in the international commercial banking community. Similar efforts are underway at Bankers Trust Company, with a product that they call RAROC 2020 -- for "risk-adjusted return on investment."[11] (The basic concepts are discussed further in the Appendix at the end of the paper.)

Senior managers hold similar views about the importance of profitability management systems. For example, a bank that operates in the southeastern United States was losing significant revenue because its profitability system did not have complete and accurate information. After reengineering its business processes to enable the capture of the relevant information about business performance, it was able to increase revenues and profitability for its products and its customer relationships.[12] In addition, Stuchfield and Weber (1992) report on the use of trade profitability analysis approaches at Britain's Barclays de Zoete Wedd, a securities firm that deployed a system called BEATRICE to implement activity-based costing concepts in financial market trading operations. These systems create beneficial leverage for the firm in its marketplace, but they also work to transform the marketplace: suddenly, every competitor needs to "hook up."

We next discuss how IT can create business value by focusing on price recovery, in the trading and risk management process in international banking.

4. MINI CASES

We conducted a series of interviews with multiple respondents at six large international commercial banks. The aim was to discover the extent to which these banks' experiences with IT investments supports our argument that the price recovery effects ought to be measured to provide a basis for an accurate picture of the business value of IT in international banking trading and treasury operations to emerge.

Although we believe that the first-best approach to developing research evidence in support of this proposition ought to be model-driven empirical research, we nevertheless recognize the importance of being pragmatic. At present, there are no papers in the IS literature that provide an obvious basis for modeling the role of IT in trading and treasury service production.[13] Further complicating this picture is the fact that there are also very few papers in the literature in general that deal with technology and international banking operations in a substantive way.[14] A related pragmatic consideration in this research involved our recognition that international commercial banks are among the most

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[10] The interested reader should visit J. P. Morgan's site on the World Wide Web, which provides a number of technical documents that describe the analytical approach used by RiskMetrics. The URL is http://www.jpmorgan.com/MarketDataInd/RiskMetrics/pubs.html.

[11] "RAROC 2020: The First Complete Risk Measurement Service," Bankers Trust Company New York, 1996 (http://www.bankerstrust.com/raroc/tech/index.html).

[12] Wortmann, H. "Monitoring and Reporting Management Data for the '90s," *American Banker's Management Strategies*, December 19, 1994, p. 6A-7A.

[13] However, Dewan and Mendelson (1995) present an analytical framework that attempts to discover the value and leverage of securities and money market trading systems in a competitive marketplace. They consider system influences on delay time, among other issues.

[14] One exception that we know of is the ongoing doctoral dissertation research of Prabu Davamanirajan of J. P. Morgan and Carnegie Mellon University. The interested reader should see the following papers that deal with trade services and trade finance operations in international banking: Davamanirajan, Mukhopadhyay and Kriebel (1996); and Davamanirajan, Mukhopadhyay, Kriebel and Kauffman (1996). In addition, there is literature in other disciplines that discusses "technology" and its impacts on international banking and the international economy in the broadest sense. See, for example, Smith (1993), Smith and Walter (1990, 1996), Steiner and Teixeira (1990) and Wriston (1992).

sophisticated investors in and users of IT; thus, we questioned whether using a highly simplified analytical model would be the right starting point to discover value.

For these reasons, we have chosen to examine IT investment in international banking operations using the case study approach. We believe that the ideographic research explanations are especially useful in exploratory research that aims to formulate a basis for model development, theory building, and follow-up empirical research (Benbasat, 1984; Benbasat, Goldstein, and Mead, 1987; Eisenhardt, 1989; Kauffman, Konsynski and Kriebel, 1993; and Lee, 1989). Eisenhardt (1991) believes that multiple cases are a powerful means to create theory because different cases often emphasize complementary perspectives. By integrating these individual cases, the researcher can develop a more complete picture. In addition, Tsoukas (1989) has noted that such explanations are helpful in identifying the conditions that lead to information systems success within a firm. In this instance, we chose to examine the conditions and outcomes of IT investments across a small population of firms that we believed would simulate the variety of outcomes likely to be present had we actually been able to work with a data set for a larger number of firms. The mini cases highlight price recovery as a missing link to firm performance.

4.1. Trading Platform Integration in the Merger of Manufacturers Hanover Trust and Chemical Bank

In January 1992, Chemical Bank merged with Manufacturers Hanover Trust (**MHT**) to become the largest money market trading operation in the United States.[15] The merger brought together two firms that were distinct in many ways, including the nature of their trading businesses, and reflected an industry-wide trend to achieve larger scale economies in bank operations. It also improved bank's debt ratings, and enabled senior management to take advantage of business complementarities that would improve profitability, while eliminating redundant operating costs.

To reap the benefits of the merger, the bank needed to invest in IT. IT investment in the merged bank's trading operations centered on the creation of a single integrated trading platform that would replace and update Chemical's and MHT's trading infrastructure. According to Brian Slater, then Managing Director in MHT's Global Bank, there are three potential approaches that firms can consider when they merge their systems:

- The *acquisition value approach* involves the selection of the "best" system from one bank, while the other is dropped. With some financial products, it was relatively easy to determine which system would be kept. For example, MHT was known to be strong in derivative trading operations, and so IT supporting that operation would be retained to become the core of the merged bank's new derivatives trading architecture; Chemical's derivative trading systems would be eliminated. By contrast, in the foreign exchange dealing business, Chemical was known industry-wide for its capabilities, and so IT supporting that operation would be retained, while MHT's would be dropped.
- The *pure merger approach* involves more time spent at the outset to determine how best to merge each bank's trading architecture into a unified whole. This approach often is viewed as being politically least costly, because it promotes interorganizational compromise. But, it is also recognized as an approach that postpones having to make the hard decisions.

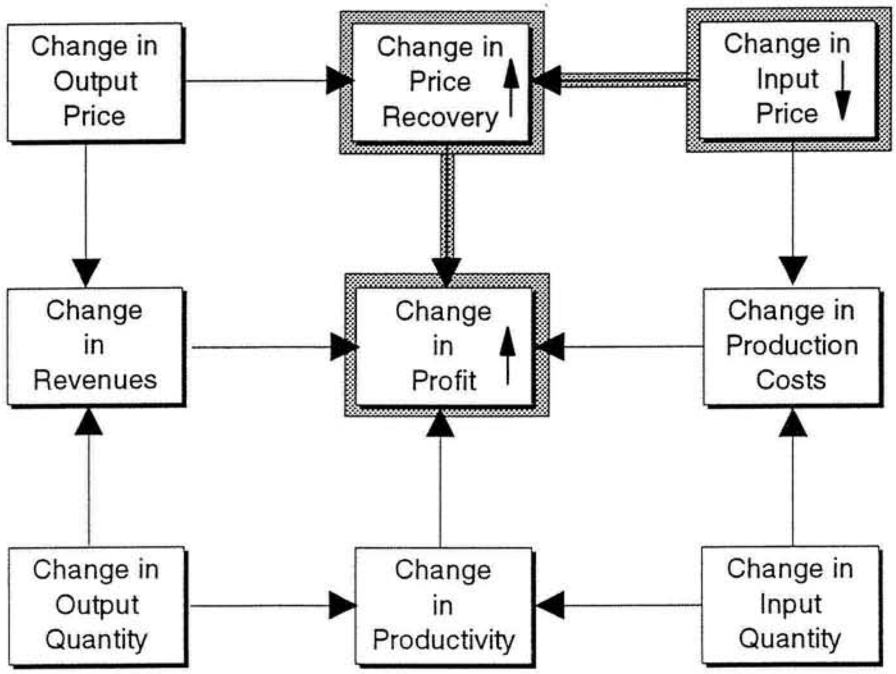
[15] On March 31, 1996, Chemical Bank merged yet again, this time with the Chase Manhattan Corporation of New York, under the Chase name. Rupi Puri, Chase's head of global markets, operations and technology at the merged bank, called the move "the biggest ever dealing room merger executed on a global basis." See A. Sikri, "New Chase Manhattan Combines Dealing Rooms Across Globe," *Teleres News*, April 10, 1996 (http://www.teleres.com/teleres/news/ 960410/011.html). The merger will enable the pre-merger Chemical to continue to retain its position as the largest money market player in the United States.

- Finally, a *clean sweep approach* is possible, as both firms' application architectures are eliminated, and a new one is designed.

Chemical and MHT implemented a hybrid of the acquisition value approach, choosing the best applications in parallel with each firm's unique business strengths, and then selectively outsourcing applications when neither firm's existing applications in a business area provided 70% of the requisite functionality.

The firm achieved price recovery benefits soon after the merger was completed. The merged bank consolidated the previous two banks' individual capital bases into one single pool of capital. This pooled capital base improved the merged bank's risk profile in the marketplace, which led to a decrease in its cost of capital. Because capital is the raw input of banks' production, a decrease in the cost of capital is a decrease in input prices. From the APC matrix, a decrease in input prices, ceteris paribus, increases profits through an increase in price recovery (See Figure 5). We define this effect as "input-side" price recovery gains, because price recovery improved due to a decrease in input price. Input-side price recovery gains in the form of a lowered cost of capital are among the most valuable inputs from IT investment that a banking firm can obtain.

Figure 5: APC Profit Variance Matrix for Swiss Bank

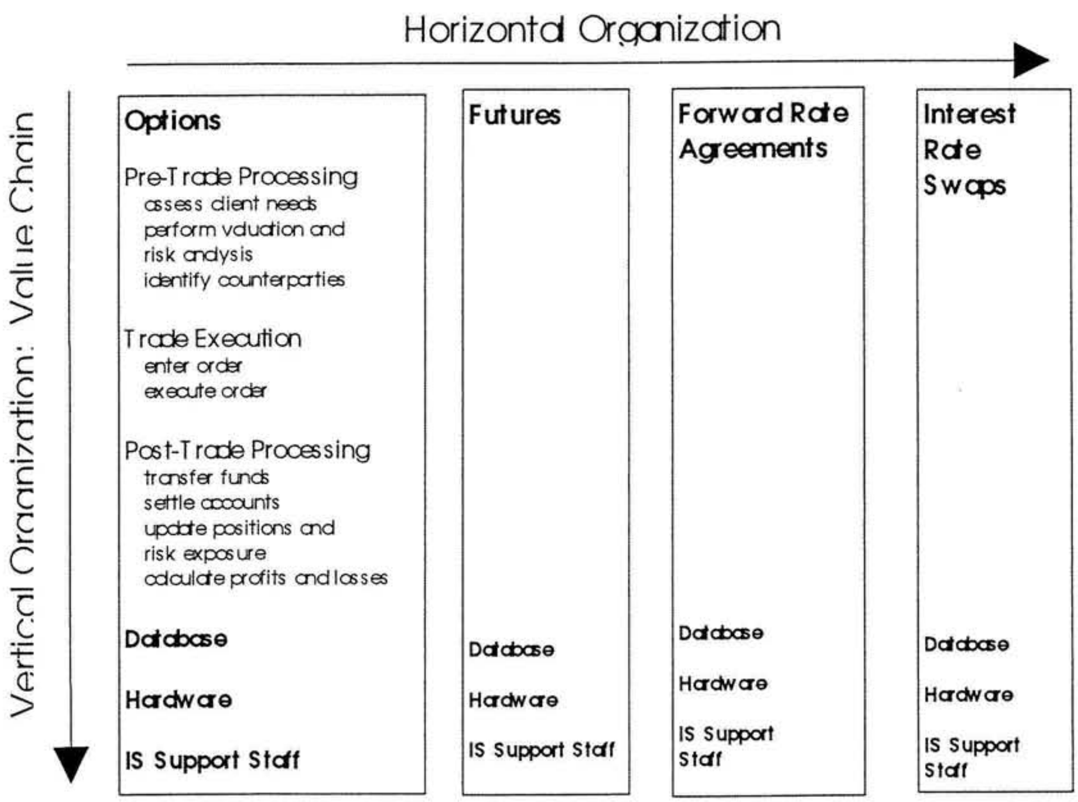


The merged bank's output-side price recovery was also affected. The bank was able to increase its profits by increasing output prices of some selected products. The bank was able to increase these output prices because, as a result of merging the operations, the bank was able to decrease the time it took to bring new products to market. The cycle time improvements enabled the bank to charge a premium in the marketplace for the fast process, resulting in increased price recovery, and, thus, increased profits.

4.2. From Vertical to Horizontal Integration at Swiss Bank, New York

Swiss Bank, a large international commercial bank based in Switzerland, with loan assets of more than $200 billion, operates a major branch in New York City to support its United States clearing operations. In the late 1980s, the bank recognized that it needed to change its IT platform to better support the trading process. Its goal was to reduce operating costs, shorten the trade processing cycle, and produce a consolidated profit and loss statement. To do this, however, the bank would need to make a substantial investment in technology.

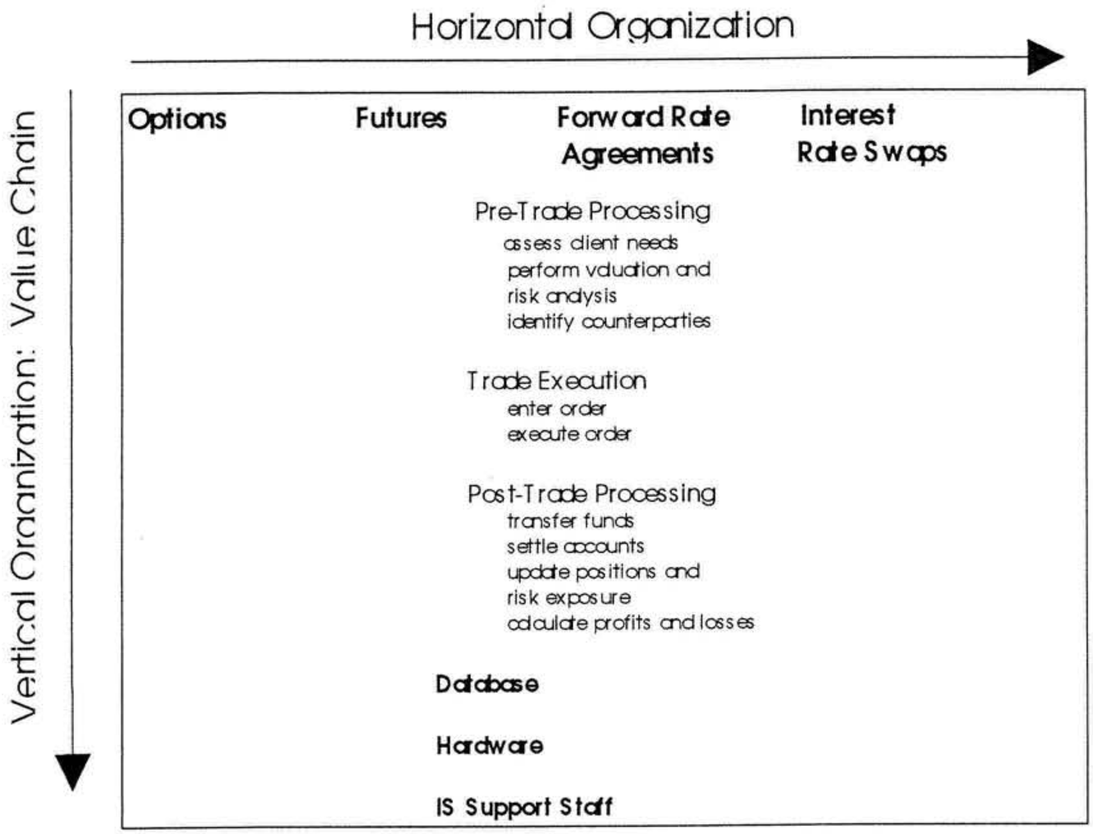
Figure 6: Swiss Bank's Trading Systems Organization *Before* IT Investment



Similar to many other commercial banking firms' systems in the latter part of the 1980s, Swiss Bank's IT platform was not integrated; its product areas were organized in silos, exhibiting considerable *vertical integration*. There were standalone systems for each financial product, including options, futures, and interest rate swaps (see Figure 6). These systems operated on disparate hardware platforms, including PCs and IBM mainframes. Some of the software applications were developed internally, while others were purchased from vendors. In addition, each system had its own database. The independent development efforts undertaken by the product areas resulted in each area requiring its own specialized application support team, leading to wasted application maintenance costs.

The bank's redesign efforts initially focused on the futures and options systems. Follow-up work continued with systems support for bullion, forward rate agreements and interest rate swaps, until the five products were integrated into one system. This resulted in one database with integrated customer information files, one hardware platform, one set of software applications and one group of IT support staff (see Figure 7), replacing the five earlier systems.

Figure 7: Swiss Bank's Trading Systems Organization *After* IT Investment



Senior management invested in IT to improve *horizontal integration*, resulting in increased ouput-side price recovery gains, which arose in several ways. First, Swiss Bank improved its ability to price its trading product outputs, leading to higher margins and higher price recovery. The bank now had daily, instead of monthly, profit and loss information. For example, the bank could now price interest rate swaps on a daily basis. If market conditions changed, the bank could adjust its prices, higher or lower, to reflect the changing conditions. In this way, the bank could incorporate recent information into its current products to obtain the best prices, without waiting for a monthly calculation.

The second way that the bank was able to increase output-side price recovery was through its improved ability to manage its customers' portfolios. Prior to the technology investment, clients' positions in separate financial products were managed separately. An aggregated profit and loss position was calculated monthly because of the difficulty in aggregating information across disparate systems. After the new system was implemented, the bank was able to analyze integrated customer profiles daily. Therefore, the firm was able to coordinate business with a customer across products, improving management's ability to assess profit margin by account.[16]

Finally, the bank was able to improve output-side price recovery through increasingly sophisticated risk management and capital allocation decisions. Through applying consistent measurement techniques across products in the new trading system using common rate data and market prices, the bank was able to manage risk across products externally, improving price recovery. Risk is the uncertainty that a financial product will increase or decrease in value in the future.

[16] Stuchfield and Weber (1992) discuss analogous gains from Barclays DeZoete Wedd's deployment of BEATRICE, which enabled the firm to perform integrated trading profitability assessment -- across products and customers. Developments of this sort in financial market trading operations are often enabled by changes to a firm's information and application architecture that stress cross-product integration.

Thus, any investment in IT which improved risk management improves price recovery. A goal of the bank, and of the financial services industry in general, is to develop a market risk management system which calculates risk, not only at the individual transaction or individual product level, but *across* product lines in order to improve capital allocation and maximize the business value of the entire firm, not just the business value at the product or departmental level. Senior management views the deployment of an integrated cross-product, cross-currency risk management system as potentially having the largest payoff.

4.3. Citibank's "Windows at Risk"

Citibank, a large, American global financial services firm, has a strong international presence, with over 3,400 locations in nearly 100 countries. The bank's worldwide operations make a strong technology infrastructure necessary to support the diversity of its businesses, and to enable high quality product delivery across its many geographic markets. Citibank historically has been one of the largest investors in IT among American banks, and is currently is focusing its IT efforts to improve its ability to manage financial risk.

From Citibank's perspective, risk management systems consist of four elements. First, there is the *technology* of risk management itself, involving the range of real-time and batch data capture capabilities for trade and position management information, comprehensive telecommunication and networking support that makes the relevant data from regional trading operations available to the firm as a whole, and finally the database processing and data distribution mechanisms that enable the regional trading operations to connect to the firm's global operations. Second, key to the management of financial risk is a theoretical and operational framework, the risk *measurement* process, within which the risks associated with different elements of the firm's portfolio can be understood. At Citibank, risk measurement involves the application of a wide range of mathematical algorithms to calculate different types of risk, such as foreign exchange risk or interest rate risk, across a variety of products and customers. The third element, also important to the management of risk, are the *people* who generate, use, or modify information related to business activities that create financial risk. Lending officers, traders, senior management, and others who determine how the bank's financial resources are allocated and mobilized need to be able to work on a consistent basis in support of the goal of profit maximization at the firm level. Without such support, even the best intentions can lead to unacceptable levels of risk. Fourth, *controls* are needed that translate the results of the risk measurement process into usable information to inform managerial decisions about potentially risky transactions at the individual, product, regional, business unit and global levels. Controls are particularly essential in the new product development process. In the absence of sufficient organizational understanding of the potential downside risks, together with inadequate financial risk controls, the expected profitability of introducing a financial innovation can be considered an unknown. This is also likely to be true for new customers and new counterparties; being unable to adequately control transactions that involve them leave the bank critically open to risk.

Thomas Huertas, a strategic planner at Citicorp, observes that the risk management system in which the bank has invested, "Windows At Risk," allows risk to be examined in terms of thirteen different dimensions, including evaluating risk by country, by industry, by product, and by client.[17] Interest rate risk, for example, can now be measured across all instruments and financial markets. This investment has enabled the bank to flexibly increase or decrease its exposures to

[17] *Citicorp Annual Report 1994*, New York, NY, p. 33.

interest rate risk and exchange rate risk, as well as support new products. Huertas compares the types of risk management products that international commercial banks offer to the table of chemical elements:

> *"[Risk management products, specifically] derivatives, allow you to pick apart the risks in any one product, and to build financial compounds attractive to the customer. Because the bank understands which risk elements make up particular compounds, it can create a series of risk inventories. Not only can it meet demand for new products as it arises from borrowers, but it can tailor quite different products for investors, while holding only as much capital as it needs to support its overall inventory."*[18]

This risk management system allows Citibank to control its output-side price recovery. By controlling risk in a precise manner through Windows At Risk, the bank is able to adequately price risk. Hypothetically, if a bank takes on too much risk for a given level of capital (i.e. input quantity of capital constant), then, on average, its trading revenues will be insufficient to cover the losses incurred, because the price of the financial products is too low. The Windows At Risk investment can be viewed as an IT investment intended to control output side price recovery.

Citibank's global risk management system can also positively impact input-side price recovery, through the bank's ability to control its cost of capital. Modern global risk management systems, such as Citibank's Windows At Risk, J. P. Morgan's RiskMetrics, and Bankers Trust's RAROC 2020, all enable risk to be consolidated across different geographical locations, different lines of business, and different financial instruments. By consolidating to measure global risk, the bank is able to determine the extent to which the risks of different positions, instruments and portfolios, correlate with or offset one another. Citibank understands, measures, and predicts correlations among risky portfolios better with this new system, enabling it to more effectively price its own capital for use in lending, trading, investments and other core businesses, and avoid major unexpected losses. In short, by being a more efficient user of its capital base, Citibank is able to more aggressively manage its own cost of capital, which, in turn, improves price recovery.

4.4. Capital and Counterparty Risk Control at Canadian Imperial Bank of Commerce

In the last five years, the Toronto-based Canadian Imperial Bank of Commerce (CIBC) has made a major commitment to extend its financial product offerings, including support for multicurrency transactions, that are increasingly a part of the core financial services required by firms engaged in multinational trade. Operational support for designing and booking multicurrency transactions places great emphasis on the extent to which a firm's applications are integrated. To provide the requisite level of support, CIBC designed and developed a new risk management system that enabled the bank to receive data from the branches for all financial products it offers. Similar to what was described for Citibank's Windows At Risk, CIBC's software produces reports that analyze risk across a number of dimensions, including risk by industry, location, customer, and product line, providing similar input-side and output-side price recovery benefits.

A second important area of investment and technological innovation for CIBC is related to its efforts to control counterparty risks. Done well, controlling counterparty risk can increase price recovery. "[CIBC] can conduct more business without setting aside 10 to 15 percent more credit each year."[19] The bank, like many other international banking firms, has recognized the increasing need to be able to halt trading instantly and on a global basis, when it becomes clear that a counterparty to trading transactions is close to failure.[20] The bank's solution was the deployment of a system that it

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[18] "The Regulators Balk," *Special Section -- International Banking Survey*, *The Economist*, April 10, 1993, p. 33.

[19] Bosco, P. "RXM Diagnoses Credit Risk Ills," *Bank Systems & Technology*, September 1995, p. 34.

[20] Ibid.

calls "RXM." RXM not only supports the kinds of modern risk management capabilities that we have discussed in this article, it also focuses on making counterparty credit decision making real-time, when necessary. The goal in this case, as in others, focuses on price recovery, enabling the bank to better manage credit pricing on a global basis, and also to avoid unnecessary trading losses. To this end, CIBC reports that because of its deployment of RXM, the bank was able to stop trading with Barings Bank Ltd. on a global basis, when it failed in February of 1995. Additionally, RXM increased productivity: "[CIBC] can actually reduce the amount authorized and still find room to transact a greater volume of business." [21]

4.5. Trading Platform Telecommunication Bandwidth at Chase Manhattan

In the early 1990s, Chase Manhattan Bank decided that it needed to replace its current trading technology with a new trading floor. The project was completed in early 1995 at a cost of about $100 million, just prior to an announcement that Chase would merge with archrival Chemical Bank.[22] Chase's senior management viewed the investment as a means to increase connectivity and communications among the bank's existing software applications, and to provide a basis for increased application integration in the future. As one senior officer commented, "Some analysts surmise that the true value of a trading room -- and the measure of its future profitability -- lies not in its state-of-the-art equipment housed on traders' workstations, but in the speed and bandwidth of its cable running beneath the floor."[23]

In this instance, managerial interest focused on reducing cycle time. Cycle time reduction is widely viewed as critical in information-intensive businesses (Wetherbe, 1995). The bank wanted to reduce the time that the trading process took, including activities in the pre-trade, trade execution, and post-trade phases. In the pre-trade phase, the goal was to reduce the time that it took for a trader to get information from the marketplace. According to a senior manager at the bank, "[In the] trading business ... the key ingredient is information. Whoever gets that information fastest has a competitive advantage."[24] "The timeliness of a trader's access to market data is critical to overall trading revenue and profitability."[25] In trading, receiving and acting upon information just seconds before competitors creates the capability for the bank to trade and realize a profit. Although the extent to which the bank's wide bandwidth approach to trading platform telecommunication pays off remains to be seen – for example, merging its trading operations with those of Chemical Bank will require significant efforts to sort out which bank's technology solutions will support various portions of its combined trading operations – one thing is clear: cycle time reduction in trading operations should have profound and measurable impacts on price recovery, as well as on more traditional measures of productivity. A related goal was increasing the speed with which risk management information could be pulled from the bank's on-line trades processing systems, consolidated, and then moved around the bank in support of pre- and post-trade activities.

In our last case, we observe that improvements in quality, which we have shown can beneficially affect a banking firm's ability to increase prices and build revenues, can also be interpreted in a more traditional way: as productivity gains that would be picked up in more traditional assessments of the business value of IT in the trading and treasury context.

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[21] Ibid.

[22] "Move Over Citibank," *News Interactive*, CNN, August 25, 1995 (http://www.nmis.org/NewsInteractive/CNN/Newsroom/A19950825/19950829/seg3.htm).

[23] Prince, C. J. "Trading Speed," *Bank Systems and Technology*, September 1995, p. 36.

[24] Ibid., p. 38.

[25] Ibid., p. 36.

4.6. The Refinement of Trade Execution at Credit Lyonnais, New York

Credit Lyonnais is a large, international commercial bank with headquarters in Paris, France. Its New York branch is among its most important foreign offices, providing the bank with a basis for operating in the American financial and money markets, and creating significant opportunities for the bank to conduct financial intermediation activities in support of French corporations that trade with the U.S. and American corporations that trade with Europe. The bank's IT investments in trading and treasury operations have focused on incremental enhancements of the trading platform. For example, one important, though seemingly minor change that the bank has made is in the trading transaction edit checking process. The edit check process determines how many transactions contain errors, and is carried out as a part of post-trade processing. The errors had been occurring during the trade execution phase, when traders entered incorrect codes to describe elements of a trade on a trade entry screen. The trade entry application was reprogrammed to change the codes and abbreviations into words that were meaningful to traders.

The bank's investment to enhance the trade execution software evidenced a dramatic and valuable change in the quality of trade execution. The error rate associated with incorrectly entered trades declined from 2.45% to 0.21%. In the bank's foreign exchange operations, for example, out of a total of 800 transactions daily, approximately 20 would contain errors. After the software enhancement, this number fell to about 1.5 transactions containing an error each day. For the long-term, the bank is moving towards having traders input their trades themselves, eliminating one important handoff, further decreasing the likelihood of a trade execution error.

The increase in *operational quality* can be traced through to an impact on productivity in two ways. Referring to the APC profit variance matrix, first, the increase in quality created a beneficial input consumption effect: fewer people were needed to process the same number of transactions, as less rework needed to take place due to the reduction in trade execution operating problems. Second, there was an increase in output quantity, as more trades could take place at the same product price and input cost levels. Credit Lyonnais' experience provides a useful ending point for our analysis of the impacts of trading and treasury technologies, because its productivity gains are relatively traditional.

5. DISCUSSION

So is it "paradox lost" or "paradox explained"? Our mini-case examples provide evidence to suggest that the productivity paradox of IT can be understood in new ways, echoing the perspective found in Brynjolfsson (1993). In particular, we have found that the productivity paradox may be viewed as the following:

- as a *model misspecification problem* – failing to consider how to appropriately model and measure the beneficial impacts of improved price recovery, quality, and cycle time can only result in significant and systematic biases in the "numbers" that academic, government and corporate observers have focused on;
- as a *data deficiency problem* – in the absence of widely accepted standards for price recovery-side IT value metrics, senior managers will be uncertain as to what kinds of data are appropriate to collect on an ongoing basis; and,
- as a *business strategy / technology alignment problem* – by emphasizing the wrong kinds of measures, the measurement process shifts senior management's attention away from gauging the leverage of IT on the important outcomes of business strategy to outcomes that may be less important in determining the overall performance of the firm.

For these reasons, traditional measurement approaches to the business value of IT would have failed to capture the true impacts that we found to be important in the international banking trading and treasury process. As we have shown, technological innovations that enable a banking firm to improve quality and coordination, control input and output prices, reduce cycle time, and achieve better integration, can have profound impacts, changing the nature of the business in the process in more ways than productivity assessment can adequately describe. Traditional measurement approaches also would have failed to provide a sound basis for aligning technology with important elements of the firm's business strategy. As we have shown, automating to increase understanding and control of the price of, and margin on economic capital is central to the trading and risk management process. The ability to price risk correctly is a variable that management can control to increase the bank's overall profitability and performance.

Although our research has focused on the international commercial banking industry, there are other service industries in which similar evidence could be obtained, where managing price recovery is central to a firm's success. Consider the hotel industry, for example, and IT investments made by Hilton Hotels, Radisson Hotels and the Marriott Corporation. Marriott's MARSHA reservation and revenue yield management system provides analytical, statistical and data warehousing functions that enable the firm to provide corporate guidance to regional hotels' managers to implement pricing policies so as to maximize revenue yields for hotel rooms in the presence of ever-changing local demand.[26] The rental car business' price recovery and revenue yield management challenge is even more complex. Firms such as Hertz, Avis and National Car Rental need to accurately forecast demand for rental cars, as well as availability within a region, to maximize revenue yield. Avis Rent-A-Car's efforts began in the late 1980s with mainframe reservation and revenue yield management DBMS automation. The firm's latest efforts have produced a client-server application that eliminates the need for reservation clerks to consult paper documents; instead, they rely on online local tables and decision trees that provide support for booking competitive, high yield rental car reservations. Avis' automated "reference rack" also contains information on corporate discounts, credit IDs, policies about additional drivers at a particular airport, and procedures and codes based on location, enabling a clerk in a nationwide reservation operation to make arrangements that are customized at the local level.[27] In addition, these kinds of systems improve the quality of the service for the customer, and reduce the cycle time. Today, you can make arrangements for a mortgage loan in three days instead of thirty, call a single national number to have pizza or flowers delivered locally in under thirty minutes, and check in at a Marriott Hotel in 11 seconds[28] – all of which are instances that highlight the emphasis of IT investment on price recovery for the firm that provides the service. Thus, if there is any paradox, it is why corporate America has not sought to move more rapidly to measure and manage the price recovery gains of IT.

6. MANAGERIAL RECOMMENDATIONS

In light of our mini-case findings and discussion above, we stress the importance for organizations to formulate a new managerial agenda for measuring price recovery. We recommend the following steps to senior managers who are willing to begin to steer by a new IT value compass:

(1) **Recognize the importance of developing a *balanced quantitative scorecard* for assessing the business value of IT in your organization.**

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[26] Personal communication with Marsha Scarborough, Marriott Corporation, Washington, DC, January 1996.

[27] "Overview: Avis Rent-A-Car," *Computer Networks*, March 1, 1994 (http://server1.cmp.farm.barrnet.net/cgi-bin/.)

[28] Heil, G., and Parker, T. "One Size No Longer Fits All -- Technology Lets Companies Customize Goods and Services to Give Customers What They Want," *Information Week*, February 27, 1995 (http://server1.cmp.farm.barrnet.net/cgi-bin/).

Just as Kaplan and Norton (1992, 1993, 1996) recommend a "balanced scorecard" for corporate performance assessment that recognizes quantitative and qualitative aspects, and short-term budgeting concerns relative to long-term performance, so do we recommend that senior managers in IS balance the quantitative side of their own scorecards, to reflect price recovery benefits and complement efforts to measure productivity gains. Although the measurement of price recovery gains will not be easy to implement due to the lack of standards and experience, price recovery metrics can provide a new and relevant basis to measure IT investment success. From the cases examined above, we have observed that the real business value of information technology lies in its impact on the price and cost structure of the firm. Pricing decisions in the pre-trade trading process consist of mathematical risk calculations in which the ability to price quickly and accurately, due to improved information systems, leads to improved profitability.

(2) Explore the extent to which price recovery considerations are *already* included in project planning and capital budgeting plans, even if price recovery is not explicitly measured in IT project performance assessments.

Many organizations reflect the potential for price recovery gains in their capital budgeting plans, even if the evaluative metrics that are applied *ex post* primarily focus on productivity effects (Swanson, 1988). Instead of considering price recovery as a quantitative measure, the usual practice is to include it in the softer, qualitative part of the evaluation, where the lack of data and lack of measurement expertise limits the rigor of the analysis. Organizations that already implicitly consider price recovery effects in capital budgeting and project funding analysis can use their past experience to rapidly identify where, in their organizations, price recovery measurement will provide the greatest managerial guidance.

(3) Begin to brainstorm and experiment with price recovery metrics in business units where IT is believed to be creating the largest price recovery gains within the firm.

Tactical measurement begins with identification of the appropriate *value loci* within the firm (Kauffman and Weill, 1989). Because the American Productivity Center profit variance matrix boils price recovery effects down to changes in the input prices faced and output prices charged by the firm, the procurement and the marketing/delivery channel management activities of the firm provide natural starting points to explore price recovery from IT. Choosing strategic business units which already recognize the price recovery gains from IT in their operations will make it relatively easier to determine what kinds of metrics are needed, and where measurement must occur.

(4) Use experience gained from initial efforts to develop price recovery metrics for strategic business units that traditionally have been major investors in IT, but for which productivity gains have been hard to find.

If an IT value metrics program is to be worthwhile for the firm, then it must seek to measure where the leverage of technology has been difficult to understand previously. By estimating just two things, input and output side price recovery, senior managers may find that the payoff of an IT investment is large enough to obviate concerns about the lack of productivity gains in the area.

(5) Align IT investments with a range of relevant performance outcomes, including productivity and price recovery-derived benefits, that describe the outcomes of successful business strategy.

Referring once more to Kaplan and Nolan's work on the balanced scorecard, it is important to recognize that whatever additional information price recovery measurement yields for senior management, it should be viewed in the context of a broader set of evaluative dimensions for performance. These may include customer satisfaction, application and service quality, innovation, and transaction volume and value, as well as other more direct measures of financial performance – including price recovery.

(6) After price recovery has been measured, identify how those gains can be incorporated into compensation, and create appropriate incentives that will further strengthen the alignment between IT investments and corporate strategy.

When a system that measures the performance of IT investments has been implemented, the real test for its relevance is whether it gives managers the right incentives to build and deliver systems that are tightly linked to the success of the firm's corporate strategy. At some point in time, the measurement system must be linked to compensation. A learning organization should experiment with how price recovery metrics can relate to other desirable performance outcomes for the IT investments, and, over time, refine their use so that senior managers in IS are sending the right message about IT investment evaluation in the context of overall corporate performance.[29]

7. FUTURE RESEARCH

Our research on the price recovery effects of IT investment is developing in several directions. First, our current efforts focus on continuing data collection at a number of international commercial banking firms that will enable us to carry out an empirical study of price recovery in trading and treasury operations. The mini-case studies that we report on in this paper served as a basis to develop an industry survey that includes a variety of indicators of price recovery. Although we are unable to predict the significance of price recovery effects in our empirical findings, initial indications from data collection interviews suggest that the industry and the business process we selected is an appropriate context for this type of research.

Second, the results of this paper demonstrate the need for improving the theoretical basis for valuing IT investments. Advances in theory can provide normative guidance for senior managers seeking to exploit the potential of IT in their businesses. Frequently, IT investments have not been viewed as successful, in spite of popular press reports of productivity *and* price recovery gains. Consider electronic banking technology investments in the U.S. in the 1980s. Productivity and customer service quality were significantly improved (and customer willingness-to-pay for the services increased too), but banks lost money; IT created value, but destroyed profits (Steiner and Teixiera, 1990). Did the expected productivity and price recovery gains fail to materialize? Firms failed to recognize that the competitive equilibrium outcome for electronic banking investments would cause almost all firms to invest, so that no unique competitive advantage could be obtained. Although productivity gains emerged, they were enjoyed by all participants who achieved the necessary scale size. Price recovery gains failed to materialize, in spite of improving service quality and greater product variety. Clemons and Kimbrough (1986) have argued that many such applications of IT are "strategic necessities," with the result that firms are confronted with "hook up or lose out" choices; deploying a technology may yield competitive parity at best, while failing to do so will hasten the firm's exit from the industry.[30]

Other circumstances involving highly "successful" strategic systems may lead to less desirable financial performance outcomes (Vitale, 1986), irrespective of the productivity and price recovery gains they yield. The London Stock Exchange, for example, reengineered its traditional floor-based, market maker-intermediated trading environment to

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[29] "The Measure of Success," *Off the Record*, January 1996 (http://mediapool.com/offtherecord/atb-psc.html).

[30] For these and other reasons, our efforts to estimate the price recovery gains of IT investment in international banking trading and treasury operations include an analytical approach that recognizes the highly competitive nature of the international banking environment, measurement tactics that yield information on price recovery in absolute and competitive efficiency terms for the firms we survey, and hypothesis tests that provide a reading on the significance of the effects. For another example of research in this area that deals with similar analytical, measurement and testing issues, see Davamanirajan, Mukhopadhyay and Kriebel (forthcoming).

a wholly electronic financial market in a move that has come to be known in financial markets circles as "The Big Bang" (Clemons and Weber, 1993). The Exchange was stunningly successful in creating the impacts that were intended: a broader pan-European marketplace, greater liquidity, reduction of the market makers' information advantages, and lower trading costs. The strategy was so successful that the changes were later found to have caused wealth transfers among market participants on the order of $1 billion or more. However, the effect of the strategic system was significantly altered when the Exchange revised the rules to protect broker-dealers once again. The market had lost its patience, despite reduced trading costs, greater liquidity, and higher transaction volumes. Today, most observers think of it as a strategic success, but a financial nightmare. These experiences point to need to balance efforts in IT value metrics development with efforts to build theory that will guide their use by establishing the relevant competitive context (Banker, Kauffman and Khosla, 1996).

A third area for research on the price recovery benefits of IT is in the arena of electronic commerce, an opportunity that many firms are experimenting with and trying to understand. The linchpin in electronic commerce is the firm's ability to determine the consumer's willingness-to-pay, for example, in the purchase of on-line news and information that may result in *micro-charges* (not a dollar, but a penny or even a fraction of that). The productivity gains and consumer welfare benefits associated with the move to electronic commerce will be large, we expect, but the extent to which firms can achieve acceptable price recovery by improving their input-output price margin is open to debate. Clearly, from the standpoint of competitive outcomes in market equilibrium, emphasizing the productivity gains associated with the marketspace revolution surely will miss the point.

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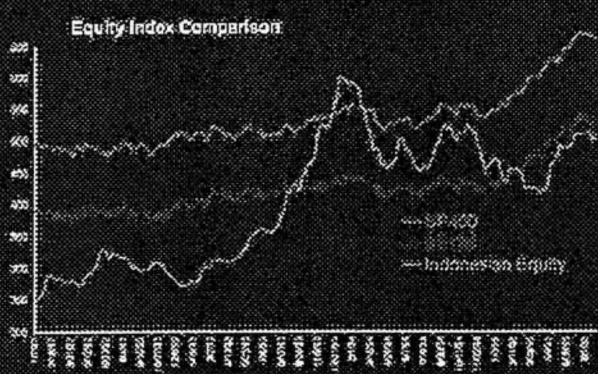
APPENDIX

Adding Value with Information Systems for Financial Risk Management

Bankers Trust's *RAROC 2020* financial risk management software and methodology emphasizes the collection and analysis of large amounts of data that enable instrument and portfolio risks to be assessed. The illustration below depicts an equity index comparison among the Standard & Poor's 400 (**SP400**) equity index, the Standard & Poor's 100 (**SP100**) and a portfolio of equities that are traded in Indonesia. The graph depicts the extensive volatility of Indonesian equities relative to the SP100 and also suggests the extent of the correlation of the movement of the SP100 and SP400 indices.

An Extensive Proprietary Correlation Matrix

Some securities move very closely in sync with each other, like the S & P 400 and 100 indices. Others follow very different paths. Knowing where this takes place in a portfolio allows one to see natural hedges, where they exist, as well as hidden exposures.



A key component of the RAROC 2020 analysis is Bankers Trust's proprietary correlation matrix of over **500 risk factors and 125,000 correlations** developed from three years of historic pricing patterns and volatilities. This matrix essentially mirrors the matrix we use to allocate capital to Bankers Trust's own positions.

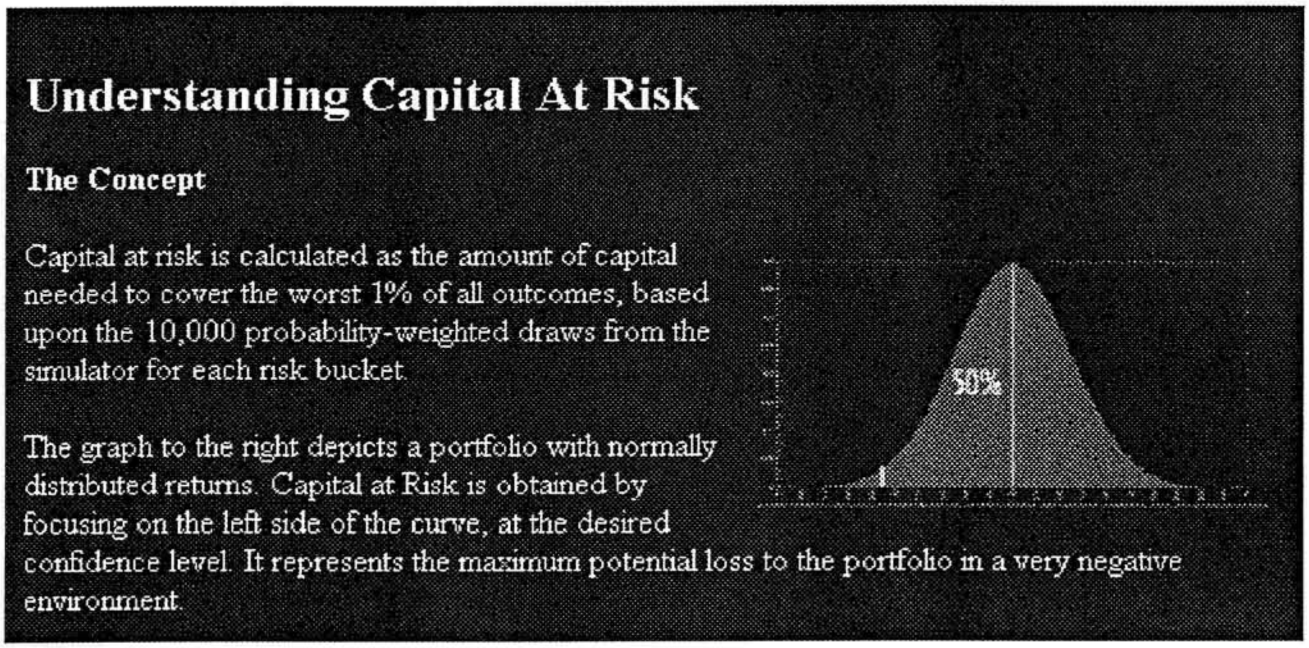
Correlation Matrix

	JPY	*DEM*	*BEF*	*MEX*
JPY	1	.5405	.5191	-.0760
DEM	.5405	1	.9723	-.0615
BEF	.5191	.9723	1	-.0522
MEX	-.0760	-.0615	-.0522	1

The **correlation matrix** associated with a portfolio summarizes the way in which the assets' returns vary in relation to one another. Here we see the factors in the matrix which are related to the option depicted in the example above.

Source: "RAROC 2020: The First Complete Risk Measurement Service," Bankers Trust Company, New York, 1996 (http://www.bankerstrust.com/raroc/tech/index.html).

As the illustration suggests, the management of financial risk focuses on discovering the extent to which the expected returns on a firm's positions are likely to move in relation to one another. In this context, it also is crucial to understand the extent of the volatility of a portfolio asset, so as to gauge the firm's exposure to loss from that asset. As a result, having a powerful information systems and database capability to track the historical co-movement and variance of asset prices is crucial to gaining an understanding of the potential exposure to loss, if events in the market cause key pieces of the firm's portfolio to lose value. The illustration below depicts the idea of *capital at risk* or *value at risk*, discussed earlier in this paper. Tools such as J. P. Morgan's RiskMetrics and Bankers Trust's RAROC 2020 provide powerful tools to enable the financial risk manager to conduct Monte Carlo analysis each morning, just prior to the opening of the market. By applying the correlation matrix to the portfolio position of a given business area, management can gauge the extent of the economic capital that is at risk, should the market experience a two or three standard deviation price shock. (To get some perspective on this, the Black Monday Crash of October 1987 was a ten standard deviation market shock, and as such, wholly unexpected.)



Source: "RAROC 2020: The First Complete Risk Measurement Service," Bankers Trust Company, New York, 1996 (http://www.bankerstrust.com/raroc/tech/index.html).

As the normal curve of position outcome shows, high technology approaches to financial risk management enable the firm to gauge how much it will lose on an expected basis – for example, at the 95% or 99% confidence levels -- and also to take advantage of the extensive inter-correlations of elements of its portfolio that naturally reduce exposure. Until recently, discovering and working with information about such inter-correlations has been difficult or impossible. Moreover, managers of trading operational have always found it hard to identify and implement the "stop loss" policies that are economically efficient. But today, through systems approaches such as the one discussed here, "best practice" risk controls not only can be deployed within the firm to improve its performance, they can also be promulgated as standards for the market at large,[31] further increasing the confidence levels of investors and regulators.

[31] "J. P. Morgan and Reuters Sign RiskMetrics Development Deal," *Risk Management Operations*, May 20, 1996.