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APPROACHES TO IMPROVING BANK SHARE VALUE USING CREDIT-PORTFOLIO MANAGEMENT AND CREDIT-TRANSFER PRICING

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Prudent credit risk management within a bank requires that a number of agents within the firm communicate, agree, and act in a concerted fashion to manage credit risk both at the individual exposure level and at the broader portfolio level. This can be challenging, given the nature of credit portfolios. Even if highly diversified, credit portfolios display heavily skewed loss distributions that imply relatively long quiescent periods (during which losses are lower than their mathematical expectations and the benefits of risk management less visible) and occasional periods of much higher losses. This phenomenon makes it difficult to maintain focus on the impact of individual trades or loans on the longer-term risk of portfolio losses, particularly in large organizations. In this nontechnical paper, which draws on and extends portions of Bohn and Stein (2009), we reflect on some of these challenges and discuss mechanisms, such as credit-transfer pricing, by which banks can better align the behaviors of underwriters, risk managers, and senior managers within large institutions while also increasing the communications between these groups. This approach grew out of industry practice and is currently in use to varying degrees by a number of large banks worldwide. While many challenges still persist in its implementation, innovations in both extending credit and modeling credit continue to evolve to address them, making implementation more practically feasible.

1 Introduction

Recent difficulties at banks have highlighted the need for institutions to consider approaches to capital allocation strategies that extend beyond day-to-day risk management. These approaches necessarily focus also on the incentives that unintentionally lead banks to create portfolios with concentration risk. Credit-transfer pricing techniques offer methods that bridge origination and trading on the one hand, and longer-term risk

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management on the other. The basic premise of these techniques is that credit exposures be evaluated with respect to *the entire portfolio* of the firm.

In this paper, we discuss credit-transfer pricing, a technique which can be used to inform risk managers and motivate bankers to act in a manner consistent with their banks' stated risk appetites by creating incentives for all parties to mitigate the risk of extreme losses.

Though they are simple to describe, transfer-pricing mechanisms are often challenging to implement. The challenges arise both due to technical limitations of the quantitative models available for measuring and pricing credit risk and due to organizational dynamics that must be managed for the mechanisms to be effective. We draw on and extend portions of Bohn and Stein (2009) to first review in nontechnical terms some of the basic themes of credit risk-based transfer pricing and then tie these themes back to practical approaches that financial institutions have used both to better manage risk and to better align the incentives of managers at different loci in a financial organization.

This paper is not quantitative and does not discuss the details or implementation of the quantitative *models* that underlie the infrastructure of active credit portfolio management (ACPM). Rather, we focus on *strategies* for using these tools in practical settings. Readers interested in more technical treatments of the models will find additional details on these topics in, e.g., Duffie and Singleton (2003), Lando (2004), and Bohn and Stein (2009).

We offer some stylized observations drawn from experiences that we and others have had in implementing risk tools at banks. Based on these experiences, we have concluded that successfully implementing credit risk tools on an enterprise-wide basis requires organizational incentives that drive the institution toward portfolio-based decision making, while at the same time increasing the communication between senior managers and risk managers about the firm's risk profile. At the senior-most level, the addition of activities such as stress-testing exercises and scenario analyses as part of a holistic credit risk management program can further aid in this communication by enabling less technical managers to gain intuition regarding the institution's risk profile. More transparent communication can also elevate discussions of credit-portfolio management to a more strategic level.

Said simply, business heads, loan officers, and traders throughout the bank can be seen as bearing not just the *direct cost* of originating their specific subportfolios, but also the *indirect cost* of the economic capital allocations that result from their activities, which may increase the correlation or concentration risk of the overall portfolio. This costs both impacts and is impacted by the activities of many other businesses (for which the managers may have no direct responsibility).

Recent large, high-profile losses at global banks, some of which have even implemented various credit-portfolio-risk management systems, suggest most—including some of the most advanced in credit-portfolio and risk management—still may not yet be able to gain a complete view on the aggregate risk across their full portfolios. Furthermore, if traders, portfolio managers, and bank executives are absolved of the risk or, equivalently, the capital costs of taking particular positions, the incentives for many will be to circumvent risk systems because in that setting, winning trades mostly accrue to individual bonuses and losing trades are absorbed by the rest of the bank.

A well designed and comprehensive credit-transfer-pricing mechanism substantially reduces (though cannot eliminate) distortionary incentives, restoring a bank share value perspective to each decision a trader or loan officer takes. The challenge for many institutions lies in linking portfolio concentration risk to individual decision making, because portfolio concentrations can arise from the (often uncoordinated) decisions of many individuals across the bank.

Of course, firm-level risk may be pedestrian compared with the systemic risks an organization may face as part of the global financial network. As markets become more tightly coupled and organizations increase the types of business and trading relationships they share, this problem compounds. While regulators and market participants are working quickly to develop monitoring systems to highlight potential "hot spots" in the financial system, it seems certain that these efforts will take time due to issues such as confidentiality concerns, the more fundamental lack of data standards, and data quality issues across firms (see, Stein, 2013 for a discussion). While measuring and monitoring systemic risk cannot be done at the firm level alone, credit-transfer pricing offers a framework for mitigating firm-specific portfolio risks, and thereby provides an important perspective for organizations as they begin discussions of their exposures to various systemic events.

1.1 Concentrated portfolios

Although banks have been repositories of credit risk for centuries, only recently have any significant number of banks begun to *actively manage* credit-portfolio risk in a quantitative manner. In the past decade and a half, robust tools for managing credit portfolios have been introduced more widely and at reasonable cost. Prior to the availability of relevant data and tools, banks' portfolios were opaque because banks were only able to provide limited disclosure about portfolio risks and leverage.

This low level of disclosure was often tacitly accepted by market participants and by banks themselves since the cash flows from credit portfolios are, most of the time, predictably stable in their regular—if small—return on assets. This quiescence in portfolio performance arises due to the nature of a credit exposure's return profile: Many borrowers have a high chance of repayment under most states of the world. However, in states of the world in which borrowers *do* fail, the resulting loss from an individual borrower can be large and is often accompanied by losses from many other borrowers. In less actively managed credit portfolios, this correlation drives a return profile over time that exhibits small regular returns punctuated by disproportionately high losses.

An interesting attribute of credit portfolios is that they typically continue to benefit from diversification (in terms of reduced volatility and reduced downside loss risk) as additional small and minimally correlated exposures are added to them. The incremental benefit of diversification for portfolios with symmetric return distributions, such as those often exhibited by equities, can become increasingly smaller once a portfolio contains tens or hundreds of names. In contrast, though the probability of correlated extreme losses is small in credit portfolios, it is neither negligible nor economically insignificant, and, unlike an equity portfolio, a so-called fully diversified credit portfolio will typically retain substantial skewness due to the binary payoff of credit risky assets and the nondiversifiable component of their correlation structure.

The portfolio skewness is further compounded in that credit markets appear to originate credit in a markedly undiversified fashion. As a consequence, holding the (local) market-weighted portfolio of outstanding credit often produces

highly concentrated portfolios. These circumstances contrast with those seen in equity markets in which the market-weighted portfolio is typically considered to be well diversified. Moreover, since banks tend to specialize in particular geographic and industry segments of credit origination, they often generate substantially more concentrated portfolios than even the market-weighted portfolio.

This implies that while active management may not produce sustainable economic benefit for equity portfolios, it can produce substantial benefit for credit portfolios.

1.2 Incentives for bank management

In this paper, we consider useful strategies for implementing and deploying a mix of systems, models, and policies across a firm in order to minimize the economic capital required to support its portfolio, given the firm's risk appetite. This activity frees up capital for investment in noninterest income generating businesses, which in turn supports the firm's longer-range strategic business objectives.

The unifying motivation for bank boards and senior management teams to adopt active credit-portfolio management is an economic one. By effectively managing and clearly communicating to investors its levels of portfolio risk, a bank may enjoy higher equity valuations.

If investors are averse to the disruption of future cash flows due to local credit shocks, they will be troubled by the increasing likelihood of such events as a particular bank develops concentration risk in its portfolio due to its lending activities. These concentrations (specializations) make sense from a franchise perspective (the focus on broad and deep relationships with specific clients creates a competitive advantage in cross-selling other products and services to these clients). However, investors may nonetheless penalize bank equity value out of concerns for the accompanying portfolio concentration risk, which makes the overall portfolio of assets riskier. This penalty may in fact overwhelm the value contribution of noninterest or fee income generated from the broad and deep relationships.

In a sense, *unless* a bank can demonstrate that the portfolio component of its value is managed to reduce the potential for large disruptive credit losses, the uncertainty around the bank's susceptibility to clustered credit events will motivate investors to value the bank as if the risk were present and (relatively) large.[1] In this context, the incentives for bank boards and leadership motivate them to manage their credit portfolios so that the risks are more readily quantified and to provide investors with clear signals that they are doing so. At the same time, the bank cannot focus exclusively on credit risk management: the bank also benefits from incentives to build sources of stable noninterest income.[2]

1.3 Active credit portfolio management (ACPM), credit-transfer pricing, and incentives for bank staff

While specialization in key customer or market segments can create significant economies of scope for a bank, it can also create substantial concentrations in unmanaged portfolios, which can make them unnecessarily volatile and economically inefficient. In economic terms, this implies that although the bank can realize the same level of return on the loan portfolio, the bank must reserve more capital than it would if the portfolio were managed more efficiently.

However, while credit exposures are *originated* at the loan officer (trader) level, the *impact* of a loan (trade) on the portfolio's capital can only be *assessed and managed* centrally (correlation effects can only be estimated at a portfolio

level). Thus, seemingly benign or even beneficial exposures—those that have low default probability on a stand-alone basis—may actually increase the bank's overall risk when viewed from a portfolio perspective.

The practice of active credit-portfolio management has evolved in response to this dynamic. Much of the research and insight that relate to active credit-portfolio management developed in the 1990s and 2000s with a focus on corporate exposures, and to date, this has been where these techniques have been primarily applied.[3] During the past two decades, the rapid growth of credit markets has created an environment in which some banks have been able to manage and hedge large portions of the credit exposures generated by their corporate franchise businesses as a means to providing more stability in their portfolios. During this time, academics and professionals have collectively refined their knowledge about quantitative techniques and models for sizing various portfolio risks.

While researchers are continuing to extend this knowledge, a number of quantitative techniques have become a common and core component of modern corporate credit-portfolio analysis. As a result, in addition to the challenges in broadening the *understanding* of credit risk drivers, key challenges now appear to center on how to *deploy* these tools and systems. Effective analytics deployment requires not only that users understand these tools (including their limitations), but also that they have appropriate incentives to use them in a manner consistent with the strategic objectives of their bank. In practice, this typically has less to do with modeling or IT issues, and more to do with the organizational structure and culture in which models are implemented and used.

Key to the realization of a bank's risk strategy is the development of a clear mechanism through which the disparate parts of the bank can coordinate and communicate about the overall risk of the bank's portfolio. Unfortunately, implementing such a mechanism can be particularly difficult in banks, where the origination function is often far removed from the risk management function, and yet where the portfolio function must often retain originated exposures. Even in cases in which lending groups wish to originate the appropriate exposure (i.e., in line with the bank's risk objectives), it is sometimes difficult for bankers in these groups to know what the appropriate exposure is.

This difficulty arises from the challenge in generating *transaction-level* metrics that contemplate the complexity of the bank's *overall* credit portfolio. It is not uncommon for a bank portfolio to contain tens or hundreds of thousands of individual exposures, originated by many franchises within the institution. Coordinating the incentives of these various actors becomes even more complicated due to the fact that the downside risk from concentrations in a bank's portfolio (i.e., large, correlated losses across the portfolio) only reveals itself periodically, and is thus difficult to connect to the origination activities.

Creating the link between origination activities and the bank's portfolio risk is the focus of what we discuss in the remainder of this article.

The basic concept is straightforward:

All credit risk originated by business units can (to some degree) be priced based on the cost of either hedging this risk or allocating capital to absorb unexpected losses associated with it.

To the extent that a business unit enters into a transaction it evaluates as profitable, or lends to a client it assesses will generate large future revenues through other activities, the business unit should pay for the hedging/capital cost of the transaction as one of the expenses associated with

its business. Whenever the risk-adjusted value of the expected profit does not exceed the cost of managing the added credit risk of the transaction, the business unit has little economic incentive to enter into the transaction (unless it can pay for the cost through other activities related to the transaction).

Central to such analysis is the evaluation of this "cost" in concrete terms. Because bank portfolios tend to be lumpy, it can be helpful to think about the hedging costs not only in terms of a market price, but also in terms of a "portfolio-referent" risk measure or price, i.e., the price that the new loan should have, given the exposures that the bank already has in its portfolio. We will consider both of these approaches in Section 3.

To facilitate portfolio-referent analysis, an important organizational feature of a number of larger banks today is the ACPM function. This operating unit, which can have responsibilities ranging from hedging to more fully developed investment and trading activities, provides a mechanism for centrally managing the bank's portfolio risk and for communicating the impact of new transactions on the portfolio. While the arguments for ACPM in a bank are grounded in strong economic principles, the realities of practical implementation typically require defensible modifications to the theory to suit the needs of each institution and practical market frictions. Our objective is to describe, at a high level, a mixture of conceptual perspectives and practical solutions.

The remainder of this paper is structured as follows: Section 2 outlines conceptually how bank valuation provides an impetus for a bank's senior management to implement prudent risk and portfolio management strategies. Section 3 discusses the implementation of practical transfer-pricing mechanisms. That section also describes some substantial challenges that still exist, both quantitatively and organizationally, in implementing ACPM frameworks using the current generation of credit risk models. Given the role of quantitative models in developing transfer prices, Section 4 briefly discusses model risk and the role of stress testing and qualitative approaches as important complements to quantitative methods in ACPM. Section 5 concludes. An Appendix contains a brief review of some of the literature on bank portfolio diversification and income diversification to provide motivating context.

2 Credit risk and the valuation of bank equity

In the introduction, we offered arguments for how prudent credit risk management practices, when balanced with a bank's strategic business opportunities, can also help maximize the long-term value of the bank's equity. This valuation process implies strong incentives for banks to better understand and communicate the risk profile of their credit portfolios.

Given the importance of banks to the world economy and most regional economies, we might expect to find extensive research on bank valuation. Historically, this was not the case. While some research had been done in this domain (e.g., Kane and Unal, 1990; Dewenter and Hess, 1998; Megginson *et al*., 1995), the earlier literature is far from extensive compared with other areas of finance. To the contrary, most researchers who delve into topics ranging from general equity valuation to capital structure often explicitly *exclude* banks and other financial institutions due to their unique characteristics.

To understand the link between portfolio risk management and bank valuation, we first consider a bank's business at the most abstract level. We characterize a bank's enterprise as being composed of two broad types of portfolios: a portfolio of *business franchises* and a portfolio of *financial assets*.

A bank's core business franchise involves taking in deposits with short maturities and using these funds to undertake a variety of lending activities to governments, corporations, small businesses, and individuals at longer maturities. Thus, banks transform short-dated deposits into longer-term loans, thereby solving a liquidity problem common to most economies.

These deposit and lending activities are typically composed of sub-businesses such as:

- retail deposit businesses that provide a way for individuals to safely deposit money and (sometimes) earn a return on their savings, which also provides an inexpensive source of funding for the bank; and
- loan origination businesses that provide a way for borrowers to obtain financing and for the bank to earn interest income.

Banks may also leverage their relationships with both depositors and borrowers to build other kinds of service businesses. For example:

- Cash management services
- Foreign exchange services
- Merger and acquisition advisory services
- Investment banking services (underwriting, structuring, etc.)
- Financial product distribution channels
- Wealth management advisory services

The result of many of these lending and service activities is the creation of credit risky exposures, which are added to the bank's existing portfolio of financial assets and which should be managed.

We find it useful to distinguish between *deriving noninterest income* (from customer relationships in the franchises) and *managing a portfolio of financial assets* (that are accumulated as a by-product of lending activities and other services). In this context, a bank increases its share value by first building profitable businesses, based on lending and noninterest income, and then managing the credit portfolio generated by these activities in order to reduce the risk of extreme portfolio losses (and to free up capital for additional investment in the franchises).

Bank valuation is related to these two "business" lines (lending/service franchises and portfolio management) and how the owners of a bank make use of debt to improve the return on their equity. The level of leverage in a bank's capital structure, all else equal, increases the bank's default probability and thus directly impacts the cost of funding for that bank.[4] In abstract terms, a bank must consider a level of leverage high enough to generate a reasonable return, but not so high that it increases the bank's default risk to the point that the cost of funding becomes prohibitively expensive.

2.1 A conceptual framework

The familiar class of *structural models* of default provides a parsimonious, yet rich conceptual framework for integrating leverage, volatility, and default probability. The most well known of these (Merton, 1974) contemplates a firm with a single class of zero-coupon debt and continuously valued assets. In this model, default occurs when the value of the firm's assets falls below the value of its debt (i.e., when equity falls to zero). Under the assumptions of the model, the volatility of a firm's assets and the cushion between the current value of assets and the face value of the debt determine the firm's probability of default (PD). Thus, increasing the volatility of the firm's assets (in the franchise or the credit portfolio or both) or increasing the face value of the firm's debt relative to total assets (levering up) will increase the PD.

While such models can be extended in a number of ways to accommodate real-world frictions (such as taxes, incomplete data, or richer capital

structures), there does not currently appear to be an agreed upon and coherent theory of optimal bank capital structure. However, market behavior suggests that a bank will attempt to maintain a strong enough level of credit quality to borrow at rates that allow it to profitably construct a portfolio while also acting as a service provider in key businesses (e.g., businesses in which the bank requires a specific credit quality to act as a counterparty or provide guarantees). Thus, the motivation to boost return on equity by levering up is tempered by the reality that too much leverage creates risk and raises funding costs, which can eliminate the opportunity to build equity value at all.

Since the level of economic capital a bank holds against losses is a direct cost and also directly affects both the bank's leverage and the impact of large losses, a bank's board and senior management have incentives to focus on the *credit risk of the bank*. In doing so, they need to focus not only on the level of leverage the bank maintains but also on the volatility of the bank's holdings. Thus, leverage and, to a lesser degree, volatility become control variables.[5]

In a frictionless world, and holding all things equal, the structural model suggests that equity holders should prefer riskier strategies and should thus seek to maximize volatility.[6] Furthermore, the capital structure of the firm (its leverage) should be theoretically removed from an assessment of what drives the overall enterprise value. That is, Merton's structural model emphasizes the insight of Modigliani and Miller (1958) that a firm's total asset value is independent of its capital structure. However, it is difficult to imagine many practical settings in which the *volatility* of assets increases, but the *value* of the aggregate assets is unchanged. (For example, if asset volatility increases due to increased volatility of earnings on the assets, this volatility will decrease the value of the assets as well since the cash flows they generate are less certain.)

Because it is expensive to raise capital in real financial markets (either through debt or equity financing), particularly for a riskier firm, banks would prefer to support their businesses primarily with internal capital and retained earnings. If a bank can do this, it can fund a growing balance sheet (i.e., portfolio of financial assets) with mostly deposits, and supplement this capital with some debt (the benefits of which are enhanced through the indirect subsidy of the tax deductibility of interest expense).[7]

Determining the appropriate level and structure of external financing is the crux of the funding challenge. Since the PD of the bank affects the cost of issuing new debt (and its ability to participate in key businesses), the bank has a strong incentive to lever up only to the point where the bank's default probability does not result in borrowing cost increases that overwhelm these other advantages. This implies maintaining enough of a cushion whenever possible to avoid either having to borrow in the debt markets at unfavorable rates or, alternatively, having to issue equity at unfavorable terms.[8] This, in turn, implies maintaining a level of volatility and leverage that makes default a reasonably remote possibility. The aversion to default is further compounded since, at the very time a bank most needs to raise capital (i.e., when its own internal capital has been depleted), it is likely that its borrowing costs will be highest because the bank's leverage will have increased and it will be perceived as having a higher likelihood of defaulting.

Volatility may be more difficult to manage directly. However, we see, through structural models, the explicit theoretical link between the volatility of assets (including the financial

portfolio), the level of leverage, and PD. By virtue of the costs of both borrowing and bankruptcy, we see the relationship with the value of the bank's equity. Regardless of their financing strategies, banks should always seek to generate a sustainable, growing positive net cash flow stream with only as much volatility and downside risk as is necessary to produce this cash flow stream. If the volatility of the bank's portfolio is higher than necessary, the cost of borrowing will also be higher than necessary, *but despite the added volatility, there will be no added return*. Said differently, excess portfolio volatility implies that the portfolio could generate the same return for the bank at a lower (capital) cost.

The primary driver of volatility in a portfolio of credit risky exposures is the correlation among those exposures. Even though this correlation tends to be quite low compared with, say, the correlation among equity exposures, the diversification of credit exposures usually requires a *larger* number of names than is the case with equity or other instruments with less skewed payoffs.

The skewness results from a *lack of large increases* (above par) in the values of individual exposures to offset the rare but *large decreases* in the values in distress.[9] As noted earlier, this property makes the risk profile of credit portfolios quite different from equity portfolios.

Portfolio diversification can dramatically reduce the volatility of a credit portfolio and thereby provide an institution with some measure of stability in its portfolio's loss profile. However, even in diversified portfolios, substantial volatility typically remains. This implies that even a well-diversified credit portfolio will typically exhibit significant skewness *that cannot be diversified away*. As part of a specific business strategy, a bank may choose to accept a certain level of both nondiversifiable and diversifiable concentration risks. For example, if the expected profit is sufficiently large relative to the economic capital a bank must reserve against a set of correlated exposures, the bank may decide to deliberately build up a concentrated position in this group of exposures. However, it is difficult to determine whether such levels of risks are commensurate with a bank's risk appetite if these risks are underpriced.

Underdiversification is typical in unmanaged bank portfolios, since they are not usually constructed with a portfolio perspective in mind. Each new loan a bank originates typically changes the portfolio's credit risk. It may change the expected (average) loss for the overall portfolio, which measures the degree to which the bank will, on average, experience losses due to the credit quality of each loan in its portfolio. However, regardless of the stand-alone expected loss (EL) of a new exposure, adding it to bank's holdings, also changes the concentration in the existing portfolio since the new exposure will either increase or decrease the portfolio's diversification. While the contribution to the portfolio's EL can be calculated trivially based only on the summary EL of the portfolio and of the new asset (and their relative sizes), the contribution to *diversification* (which we characterize as contributions to unexpected loss, tail risk, expected shortfall, etc.) can only be calculated with reference to the full portfolio of the bank, which is not typically visible to the manager creating the exposure. Because the level of diversification directly impacts the amount of capital a bank will reserve to support the portfolio, managing diversification is the mainstay of a credit-portfolio manager's function.

Given a bank's risk appetite, the challenge of aligning organizational incentives arises because concentration risk manifests itself *over a number of years and across the entire portfolio*,

while traders and lending officers are typically compensated over *shorter time horizons and for individual transactions*. During normal times of low credit losses, lending officers and traders may erroneously conclude that a given level of return in a particular year provides sufficient compensation for credit risk. During these quiet times, concentration risk may appear to be an abstract, academic concern, which can lead to the perception that there is little benefit from active credit-portfolio management. The benefit of credit-transfer pricing is that it can help keep the total cost of new lending foremost in the minds of executives, lending officers and traders during the good times, which can lead to a more robust, diversified portfolio constructed to weather the bad times.

2.2 *Historical examples of underdiversification*

To make these abstract notions more concrete, consider two examples in which analyzing the *portfolio impact* of a particular new exposure would have motivated different conclusions than would analyzing the *stand-alone risk* of the single exposure in isolation:

- Japanese banks in the 1990s tended to hold portfolios heavily concentrated in large Japanese companies. Some of these companies (such as Toyota and NTT) had quite low individual default probabilities and were viewed as safe on a stand-alone basis. In fact, adding a high-quality borrower like Toyota to the portfolio would often *improve* the average EL of the portfolio (i.e., make the EL lower). However, the risk contribution (RC) of a large, high credit quality company such as Toyota to a portfolio that was already overweighted in Japanese exposures would likely have been larger than the RC of a mid-size European company of lower stand-alone credit quality, since the large Japanese exposure would not decrease concentration in the portfolio (it actually increased it) but the European firm would.

The stand-alone EL measure (which does not contemplate diversification benefit) for, say, Toyota would have suggested adding it to the portfolio, while the portfolio-referent risk measure (which considers diversification benefit) would have implied that the lower credit quality, non-Japanese company would provide more benefit. (Typically, the correlation across *geographies* is lower than the correlation across *industries* within any particular geography.)

- U.S. banks in the 1970s tended to hold portfolios of large, high-quality U.S. corporate borrowers. We now know that the marginal RC of an additional *large* corporate borrower in the portfolio was typically higher than the RC of a *small to mid-size* company even if the smaller company were from an industry already heavily represented in the portfolio. (Especially for larger firms, the correlation between company *size groups* within the same industry is lower than the correlation between *industries* for a given company size group.)

Historically, the result of constructing such portfolios was that banks would often experience portfolio shocks. In a prototypical setting, a bank would invest heavily in building franchises based on relationships with lucrative clients. These relationships led naturally to loans, which strengthened the relationships and led to other business with existing clients. At the same time, having developed a franchise in a specific sector or geography, a bank had a tendency to increase its lending into the geography and sector in which it had developed this business in order to enjoy economies of scope and scale. At some point, bank customers in a concentrated geography and sector would cycle into economic difficulty, at

which point the bank would experience disruptive losses.

Variants of this story were manifested in the U.S. in the 1970s and 1980s and in Japan in the 1990s. (An even more interesting case of concentration risk arose in the most recent financial crisis with many banks holding too much exposure to U.S. and U.K. residential real estate.[10]) The typically low market-to-book multiples equity investors have historically awarded banks may be a consequence of this cycle of concentrated lending. Investors may penalize banks that hold portfolios that are not diversified beyond the focus of their origination activities.

This is why the challenges portfolio managers at banks face in credit risk management are different from those of even their colleagues who manage portfolios of corporate bonds (or syndicated loans). Bank portfolios are different because banks *originate* credit exposures directly, and these exposures, if not traded or otherwise hedged away, *remain in the portfolio* until these instruments pay off or default.

Unlike a bond fund manager who builds his portfolio by selecting the assets he believes will contribute to the portfolio's risk-adjusted return and passing over those assets which he feels will not, a bank's credit-portfolio manager must develop strategies subject to the constraints imposed by the loan book, which is populated by the exposures that loan-origination officers create. Since the bank may have a number of objectives in originating a loan, the loans may not always be originated with an overall portfolio construction perspective in mind.

Active credit-portfolio management has evolved to permit banks to continue to specialize in noninterest income franchises in which they enjoy competitive advantages, while at the same time creating risk measurement and incentive systems to prevent sudden shocks to their portfolios.

2.3 Income diversification, ACPM, and bank value

An important premise motivating the ACPM framework and the observations in this paper concerns the contribution to the value of a bank of having a growing, stable fee or noninterest income stream. Under the assumption that a bank implementing ACPM already has a set of profitable and value-creating business franchises,[11] the bank should perform better if it gears incentives toward building a diversified credit portfolio that minimizes the risk of extreme losses as a means of building those service franchises and growing their stable income streams. This effectively allows the bank to focus more of its capital on growing its franchises rather than protecting itself in times of stress, given a target risk level.

Redirecting incentives toward increasing noninterest income must be accompanied by adequate management oversight to ensure that new income streams are reasonably diversified, approximately recurring, and expected to grow. Thus, the *type* of noninterest income matters. For example, noninterest income earned from cross-selling products and services to a bank's borrowers will tend to be more stable than noninterest income earned from proprietary trading. On the other hand, all else equal, cross-selling new products to existing customers will increase the bank's overall concentration.

Franchise businesses sometimes incorporate notions of relationship lending or even "break-even" or "loss-leading" products that are provided to clients in order to entice them to also use other higher-margin services. These strategies do not always account for the capital cost associated with increasing the bank's exposure to the same

client. A credit-transfer-pricing system can be an effective mechanism to improve management's understanding of the *total cost* associated with selling a range of products and services to a customer who may, for example, borrow or obtain commitments to borrow at a rate not economically profitable on its own.

A number of studies have explored the empirical impact of income diversification on bank value. Their theoretical and empirical results paint a mixed picture. There are a number of potential reasons for this—from differing samples of institutions studied to the variety of measures chosen to measure performance and diversification. The nascent state of the research on the broader impact of active credit-portfolio management on a bank makes it difficult to draw concrete empirical conclusions from this literature, which spans income diversification, optimal loan portfolio construction, and bank valuation. (While a full review of this literature is beyond the scope of this paper, Appendix A provides a partial review for context.)

In looking over this sampling of the literature, however, we can broadly summarize the results with two stylized facts:

(1) It seems reasonable to view ACPM and its accompanying diversification as a net benefit to banks, both in terms of volatility reduction and possibly in terms of increased risk-adjusted returns.
(2) When banks diversify the noninterest components of their income streams, the results are more mixed and harder to interpret. This may be due, in part, to the difficulty in determining whether banks are diversifying into natural growth areas or into areas in which they have little experience or competitive advantage. It may also be the result of differing methodologies and measurements.

3 Transfer pricing and incentives: a *lingua franca* for the bank

In addition to reducing portfolio volatility, ACPM can enable credit-transfer pricing, which can align portfolio construction incentives across the bank. This in turn facilitates more efficient use of capital across the bank, freeing it up for investment in (core) noninterest income-generating businesses.

The goal of a *transfer-pricing* framework is to ensure that the bankers who originate loans are aware of the costs to the bank, from a risk and capital allocation perspective.

The concept is not new. In fact, funds transfer pricing is used by many banks to reflect the cost of *liquidity* from an asset-liability management perspective when a loan is made. That is, the cost of deposits or debt used to fund the loan is calculated as one of the costs of making the loan.

Interestingly, the same analysis has not traditionally been done for the cost of *economic capital,* which a bank must hold as a cushion to absorb losses. Similar to funds transfer pricing, a bank can use credit-transfer pricing to associate a cost with the use of bank capital to support the credit risk inherent in the new loan after the loan is made.

The goal of implementing credit-transfer-pricing systems is both to discourage economically unprofitable lending and to make capital costs explicit. The overall net profit of a client relationship then becomes the arbiter of which relationships a bank builds and which it discontinues.

A credit-transfer price reflects the price a portfolio manager, who is centrally managing all the bank's exposures, would be willing to accept (i.e., after accounting for diversification benefit) in return for taking on the incremental risk of the new exposure.

Conceptually, credit-transfer pricing places a cost on the use of capital inherent in the extension

of credit to an obligor. Originating a loan that stays on the bank's balance sheet consumes some of the bank's capital. If that loan is placed in a centralized portfolio and managed accordingly, economics imply that its spread at the time of origination should be sized such that the return per unit of risk of that loan is at least as good as or better than the return per unit of risk earned by the exposures that make up the portfolio (otherwise the portfolio's return/risk profile will decline).

The express goal of the credit-transfer price is to provide an economic incentive for the relationship manager or trader originating a loan or entering a trade to either charge a profitable spread on a transaction or to find other noninterest income (or both) such that each customer relationship adds to, rather than subtracts from, overall bank share value. This contrasts with the historical focus of line managers on the profitability of their single business units, alone.

3.1 Some common credit-transfer-pricing measures

In practice, a number of measures may form the basis of a credit-transfer-pricing system. The specific measure a bank uses will depend on the structure of the bank's capital allocation process and on the tools available. Here, we describe three common measures that may be used as the basis for credit-transfer pricing (see Appendix B for more detailed definitions of the components of these measures):

(1) p_S (Sharpe ratio- or risk-contribution-based transfer price): Calculated as the expected spread (ES_S), above the EL such that the new exposure's individual Sharpe ratio equals or exceeds the portfolio's Sharpe ratio (or an alternative benchmark Sharpe ratio such as one observed in the market, etc.). The actual transfer price would be:

$$p_S = ES_S + EL \quad \text{or} \quad p_S = TS_S.$$

(2) p_V (Vasicek ratio- or tail-risk-contribution-based transfer price): Similar to 1, above, but calculated with respect to the Vasicek ratio. Calculate the ES_V that produces an individual Vasicek ratio that equals or exceeds a benchmark Vasicek ratio (portfolio, market, etc.). The actual transfer price would again be:

$$p_V = ES_V + EL \quad \text{or} \quad p_V = TS_V.$$

(3) p_C (CDS-based transfer price): Estimated based on the CDS spread (either through direct observation in the market or through modeled prices based on a set of generic CDS curves estimated from recent market data) for the exposure:

$$p_C = \text{CDS spread}.$$

Note that we use the term *CDS* to represent a more generic market spread. In practice, Option 3 is sometimes implemented through a more sophisticated and detailed "waterfall" approach in which a variety of market prices and proxy pricing models are ordered from most to least accurate and the most accurate market price available is used to arrive at a credit-transfer price.

Ideally, the appropriate method for calculating a credit-transfer price should reflect a measure of spread per unit of contribution to overall *portfolio* risk. Options 1 and 2 are, in fact, true portfolio-referent approaches, while option 3 is a market price approach.[12]

3.2 Portfolio-referent measures

In order to highlight the practical challenges in implementing credit-transfer pricing, we compare the two portfolio-referent measures. The strength of the risk-contribution (RC)-based measure (p_S) is its intuitive interpretation and its mathematical tractability. These characteristics

make it easier to educate bank staff impacted by transfer pricing. Given the nature of correlation, the sum of individual exposures' unexpected loss estimates do not add up to the portfolio unexpected loss but rather, are functions of the change in concentration in the overall portfolio. This sensitivity to concentration is desirable in a credit-transfer-pricing measure. The weakness of the risk contribution measure is its lack of information with respect to the possibility of *extreme* loss.

In contrast, the tail risk contribution (TRC)-based approach (p_V) addresses this extreme loss potential explicitly. However, TRC may generate results that seem counterintuitive when compared with RC-based measures. For example, exposure to large, low-risk borrowers such as NTT or IBM (as in our earlier examples) may result in a relatively low *RC* estimate (p_S), but the *size* of the exposure may also result in a relatively high *TRC* estimate (p_V). This is because in states of the economy in which default becomes more likely for all firms, holding large positions in *any* single name can expose the financial institution to large losses more than a small position in even a high-risk borrower. (Since in extreme states of the economy *all* firms approach default, stand-alone risk starts to matter less.) Furthermore, the large, low-risk borrower may be more highly correlated with the rest of the portfolio due to the relationship between firm size and correlation.

An advantage of the TRC-based approach is that as the size of a transaction increases (all else equal), the TRC-based approach will reflect the fact that the hedging cost to a given portfolio increases at an increasing rate, while the RC-based approach will increase the cost at a rate that is much closer to linear in the transaction's size. Proponents of the TRC measure note that this feature (cost increases in the size of exposure and does so at an increasing rate) is a desirable property for controlling concentration risk. Since capital is reserved against extreme loss, the TRC-based measure better reflects how the risk of extreme loss is changing as exposure to a borrower or a correlated group of borrowers increases.

3.3 Implementation challenges for portfolio-referent measures

While true portfolio-referent measures such as p_S and p_V are theoretically compelling, they can be practically difficult to implement in certain settings—particularly as a first step—for a number of behavioral and organizational reasons. Prominent among these are that institutions undergoing such implementations must sometimes contend with internal resistance to quantitative tools. In addition, these approaches may introduce unintended incentives.

Internal resistance can arise because the implementation of a portfolio-referent transfer pricing approach represents a fundamental change in mindset for many bank staff. Bank relationship managers may initially oppose credit-transfer pricing since it constitutes a radical departure from how many of them build their loan business. Portfolio-referent pricing forces loan officers to shift their focus from the *size* and *quantity* of loans to the economic or risk-adjusted *profitability* of loans.

The introduction of new portfolio models for measuring risk can add to the resistance. As we discuss in Section 4.2, the output of the underlying models can sometimes be difficult to validate explicitly making it challenging to establish acceptance across the bank. For example, both RC and TRC require a calculation of some measure of correlation, which requires acceptance of models that may be (relatively) new and often harder to understand. This is an area in which stress-testing

exercises can be useful in providing intuition for the behavior of the models.

But even if the approach and models are accepted internally, portfolio-referent transfer pricing may also introduce unintended incentives due to the potential for the credit-transfer-pricing measures to motivate staff to build suboptimal *businesses*.

To see how these incentives can arise, consider the role of concentration risk in the transfer price. Since correlation becomes an important factor in a credit-transfer-price calculation, geographies and asset classes that are not currently represented in a bank's existing portfolio tend to have lower correlations (all else equal) and thus the transfer prices for these less familiar transactions will be relatively lower. This may inadvertently motivate relationship managers to seek out unusual loans in markets where they and the bank have limited expertise or for relationship managers to enter businesses outside of the bank's core competencies. Conversely, relationship managers may reduce loans to obligors in markets where the bank does have expertise that is resulting in other fee-based businesses. (See the research on income diversification in Appendix A.)[13]

3.4 Market-based credit-transfer-pricing measures

Given the challenges in implementing portfolio-referent transfer pricing, some institutions adopt less sophisticated CDS-based transfer-pricing approaches to develop credit-transfer prices (p_C). The advantage of a market price approach is the simplicity with which the source of the credit-transfer price can be communicated. The fact that the price can be objectively observed and is less dependent on models often makes this approach more appealing to line businesses. Generic curve estimation methods are typically easier to validate and communicate than RC- or TRC-based models and credit-transfer prices can be described explicitly in terms of hedging costs.

The big disadvantage of market price-based measures is, of course, that the market portfolio seldom reflects the bank's portfolio and thus the measure does not account for concentrations in the specific holdings of the bank. Although they can be viewed appropriately as estimates of the cost of hedging an exposure, CDS spreads typically provide only a weak proxy for the impact of most new exposures on the bank's existing portfolio. Thus, if the hedge is not actually put in place for *every* exposure, the risk of the bank's portfolio will not be fully commensurate with the hedging costs associated with CDS spreads. Said differently, the theoretically appropriate hedge should reflect all portfolio interactions.

A secondary disadvantage of the CDS-based approach arises in times of illiquidity (e.g., 2008 and 2009) when it becomes difficult to disentangle liquidity risk premia and credit risk premia. At such times, large swings in CDS spreads may cause a bank's capital budget to vary widely. In these liquidity-constrained periods, changes in CDS spreads may become temporarily de-linked from the credit risk of underlying exposures and relate more to supply and demand mismatches in the CDS market. This kind of market environment can, in turn, create procyclical behavior in capital allocation since economic capital requirements tend to increase during periods in which asset prices are depressed, requiring banks to manage more scarce capital during these periods of stress, which can in turn reduce available credit and liquidity systemically.

Finally, because CDS are generally only traded for the largest names in the marketplace, it can be difficult to find a CDS contract that actually reflects the characteristics of a specific exposure that the bank has. As a result, various interpolation and extrapolation algorithms must be constructed

to approximate the CDS spread in situations in which there is no contract on the underlying exposure. It is not clear that these mappings are any more intuitive than other models.

Thus, banks contemplating CDS-based transfer prices often consider trade-offs between theoretical robustness and practical business concerns.

3.5 Considerations in credit-transfer price selection

For the purposes of credit-transfer pricing, views on the practical limitations of correlation models (which we discuss in the next section) may initially lead institutions to adopt market price-based transfer-pricing algorithms as opposed to portfolio-referent-pricing algorithms. In these cases, the portfolio-referent algorithms are sometimes still used to monitor the exposures that may be contributing too much tail risk to a portfolio and then used to override market prices if the size of the difference is large and an analyst has a reasonable explanation for the difference. Eventually, this shadow (portfolio-referent) system can become the primary system.

As banks, models, and markets become more sophisticated, institutions may migrate to credit-transfer prices that are more in line with portfolio metrics. For many less advanced banks, imperfect credit-transfer pricing is still preferable to traditional single-name analysis. For these institutions, the CDS market provides one mechanism for incorporating transfer-pricing-based incentives in origination.

The goal of all of these forms of credit-transfer pricing is to ensure that bankers and traders originating and trading credit or providing credit-related services are aware of *all* costs (from a concentration and correlation risk perspective) of a particular business opportunity. While this awareness typically does not prevent a relationship manager from granting a loan at a loss, it does make explicit the (previously hidden) cost of doing so, which can be incorporated into the analysis with the forecasted profitability of the relationship.[14]

4 Mitigating model risk and the use of stress-testing

Although knowledge and technical abilities regarding credit risk quantification have expanded dramatically, particularly in the areas of PD and LGD estimation for corporates, there remain substantial hurdles. Paramount among these is the practical difficulty in estimating and validating correlation models, which are essential to effective portfolio management and the calculation of a portfolio-referent transfer price.

Importantly, the gaps in knowledge of correlation express themselves most clearly in estimates of extreme tail risk. There are a number of approaches in current use for estimating credit-portfolio-loss distributions. Each approach provides a mechanism for sizing the tail of the loss distribution at any quantile. However, the processes that drive credit risk during times of extreme stress may be quite different from those that drive credit risk during normal or even "pretty bad" times. Further, it can be difficult to empirically validate extreme tail estimates. Even more generally, we do not yet have rigorous theories for characterizing model risk.

For these reasons, regulators and market participants have exhibited a renewed focus on combining analysis from standard credit-portfolio frameworks with stress testing and business judgment when evaluating extreme loss scenarios. This in turn has led to an increased interest in developing correlation models that can accommodate macroeconomic sensitivity analysis in addition to producing portfolio loss distributions

(cf., Stein *et al.*, 2011). It has also led researchers to explore new techniques designed to accommodate additional sources of correlation, not explicitly modeled, through the use of frailty techniques drawn from the health sciences (Duffie *et al.*, 2009).

One common feature of successful implementations is that they make it possible for model users to interpret and diagnose model input and output in light of their general intuition, which can help mitigate model risk. Qualitative assessment of model risk is often an important driver of model selection in practical settings, i.e., a "rougher" model that can be easily interpreted and diagnosed is sometimes preferred. (This contrasts with assessments of theoretical elegance, which is sometimes the criterion used for selecting a model in an academic context.)

Similarly, the use of stress tests, scenario analysis, and sensitivity analysis provides guidance on the appropriateness of a model in a specific setting. These types of internal testing regimes, though resource intensive, may be viewed as central to implementing useful portfolio management and credit-transfer-pricing applications.

One of the greatest ACPM implementation challenges appears to relate not to the models, but to the psychology of some users. Resistance to ACPM practices can arise from the tendency of relationship managers, risk managers, and senior executives to concentrate on anecdotes and qualitative judgment based on their experience. Line origination staff may be inclined to focus only on their customers and not on the portfolio impacts of the exposures they originate. Experienced bankers may also hold the view that their understanding of each of their customers is superior to the dry analysis of a quantitative model. Even analysts in risk departments may prefer to evaluate each new exposure on a stand-alone basis.

While executives at institutions transitioning to ACPM may understand the importance of portfolio-based decision making, they may still lean toward the more familiar single-obligor analyses based on anecdotal discussions of industry structure, a company's product and its CEO.

Clearly, industry experience and common sense are crucial to building and using credit models wisely. In general, it does not appear that these approaches can, in and of themselves, form the basis of credit policies for complicated portfolios of correlated assets. Rather than replacing qualitative judgment, however, it is instructive to use quantitative models as frameworks within which to conduct qualitative discussions and gain insight beyond the quantitative output, or, conversely, to examine the implications of qualitative statements.

However, the larger role for qualitative judgment is in assessing the reasonableness of model output and assumptions, for example, conducting (on a regular basis) stress testing and benchmarking exercises to ensure that the language of risk retains the same meaning from transaction to transaction and period to period.

Stress testing and scenario analysis provide concrete, intuitive descriptions of states of the world that might occur and they provide insight into how quantitative models translate those states of the world into portfolio losses. This is valuable for understanding a model and a portfolio and for gaining intuition for the drivers of credit risk in the portfolio. Furthermore, it is not uncommon for a regulator, a manager, or the chief economist of a bank to be concerned with one or several specific scenarios. By examining the implications of the scenario(s) of interest, these risk conversations can become more productive.[15]

In addition to providing reality checks for models and hurdles for portfolios, stress-testing exercises

provide organizational and managerial benefits. These activities can elevate risk management discussions beyond the domain of the purely quantitative and into the domain of broader corporate strategy. The selection of factors to be considered in scenario design and the analysis of output resulting from stress-testing exercises often precipitate intense and productive discussions between managers and risk managers within a financial institution.

By explicitly running stress tests using key scenarios of interest, the bank gains insight into how the portfolio might behave under such a state of the economy. The bank may also use this approach to evaluate states of the world that are different than those in the historical record or in the economic space spanned by, for example, a portfolio simulation engine. By comparing the estimate of portfolio losses under stress scenarios with the economic capital from the model's estimate of portfolio losses, users can bring together the useful aspects of managerial and analytic judgment with the model-based results in a way that provides better insight.[16]

Thus, the portfolio perspective—informed by both quantitative characterization of the return and risk profiles of a bank's holdings and qualitative discussion of the results of stress tests—provides a useful framework for senior management to improve discussions regarding overall bank strategy. Quantitative models may be viewed as serving the specific purpose of distilling information and reducing the level of complexity in understanding the return and risk of the bank's portfolio and of each individual exposure, while qualitative analysis can be used productively for interpreting and checking the output from the quantitative framework and for imagining states of the world that have never occurred (and thus cannot be examined empirically).

5 Conclusion

In this paper, we have reviewed some of the motivations for both senior managers and line lenders to actively manage the credit risk of a bank's portfolio. Central to this review are four main points:

- A bank's valuation is impacted by two sources of volatility: the volatility associated with its holdings of credit risky instruments (e.g., loans) and the volatility associated with its service franchise(s). The volatility of the latter tends to be higher, but investors may penalize the disruptive potential and asymmetric payoffs of the former and will likely reward the bank for reducing this volatility.
- The function of growing a service business (loan origination, cash management, etc.) requires different skills than those required for managing a portfolio of credit risky assets. As a result, the franchise components of a bank's business can productively be staffed and organized separately from the business of managing a portfolio of credit risky assets.
- One mechanism for aligning the risk management incentives of various units within the bank is credit-transfer pricing. A credit-transfer price can reflect the cost of hedging a newly originated exposure. It can also reflect the amount of bank capital the new exposure uses up and it will be higher for exposures that reduce diversification. Such a pricing model provides clear incentives to business units to be aware of the overall bank position and to originate loans that, all else equal, increase the diversification of the bank.
- While quantitative tools are important components of both the risk management and credit-transfer-pricing functions, institutions benefit from considering the limitations of their models in a formal way. Formal monitoring processes, dedicated validation staff, and

frequent model review are key components of this process. Stress testing and scenario analysis can provide a useful and often intuitive mechanism for evaluating both the sensitivity of portfolios to extreme events and the portfolio models themselves.

In our discussion here, we have deliberately glossed over a number of important technical points and provided only hand-waving arguments for others; however, it is increasingly likely that the future of credit risk management at banks will be driven heavily by the concepts we have outlined—many of which have grown out of industry practice.

We have provided broad conceptual motivations for implementing ACPM. These motivations explain, in part, the adoption of ACPM in various forms by banks for over a decade. This phenomenon has been only incompletely documented and researched. Recently, however, more direct evidence of the growth in and variety of ACPM functions has begun to emerge.

A recent article (Stegemann and Jamin, 2008) presents the results of an industry study of credit-portfolio-management functions among 60 of the largest banks in North America. These banks were surveyed in 2007/2008 about their credit-portfolio-management efforts. The results suggest that most banks responding had implemented some form of an ACPM function. Further, structures of the sort we describe, in which the portfolio function is separated from the business line, are becoming more common among these institutions. The authors report that half of the respondents structure their credit-portfolio-management functions as distinct from other business units.

Interestingly, while the large majority (about 95%) of these institutions report applying credit-portfolio management to their large, corporate portfolios, only about 65% did so for small-cap corporate exposures. ABS and retail lending appear to lag further behind. It is perhaps not surprising that this coverage reflects the relative maturity of commercially available portfolio analytic tools for corporate segments versus non-corporate segments in which portfolio tools have only recently begun to be introduced.

However, for many institutions, ACPM implementations appear to have focused more on the technical, relatively easily identified aspects of *risk measurement* than on the organizational implications of these tools. Thus, for many banks, efforts appear to have been directed toward implementing systems to size and report risk rather than on developing processes and organizational mechanisms for using this information to drive decisions.[17]

Even at institutions that have implemented risk management (measurement) systems, it can be difficult for senior managers to gain a complete picture of the activities of each of a bank's business units and of each trader within them. Indeed CEOs may be hard-pressed to understand the implications of every large trade at the bank. Transfer pricing provides a mechanism that encourages traders and lenders to behave in a way that aligns with the risk appetite outlined by the bank's senior management, while also permitting risk managers to highlight to management more easily the positions that may expose the bank to the largest portfolio risks. Of course, the potential for gaming cannot be eliminated and management must also make deliberate effort to imbue the institution with a risk culture. However, when combined with stress-testing exercises, portfolio-referent transfer-pricing methods can serve as one filter for senior managers.

Clearly, there is more work to be done in refining these concepts and practices and the models that support them. In many cases, banks that have

begun to build or acquire sufficient tools and data to facilitate ACPM have found that the success of such efforts often rests not only on models and software, but also on the coordinated efforts of senior managers at the bank to move the culture of the organization toward a more holistic view of credit risk management.

Coming full circle, analytic approaches have recently emerged that take advantage of aggregate, publicly available data to extend conventional risk analytics for use in *systemic* risk analysis (cf., Adrian and Brunemeyer, 2010; Acharya *et al.*, 2010; Billo *et al.,* 2011; Kinlaw *et al.*, 2011). New analytic tools are being developed that transform the credit-portfolio problem into a systemic risk one while also accommodating the nature of interfirm relationships. These techniques, while still nascent, may offer market participants and policy makers a useful tool in understanding systemic risks that may emerge in times of market stress.

Interestingly, some have suggested transfer-pricing-like policies for charging organizations a "systemic risk tax", based on each firm's contribution to systemic risk. Such proposals, if implemented, could increase the complexity of an organization's internal transfer pricing significantly, since a transfer price would need to reflect not only the contribution of a trade or loan to the firm's capital requirements (based on its own portfolio), but would also need to contemplate the impact of that trade or loan on the additional systemic risk tax that would be levied on the firm (based on the aggregate distribution of correlated assets in the marketplace). Such computations would require not only much more information about the state of the market at any moment, but would also involve multiplayer, multiperiod game-theoretic analyses, for which it is not clear stable equilibria exist. We look forward to future developments in this area of credit-transfer-pricing as one path to better management of systemic risk in large financial institutions.

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Appendix A: A brief sampling of the literature on income diversification and ACPM on bank valuation

In this Appendix, we provide an abridged review of the literature on the impact of income and portfolio diversification on bank valuation.

We begin with some examples from the literature on the impact of income diversification on performance.

Smith *et al.* (2003) attempt to determine whether increases in fee-based income increased profit stability in a sample of 2,655 EU banks over the years 1994–1998. They find that among most (but not all) EU banks, income stability was increased, even though the noninterest income itself may have been more volatile and is thus not always more stable than interest income. The key finding is that while fee income is itself more volatile than traditional interest income, it does help stabilize profit streams.

Also supportive of the notion that income diversification is beneficial to banks are more recent

papers examining its impact on bank performance. Elsas *et al.* (2006), for example, find that diversifying into noninterest income businesses improves bank performance. Demirguc-Kunt and Huizinga (2010) corroborate this finding and go on to emphasize their observation that although bank performance improves with income diversification, bank risk also appears to increase.

Some authors, for example, Mercieca *et al.* (2007) have found that increasing noninterest income actually *decreases* bank value. This result may be influenced by the sample the authors use, which is composed of small European banks that appeared to be diversifying into businesses in which they have little expertise (as in the findings of Stiroh and Rumble, 2006, below). However, Laeven and Levine (2007) also find, using a more representative cross-section of banks, that diversifiying into noninterest income businesses weakens bank performance.

Note that it is not clear how to evaluate the observed diversification in these studies since there is ambiguity as to whether the diversification is into areas that are understood well by the institution or into areas in which the institution may have little expertise or experience. As we noted earlier, diversification of income for diversification's sake can lead to suboptimal performance. For example, Stiroh and Rumble (2006) explore whether diversification into noninterest income improves financial performance of U.S. financial holding companies (FHCs). Using data on over 2,000 FHCs from 1997 to 2002, the authors test a number of hypotheses and find that though diversification of income streams improved performance between FHCs, the increased exposure to more risky income streams more than offsets the benefits of diversification.

This lack of agreement on the impact of income diversification highlights one of the criticisms of this literature stream in particular, which is that it can be exceedingly difficult to measure the quantities of income and performance. We have similar concerns with some of the research in this area as it does not always control for other factors that may be driving performance. In this regard, we expect to see more discussion and research into disentangling the many factors that could also be driving poor performance (e.g., regulatory environment, external market factors, management mistakes, poor IT infrastructures, and poor product conceptualization).

Another important theme in this research is that even for businesses that may be familiar to a bank, the nature of the noninterest income may still matter. A bank earning fees from deposit accounts will perform differently than a bank earning fees from merger and acquisition advisory, though it is hard to control for this by examining only one summary ratio, e.g., the ratio of interest-to-noninterest income. Consider an extreme example in which noninterest income arises from proprietary trading. In this case, we would expect the income to be unstable and exhibit high volatility. Bundling such income with, say, income from cash management and retail service fees could well lead researchers to conclude that the noninterest income is not adding to a bank's value even though the proprietary trading income may be the only noninterest income stream that depresses the bank's equity value. This stylized example demonstrates the need for more research into how best to disentangle these many variables.

Technical challenges notwithstanding, the finding that increasing the proportion of noninterest income leads to riskier banks (as measured by earnings volatility, asset-value volatility, and equity-value volatility) is common to much of the research in this area. The *extent* to which this increased risk results in higher, *risk-adjusted*

return, and therefore better bank performance and higher share value (all else equal) is the primary point of contention.

We next briefly review some of the literature on the effectiveness of ACPM practices and their impact on bank performance.

In one study of active loan-portfolio management, Cebenoyan and Strahan (2004) test how a form of ACPM (implemented through the loan sales market) affects capital structure, profits, and risk. The authors draw on the Call Reports for all domestic banks in U.S. over the period June 1983–1993. These quarterly reports contain aggregate statistics on all loans bought or sold by each bank. The authors find that banks that use the secondary loan market (sales and purchases) for risk management purposes hold less capital, demonstrate lower risk, and enjoy higher profitability (after controlling for size, leverage, and lending activities). Importantly, the authors find that banks that both buy and sell loans perform better than those that either only buy or sell or that do not transact in the market at all, suggesting active management is more effective than either investing (or lending) or simply moving assets off of the balance sheet to free up capital. In one regression, for example (the paper's Table 10), the authors report a 0.15 increase in risk-adjusted return on capital (RAROC) (significant at the 1% level) for banks that both buy and sell loans versus 0.06 and 0.04 for those that only buy or sell, respectively (not significant at 5% level). However, they also observe that these banks extend riskier credit and conjecture that the reduced concentration risk is offset by this increase in risk appetite.

Using noncorrelation-based measures of diversification, Deng *et al.* (2007) explore the relationship between diversification of both deposits and assets on the cost of capital for 488 bonds issued by 64 publicly traded bank holding companies from 1994 to 1998. The authors find that diversification of assets and deposits leads to lower bond spreads, but that diversification of nontraditional banking activities has a weaker relationship with cost of capital. The authors quantify this effect as 5.9 and 4.6 basis points per one standard deviation increase in geographic and asset diversification, respectively. The authors note that these effects are larger for mid-sized banks than for either small or large banks.

Behr *et al.* (2007) examine the risk-return tradeoffs of diversification for German banks. Using a data set containing observations for all of the banks in Germany in the period from 1993 to 2003, the authors conclude that concentrated banks have slightly higher returns than diversified banks and that they have lower loan loss provisions and percentages of nonperforming loans (NPL). However, they find that the standard deviation of both the loan loss provision ratio and the NPL ratio is lower for diversified banks. After netting these competing results out, the authors find that concentrated banks generate slightly higher returns with higher risk.

Not all researchers find results that support ACPM. For example, Acharya *et al.* (2006) examine 105 Italian banks over the period 1993–1999 in an attempt to characterize the relationship between portfolio diversification and the banks' risk and return. The authors find that diversification does not guarantee superior performance in a risk-return context. This result also supports the notion that diversification for diversification's sake, only may be counterproductive: they conclude that this result is consistent with a reduction in monitoring effectiveness by banks when lending into newer and/or more competitive sectors. Note that the diversification measure used by the authors is not correlation based, so the results may reflect the authors'

measure and not diversification as defined in this paper.

Appendix B: Some useful definitions used in defining metrics for calculating transfer prices

We review several of the more popular risk measures used in constructing transfer-pricing systems. More detailed discussion can be found in Bohn and Stein (2009):

- *TS* = Total spread or the amount of expected return in excess of the risk-free return (over a specified time horizon).
- *EL* = Expected loss for a credit exposure (over the specified time horizon of analysis). In the simplest case (no credit migration at the specified time horizon), $EL = PD \times LGD \times EAD$.
- *ES* = *TS* – *EL*. Expected spread or the excess premium earned for taking on an exposure's credit risk.
- *RC* = Risk contribution or the impact on the portfolio's *volatility* after accounting for an exposure's diversification impact.
- *TRC* = Tail risk contribution or the impact on the portfolio's *risk of extreme loss*, typically defined as the last several hundred (or fewer) basis points of the portfolio loss distribution. Specifically, defining TRC as the contribution to the portfolio's *expected shortfall*, which reflects the average loss of an exposure conditional on the entire portfolio's losses exceeding the target basis point level on the portfolio's loss distribution, can be useful.
- *UL* = Unexpected loss is typically measured as one standard deviation, or the *volatility*, of a portfolio's loss distribution.
- Sharpe ratio = *ES/RC* for individual exposures and *ES/UL* for the portfolio.
- Vasicek ratio = *ES/TRC* for individual exposures and *ES/Capital* for the portfolio (Crosbie and Bohn, 2001).

Notes

[1] This is similar to the phenomenon that some observers have noted in which unrated corporate bonds trade as if they were low-rated corporate bonds. This is, of course, a special case of the more general "lemons" problem (Akerlof, 1970).

[2] Although the goal of maximizing long-term shareholder value at a specific target level of risk is naturally aligned with prudent, transparent risk management, the appropriate *level* of risk that the bank should target (i.e., the bank's risk appetite), given other business objectives, remains an issue for bank boards to determine, as do issues of appropriate compensation schemes for motivating senior managers to achieve it. Similarly, because this article focuses on diversification of *credit portfolios*, we do not address the question of whether and how to diversify a bank's *business lines* and sources of noninterest income, given a bank's expertise and business objectives. This is, however, an active area of research. In Section 2.3 we provide a short discussion of some of the research themes, and in Appendix A we provide a sampling of some of this literature.

[3] We will make the point in a number of places in this article that the tools and models for managing credit portfolio risk are more fully developed for corporate exposures than for many other asset classes. This situation has begun to improve for noncorporate asset classes in recent years (cf., Stein *et al.*, 2011).

[4] Leland and Toft (1996), for example, consider the tradeoff between leverage and the likelihood of bankruptcy. Their model provides direct insights into how the valuation of a generic firm is driven by leverage, likelihood of default, bankruptcy costs, and taxes.

[5] In practice, a bank's management must also manage its regulatory capital, which does not typically align precisely with economic capital. In this paper, we do not address the unique characteristics of managing regulatory capital. The economically substantive components of regulatory capital measurements generally coincide with the components of solid economic capital models. When regulatory capital becomes a binding constraint (as is the case in the current regulatory environment), economic capital models are still

often used to attribute or allocate this total regulatory capital in practice. That is, relative attributions or allocations of the aggregate regulatory capital are based on economic capital models, which refer back to the specific correlation and concentration risks of the bank's portfolio.

[6] This is because the equity holder enjoys all of the upside (profits) of the business, but has the option to default on the obligations (debt) of the bank, should a risky business erode the value of the bank to a point where it is worth less than the face value of the debt. This relationship (volatility-up, equity value-up) obtains directly from the option theoretic formulation that serves as the basis of Merton's structural model.

[7] Note that in some countries, subsidies (both implicit and explicit) may make the cost of deposit funding as cheap as or cheaper than internal capital. In this case, a bank will have incentives to maximize its deposit funding.

[8] For example, Miller (1995) observes:

> But the cost of equity is not a fixed number; it's a function that depends both on the risk of the firm's earning assets and the degree of leverage in the firm's capital structure… for any firm with less than average systematic risk and less than average leverage, the cost of equity would be lower; and at zero leverage, much lower… leveraging will indeed raise the expected earnings per share on the equity [for a bank with expected low performing assets], but not by enough to compensate the shareholders for the risks added by the leverage… An essential message of the M&M Propositions as applied to banking, in sum is that you cannot hope to lever up a sow's ear into a silk purse. You may think you can during the good times; but you'll give it all back and more when the bad times roll around.

[9] For example, in good times a bank earns the spread on the loan, typically measured in tens or low hundreds of basis points (plus any underwriting and servicing fees), but in default, the bank may lose much of the full value of the loan, often in the range of 30–70% of par or more. Though the probability of large losses is typically much lower than the probability of earning the spread, when losses do occur, they are often high.

[10] In addition, the most recent financial crisis revealed the undiversified portfolios of nonbanks, some of which built large, concentrated portfolios with CDS contracts. While the mechanism and character of concentration can vary by institution and market, many banks with some degree of concentration risk suffered greatly in the recent financial crisis, even in cases in which they had no direct exposure to residential mortgages.

[11] This, of course, is not always the case. Clearly, if a bank is unable to build solid franchise businesses, then a transfer-pricing system will be of limited value.

[12] If a portfolio manager held the market portfolio, the market price and portfolio-referent price should theoretically converge—in practice, there may be other reasons why the prices do not converge even if the referent portfolio is close to the market portfolio.

[13] There are practical workarounds for such challenges, though. An alternative to full risk accounting is for institutions to implement adjustments to credit-transfer prices manually to reflect concerns about the risks of new and untested business segments. Another approach involves instituting hard constraints and restrictions on certain asset classes or geographic segment levels.

[14] Note here that analyses of the full customer relationship may include the current transaction (perhaps entered into at a loss) as well as future revenue streams from other cross-selling opportunities. However, since these activities increase the bank's exposure to the same client, they will also decrease that client's marginal profitability, as more capital will be required for each new transaction. As a result, these future opportunities, when considered in a portfolio-referent context, may result in different profitability analyses than when done on a stand-alone basis, even after contemplating cross-selling opportunities.

[15] Note that in most settings, it is difficult to use stress testing as the sole mechanism for making quantitative statements about the capital requirements of large portfolios (see Stein, 2012 for a discussion).

[16] Recently, Rebonato (2010) has introduced a Bayesian approach, based on approaches from decision theory and artificial intelligence, for introducing a more rigorous characterizations of the probabilities of stress scenarios. This approach may hold promise for further bridging this gap in some settings.

[17] For example, less than half of the respondents in the survey reported that the CPM group had decision-making authority for activities such as hedging or pricing. Of the remainder, those that were involved in the analysis process at all had either partial decision-making authority or none at all.

References

Acharya, V., Hasan, I., and Saunders, A. (2006). "Should Banks be Diversified? Evidence from Individual Bank Loan Portfolios," *Journal of Business* **79**(31), 1355–1412.

Akerlof, G. A. (1970). "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics* **84**(3), 488–500.

Billio, M., Lo, A. W., Getmansky, M., and Pelizzon, L. (2011). "Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors," MIT Sloan Research Paper No. 4774-10.

Behr, A., Kamp, A., Memmel, C., and Pfingsten, A. (2007). *Diversification and the Banks' Risk-Return-Characteristics—Evidence from Loan Portfolios of German Banks.* Frankfurt: Deutsche Bundesbank.

Bohn, J. R. and Stein, R. M. (2009). *Active Credit Portfolio Management in Practice.* Hoboken, NJ: John Wiley and Sons.

Cebenoyan, A. S. and Strahan, P. E. (2004). "Risk Management, Capital Structure and Lending at Banks," *Journal of Banking and Finance* **28**, 19–43.

Crosbie, P. J. and Bohn, J. R. (2001). "Modeling Portfolio Risk," Working Paper, KMV.

Demirguc-Kunt, A. and Huizinga, H. (2010). "Bank Activity and Funding Strategies: The Impact on Risk and Returns," *Journal of Financial Economics* **98**, 626–650.

Deng, S., Elyasiani, E., and Mao, C. X. (2007). "Diversification and the Cost of Debt of Bank Holding Companies," *Journal of Banking and Finance* **31**, 2453–2473.

Dewenter, K. L. and Hess, A. C. (1998). "An International Comparison of Banks' Equity Returns," *Journal of Money, Credit and Banking* **30**(3).

Duffie, D. and Singleton, K. J. (2003). *Credit Risk*: *Pricing, Measurement and Management.* Princeton, NJ: Princeton University Press.

Duffie, D., Eckner, A., Horel, G., and Saita, L. (2009). "Frailty Correlated Default," *The Journal of Finance* **64**(5).

Elsas, R., Hackenthal, A., and Holzhäur, M. (2006). *The Anatomy of Bank Diversification.* http://ssrn.com/abstract=968214.

Kane, E. J. and Unal, H. (1990). "Modeling Structural and Temporal Variation in the Market's Valuation of Banking Firms," *Journal of Finance* **45**(1), 113–136.

Kealhofer, S. K. and McQuown, J. A. (1997). "A Comment on the Formation of Bank Stock Prices," Working Paper, KMV.

Kinlaw, W. B., Kritzman, M., and Turkington, D. (2011). "Toward Determining Systemic Importance," MIT Sloan Research Paper No. 4940-11.

Laeven, L. and Levine, R. (2007). "Is there a Diversification Discount in Financial Conglomerates?" *Journal of Financial Economics* **85**, 331–367.

Lando, D. (2004). *Credit Risk Modeling*: *Theory and Applications*. Princeton, NJ: Princeton University Press.

Leland, H. E. and Toft, K. B. (1996). "Optimal Capital Structure, Endogenous Bankruptcy, and the Term Structure of Credit Spreads," *Journal of Finance*.

Megginson, W. L., Poulsen, A. B., and Sinkey Jr., J. F. (1995). "Syndicated Loan Announcements and the Market Value of the Banking Firm," *Journal of Money, Credit and Banking*.

Mercieca, S., Schaeck, K., and Wolfe, S. (2007). "Small European Banks: Benefits from Diversification?" *Journal of Banking and Finance* **31**, 1975–1998.

Merton, R. (1974). "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*.

Miller, M. H. (1995). "Do the M & M Propositions Apply to Banks?" *Journal of Banking and Finance* **19**, 483–489.

Modigliani, F. and Miller, M. H. (1958). "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* **48**, 261–297.

Morgan, D. P. and Samolyk, K. (2003). "Geographic Diversification in Bnaking and Its Implications for Bank Portfolio Choice and Performance," BIS Workshop "Banking and Financial Stability", 20–21, March.

Rebonato, R. (2010). *Coherent Stress Testing.* Chichester, UK: John Wiley and Sons, Ltd.

Sellers, M. and Arora, N. (2004). "Financial EDF Measures: A New Model of Dual Business Lines," Working Paper, Moody's KMV.

Smith, R., Staikoras, C., and Wood, G. (2003). *Non-Interest Income and Total Income Stability.* Bank of England. Bank of England.

Stegemann, E. and Jamin, G. (2008). The CPM Challenge. *Risk*.

Stein, R. M. (2012). "The Role of Stress Testing in Credit Risk Management," *Journal of Investment Management*, Fourth Quarter.

Stein, R. M. (2013, forthcoming). "Aligning models and data for systemic risk analysis," in *The Handbook of Systemic Risk,* Jean-Pierre Fouque and Joseph Langsam (editors), Cambridge University Press.

Stein, R. M., Das, A., Chinchalkar, S., and Ding, Y. (2011). "Mortgage Portfolio Analyzer: A Quasi-Structural Model of Mortgage Portfolio Credit Risk," Working Paper 2011-02-1, Moody's Research Labs, New York.

Stiroh, K. J. and Rumble, A. (2006). "The Dark Side of Diversification: The Case of US Financial Holding Companies," *Journal of Banking and Finance* **30**, 2131–2161.

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