

# Essays on corporate risk management

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Degree of Doctor of Philosophy

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McGill University, Montreal

August 2010

A thesis submitted to McGill University in partial fulfilment of the requirements  
of the degree of Doctor of Philosophy

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## DEDICATION

To my father.

## ACKNOWLEDGMENTS

I am eternally grateful to my supervisors, Professors Peter Christoffersen and Amrita Nain, for their advice, support, patience, and mentoring over the years. I cannot list all the ways in which they have helped me, nor the number of occasions. I would also like to express my gratitude to Professor Lawrence Kryzanowski who as my external advisor has generously given of his time and ideas, often at short notice, and offered me enormous encouragement. Professors Susan Christoffersen and Adolfo de Motta offered key insightful guidance and support, and I am very grateful for their help with my dissertation.

The finance area at McGill has been an excellent nurturing environment, offering all the opportunities one needs to develop as a scholar. I benefitted greatly from the wisdom and consistent support of Professors Kris Jacobs and Vihang Errunza. I am also grateful to each of the members of faculty for their continuous and unselfish involvement in my progress.

The collection of data for the second paper in this thesis benefited partly from paid assistance by a team of research assistants who participated in keying an initial cut of the dataset, and I am grateful to them for their efforts.

In my writing of this thesis, Melania Nica has played a key role by repeatedly offering detailed comments. I have also to thank my Ph.D. colleagues, and the administrative team of McGill's finance area and Ph.D. program for the countless ways in which they made my time here exceptionally enriching.

Finally, like any important task in life, it would have been impossible for me to complete this thesis without support from my parents, my sister and my friends, or without the blessings of some that are with us and some that are no longer.

## CONTRIBUTIONS OF AUTHORS

This thesis consists of three manuscripts (Chapters 2, 3 and 4) that follow the Introduction (Chapter 1). Jaideep Oberoi is the sole author of the first and third manuscripts (Chapters 2 and 4) and they are his work.

The second manuscript in this thesis (Chapter 3) is a result of collaboration between Peter Christoffersen, Amrita Nain, and Jaideep Oberoi. Peter Christoffersen is a Professor of Finance at Rotman School of Management, University of Toronto and Amrita Nain is an Assistant Professor of Finance at Desautels Faculty of Management, McGill University. The three co-authors participated equally in outlining the objectives of the paper. Jaideep Oberoi, with guidance from the co-supervisors, performed the data management and analysis that led to an initial draft of the paper. The three authors contributed equally to preparing the final manuscript.

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## ABSTRACT

This thesis consists of three manuscripts that address the subject of corporate risk management with particular reference to the interest rate risk faced by nonfinancial corporations.

The first essay is a survey of the literature that includes a simple but flexible model intended to characterize the nature of interest rate risk faced by a firm. In a static context, I show that a firm is exposed to interest rate risk whether they borrow at fixed rates or floating rates, and their optimal choice will depend on the correlation between their cash flows and interest rates, but will likely involve a mix of both types of contract.

The second paper is an empirical examination of firms' ability to manage interest rate risk during Federal Reserve policy changes. By using hand collected data from annual reports, we follow firms' net proportions (after accounting for interest rate swaps) of fixed and floating interest rate debt over 11 years from 1990 through 2000. We test whether firms that actively manage interest rate exposures differ from those that have lower variability in the proportion of fixed rate debt they carry. Despite separating those likely to be hedging from those more likely to be speculating, we find only weak evidence for existing risk management theories. Moreover, we find that firms that are more active are not systematically better at anticipating interest rates, and are in fact less exposed to interest rate risk on their underlying operational cash flows.

In the third essay, I propose a reduced-form approach to determine an optimal mix of fixed and variable rate debt. This approach is based on solving a dynamic model in which firms face nominal interest rate risk. Firms borrowing at fixed rates face the risk of an increase in the value of their debt from reducing interest rates, potentially constraining additional borrowing capacity. On the other hand, firms borrowing at floating rates face the risk of significant increases in interest payments. They must thus trade-off these risks as their income and asset values evolve under a stochastic process.

## ABRÉGÉ

Cette thèse repose sur trois essais traitant de la gestion du risque corporatif, en particulier en ce qui à trait aux risques auxquels font face les entreprises non financières.

Le premier essai est une revue de la littérature qui inclue un modèle à la fois simple et flexible qui vise à caractériser la nature des risques de taux d'intérêt auxquels font face une entreprise. Dans un contexte statique, je démontre qu'une entreprise est exposée à un risque de taux d'intérêt autant lorsqu'elle emprunte à taux fixe qu'à taux variable. Le choix optimal en ce qui à trait au type de taux dépend de la corrélation entre les flux de trésorerie de l'entreprise et les taux d'intérêt, et implique typiquement un mélange de contrats à taux fixes et variables.

Le second essai est une étude empirique de la capacité de différentes entreprises à gérer les risques de taux d'intérêt lorsque la Réserve Fédérale américaine procède à des changements de politiques. En utilisant des données extraites manuellement de rapports annuels, nous étudions l'évolution de la proportion nette (en tenant compte des swaps sur taux d'intérêt) de la dette des entreprises qui est constituée de titres à taux fixes ou variables. Les données s'étendent sur 11 ans, de 1990 à 2000. Nous testons l'hypothèse à savoir qu'une firme gérant activement son exposition aux risques de taux performe mieux qu'une entreprise similaire qui garde une proportion (quasi) constante de titres à taux fixes et variables. Même en séparant les firmes plus susceptibles de gérer leurs risques de celles dont les variations sont plus probablement dues à de la spéculation, nous ne trouvons qu'un faible support pour cette hypothèse. De plus, nous observons que les entreprises les plus actives ne sont pas systématiquement meilleures que les autres pour prévoir les changements de taux et ont en fait des flux de trésorerie moins exposés aux risques de taux.

Dans le troisième essai, je propose une méthode de la forme réduite pour déterminer la proportion optimale de titres de dette à taux fixes et variables. Cette approche est basée sur la solution d'un modèle dynamique dans lequel une entreprise fait face à un risque de taux d'intérêt nominal. Les entreprises

empruntant à taux fixes font face au risque d'une augmentation de la valeur de leur dette du à une diminution des taux, augmentation potentiellement contraignante quand viendra le temps d'emprunter à nouveau. D'autre part, les entreprises ayant recours aux taux variables risquent une augmentation significative de leur paiements d'intérêts. Un compromis entre ces risques doit refléter l'évolution stochastique des revenus et de la valeur de chaque entreprise.





# 1

## Introduction

This thesis consists of three manuscripts that address the subject of corporate risk management and in particular the interest rate risks faced by nonfinancial corporations.

Academic writings on corporate risk management lie mostly within the Modigliani-Miller framework, wherein the first order of business has been to explain why risk management should be practised. To this end, two streams have emerged. The first approach involves the assumption that the firm manages risk due to ‘preferences’, similar to an individual. The second approach generates a reason to hedge against certain sub-optimal scenarios by assuming a constraint either on the firm’s ability to finance its investments externally or on its production function. These constraints may include costs of financial distress combined with tax benefits of debt, or asymmetric information leading to costly external financing. Essentially, however, both approaches amount to the introduction of either a concave objective function or a convex cost function for the firm’s managers to determine the optimal level of exposure to a given source of risk. Particular types of risk must thus be managed according to how they affect the overall position of the firm in various states of nature. Stochastic interest rates may affect the firm both through its assets (revenues and investment opportunities) and through its liabilities (financing cost and financing capacity).

In the first paper, I review the theoretical and empirical findings in the corporate risk management literature with a focus on interest rate risk. I also show in this paper that a firm faces interest rate risk both when it borrows funds at a floating rate and at a fixed rate of interest. I further develop a simple but flexible model to characterize the typical nature and implications of interest rate risk faced by a firm.

In the second paper, which is written jointly with my supervisors Peter Christoffersen and Amrita Nain, we study the ability of US firms to manage interest rate risk during changes in monetary policy. From annual reports we extract interest rate derivative and debt exposures and analyze how they change with the cyclical movements in interest rates. Our hand-collected data follows firms’ year-end positions in fixed or floating interest rate exposures from 1990 through 2000, allowing us to evaluate their performance over time as well as in the cross-section. The 1990s constitute a unique period with pronounced interest rate cycles and with derivatives reporting requirements conducive to our analysis.

We also test whether firms that actively manage interest rate exposures differ from those that have lower variability in the proportion of fixed rate debt they carry. Looking at standard firm characteristics and proxies for financial distress costs and agency costs, we find that firms with more active interest rate management are smaller,

have lower financial leverage, higher return on assets as well as higher market-to-book ratios than the less active firms.

We also find that the operating cash flows of active interest rate managers are less sensitive to interest rate changes, suggesting differences between the underlying businesses of the two categories. On the other hand, we find no systematic evidence that firms categorized as active interest rate managers are able to correctly anticipate changes in interest rates.

We finally test whether firms that are correct in anticipating interest rate changes receive any advantage ex-post, and find that firms that adjusted their exposures correctly or took no action at all enjoyed better cash flow margin improvements than those that went in the wrong direction. In trying to explain this, we find that these firms also took other actions that would lead to superior operating performance in the year after the shock as compared to those that changed their positions in the wrong direction.

Finally, in the absence of practical guidance on the choice of interest rate exposure on corporate borrowings, I propose a reduced-form approach to determine an optimal mix of fixed and variable rate debt. This approach is based on solving a dynamic model in which firms face nominal interest rate risk. Firms borrowing at fixed rates face the risk of an increase in the value of their debt from falling interest rates, potentially constraining additional borrowing capacity. On the other hand, firms borrowing at floating rates face the risk of significant increases in interest payments. Thus, they must choose an optimal mix of fixed and floating rate debt as their income and asset values evolve under a stochastic process.

All three papers are closely linked and address different facets of the same problem. First, I recognize some of the questions that remain to be addressed in risk management, especially when it comes to the nature of interest rate risk. Traditionally, users of derivative securities have been assumed to be those hedging risks. This is part of the reason that there are often contradictory findings on the nature and causes of risk management by corporations. In the second paper, we use a unique, detailed dataset to find ways to differentiate among derivative users, identifying firms that alter their exposures (with or without derivative usage) much more actively over time. In turn, the question of what exact exposure is consistent with hedging for a particular type of firm still needs to be addressed, and I attempt this in the final essay.

# 2

## Corporate Risk Management and Interest Rate Risk A Survey

# 1 Introduction

While it is easily noted that firms pay a great deal of attention to the risks they face in their business activities, it is altogether more difficult to understand the heterogeneity of their actions with respect to risk management. The corporate finance literature is arguably still at odds with itself over a complete policy framework that explains the various choices firms make when faced with different sources of risk. However, a significant body of writings is now available that offers theoretical insights on the justification for risk management and its practise. This paper is a survey of such writings along with their empirical tests, and is organised to address in particular the development of interest rate risk management by non-financial corporations.

Consider a firm which undertakes a risky business venture in anticipation of earning a positive expected return. The firm faces a complex of individual sources of risk over different time horizons, some of which may not be directly related to its business activity. Chief among these 'other' risks are market risks that are related to the financial structure of the firm. How do such risks affect the value of the firm? Which of these risks, if any, should a firm attempt to manage, and how should it determine an optimal exposure? In the following section, I succinctly review the significant body of arguments that justify the existence of risk management. In Section 3, I list some of the key findings from empirical tests of the theories. I then present a characterization of the particular case of market interest rate risk and its effect on the firm in Section 4.

## 2 Development of Risk Management Theories

Although all sources of risk ultimately affect the performance of a business and its value, some may be more inherent to the core activity of the business while others may arise incidentally due to institutional reasons. For instance, a farmer's crop may be subject to the uncertain quality of seeds, the timely application of fertilizers and pesticides, the vagaries of weather, and other similar factors. However, his income is also subject to variations in the value of his national currency vis a vis other currencies. Besides, the production decisions and output of other farmers may lead either to a glut or a shortage and affect the final price of his output. One could look further in time to how the expectation of demand for his output will affect the demand and supply for his input, and thus his production cost. Thus, the most basic unit of production, a primary producer, must make operational and financial decisions not

only about the risks he wishes to engage in and those he would rather transfer, but also about the horizon of his decision making process.

## **2.1 Why Manage Risk?**

The above process is further complicated when the decision maker is not a risk averse individual whose personal income and wealth are directly affected by his choices. In the case of a firm with professional managers, one must consider the welfare of all the shareholders. How does one align the firm's risk to meet the preferences of a potentially dispersed group of owners except to let them adjust their exposures individually? One must thus begin by recognizing the foundation laid by Modigliani and Miller (1958). As is well known, this framework describes a perfect and complete market, challenging the observer to first identify a reason for the existence of risk management by firms. Such a reason must arise from either a hindrance to investors' direct management of their risk exposures, the presence of benefits due to tax schemes, or the presence of additional costs generated by imperfect (asymmetric) information or technology. With increasingly complex and dynamic operations in large modern corporations, it is hardly surprising if shareholders do not have timely access to all information relevant for practical risk management. At best, they may be able to approximately hedge exposures based on historical or statistical information, but can hardly be expected to know the exact specifics of various contracts and their implications for the firm's risk.<sup>1</sup> The work on justifying the theoretical existence of risk management has thus taken up the more interesting questions of agents' behaviour, the firm's competitive environment, and of the impact of market imperfections (e.g. deadweight cost of bankruptcy or financial distress) on firms' actions. Before moving forward to these papers, we might start by looking at early work on the firm's choice under uncertainty.

### **2.1.1 Risk-Averse Preferences and their Effect on Firm Choice**

While there was some debate over the choice of objective function for the firm, many of the papers on firm behaviour under uncertainty explicitly modeled a risk-averse firm. Dhrymes (1964) studies the problem of a monopolist that faces uncertain demand for its various products and must allocate competitively sourced inputs to each of

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<sup>1</sup>One could estimate exposures to market variables based on historical information, but the information set still excludes the precise status of various firm dealings at the time of entering the hedge.

these products. He then argues that setting expected profit maximization as the firm's objective function would lead to an unacceptably large risk of ruin, and instead assigns a utility function to the entrepreneur that is quadratic in profit. Sandmo (1971) also imposes a utility function on the firm. On the other hand, Smith (1969) uses a Cobb-Douglas production function and convex cost of capital utilization to show that the rate of capital utilisation is inversely related with the level of uncertainty in demand for the firm's output. Another way of looking at this is that the (risk-neutral) firm must maintain a greater buffer of capital if it faces greater uncertainty, just from the point of view of profit maximization. Leland (1972) provides in a more general setting the same conclusions, although he assumes in fact that the firm is risk-averse. To justify this, he argues that *security* is well-known to be a key goal of management. From these early writings on the impact of uncertainty in demand faced by both competitive and monopolistic firms, we can draw conclusions about the suboptimal utilisation of resources in the face of uncertainty. A firm with a risk-averse objective function will produce a lower output than when there is no uncertainty. Parallely, as long as there is some convexity in cost of capital, even a risk-neutral firm will utilise a lower portion of its fixed capital resources. Thus, the notion of convexity in costs or concavity of the objective function is assumed even in the cases where the firm has risk-neutral preferences. Dréze (1985) places the firm in a general equilibrium setting and develops conditions under which the preferences of a majority of shareholders would be reflected in the managerial decisions of the firm, thus endowing it with risk-aversion. However, the question of the existence of a utility function for a firm raised by Sandmo (1971) is difficult to address when agents are heterogeneous. Nevertheless, the arguments in these papers ultimately imply a mirroring of some form of human risk aversion in the firm, even though it is difficult to establish that choices would be consistent under very general assumptions.<sup>2</sup> Finally, it is important to emphasize that the results described in this paragraph were mainly derived in a static setting, where the risk-averse firm faces ruin if it has a loss.

In a dynamic setting, however, results may be different. Anderson and Danthine (1980) show in the context of cross-hedging multiple products with futures contracts that the decisions for production and hedging must be taken simultaneously. They, too, use an expected utility maximization approach.

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<sup>2</sup>Note that the absence of consistent preferences implies that we cannot guarantee the existence of a utility function.



## 2.1.2 Differences in Context and Arguments

Papers explaining the existence and/or value of risk management can be organized along several key dimensions. First, the arguments justifying the existence of corporate risk management require, in effect, that the firm must eventually conduct its business as a risk-averse entity. This does not mean that the firm or its constituents must be risk-averse, but that by definition, its actions would be observationally equivalent to those of a risk-averse body.<sup>3</sup> There appears to be an element of tautology in finding reasons for risk management by risk-neutral bodies that necessarily make them act as if they were risk averse. However, there are formal differences in how one views the motives for risk management. For a discussion with an example, see Hunter and Smith (2002). Also see Froot, Scharfstein and Stein (1993) where they categorically state in Footnote 9 that for hedging to be valuable, the profit (read objective) function of the firm must be concave. Papers taking the direct (potentially preference based) approach rely either on the assignment of decision-makers' preferences to the firm, or on assumed exogenous deadweight costs from risk or both, that would make risk management valuable to those in control of the firm. Stulz (1984) and Smith and Stulz (1985) suggest a managerial motive for risk management due to risk-aversion. Other papers, such as Smith and Stulz(1985), explore a direct motivation for the firm to manage risk, such as convex tax schedules or bankruptcy costs. Purnananandam (2008) also falls in this category as he assumes an exogenous cost of financial distress (leading to value destruction) for the firm. Papers a further step removed in their analysis consider the effects of agency theory and asymmetric information on the firm's risk management decision. These include DeMarzo and Duffie (1991) and Breeden and Viswanathan (1998). Morellec and Smith (2007) consider the case of agency conflict between managers and shareholders. The first two papers focus on the manager's need to signal his ability to the labour market, while the last one is considered with incorporating overinvestment (Jensen 1986) as a problem in the context of underinvestment a la Myers (1977). Froot, Scharfstein, and Stein (1993) once again rely on the debt overhang underinvestment effect to incorporate the cost of financial distress in an exogenous formulation that causes external financing to be costly. Stulz (1990) argues in a parallel manner that hedging reduces investment distortions associated with debt finance such as investment problems a la Diamond (1991). Leland (1998) shows in a dynamic capital structure model that in the pres-

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<sup>3</sup>Here, I am interpreting risk management loosely as the reduction of risk, though a risk-averse entity may choose optimally to increase its risk exposure to a particular factor if it changes the overall risk-return profile of their portfolio.

ence of a tax shield, hedging is beneficial because it can increase debt capacity. More recently, Bolton, Chen and Wang (2009) present a more general model of dynamic capital structure that incorporates the need for risk management. They rely on an assumption of diminishing marginal returns in the production function to ascribe a concavity to the firm's objective function. Anderson and Carverhill (2007) develop a dynamic model of a firm's capital structure based on the trade-off between tax shields and costly bankruptcy, incorporating short term borrowing, fixed rate long term borrowing, and dividend payments. They show that the optimal liquid cash holdings under a firm value maximization objective are higher than those under a shareholder value maximization objective, leading to significant agency costs when tax rates and bankruptcy losses are high. This is consistent with the optimal policy of a risk averse entity. To conclude, modeling a firm that has an incentive to smooth cash flows across states or time is implicitly equivalent to modeling an entity with a concave objective function or a convex cost function. Such non-linearity may be introduced through information asymmetry leading to higher external financing costs (Froot, Scharfstein, and Stein 1993), diminishing marginal returns in the production function (Bolton, Chen and Wang 2009), tax shields and/or value destruction due to financial distress (Leland 1998, Purnanandam 2008).

The second dimension where differences arise is, if the reason for risk management is to alleviate the agency costs of debt, do the incentives for risk management remain *after* the financing is completed? In the absence of a credible commitment being available, one would have to evaluate post-financing trade-offs to determine whether the management, should it be in a position to reverse a risk management decision, would in fact choose to do so. This question addressed by Purnanandam essentially offers a more robust quality to theoretical findings about risk management policy.<sup>4</sup> It is needless to say that dynamic models, by their very design, are not subject to this concern. Elkamhi, Ericsson, and Parsons (2010) show that the actual costs of financial distress might be much smaller as compared to the losses that precede this state, thus emphasizing the importance of dynamic analysis.

The third dimension is the firm's competitive environment - a critical question that may lead to reversals in the predicted benefits of risk management. When a firm's policies are studied in isolation, we are implicitly limiting our analysis to the marginal case where the firm acts in a competitive vacuum. Dhrymes, Smith, Sandmo, and

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<sup>4</sup>Unless specifically contracted, it would be easy for a firm to do so. All that is needed is to take an offsetting derivatives position. In Section 3, I discuss how this type of situation is problematic for many empirical studies of risk management based on derivatives use.

Leland all make assumptions about the competitive environment of the firm facing demand and/or price uncertainty. McKinnon speculates that in a dynamic context input and output prices would adjust to account for the hedging activities of the farmer given the overall market interaction of demand and supply. Dréze places the firm in a general equilibrium setting. However, Maksimovic (1990) first shows that imperfect competition in the product market, in and of itself, gives firms an incentive to reduce the marginal cost of any of their inputs (including financing). He thus shows that firms have an incentive to obtain fixed rate lines of credit, for instance, to improve their chances of gaining market share. The flip side is that any firm not entering into such a commitment stands to lose market share. Ligterink (2000) develops a similar strategic motive for risk management, while Nain (2005) develops and finds evidence for a theory of risk management based on the degree of concentration in the industry and the ability to pass through costs to customers. Adam, Dasgupta, and Titman (2007) show that hedging is not specifically an exclusive outcome from risk aversion or market frictions, but the outcome of strategic choices of firms based on the structure of the demand function in their industry and on the decisions of competitors. They do this by extending the description of firms developed in Froot et al. (1993) to endow them with a “production flexibility option” so that they may choose their output levels after they have made their investments and observed the hedging choices of other firms. These firms still have a convex (variable) cost function and are financially constrained, so they should act as though risk-averse in the sense discussed above. However, the flexibility in output quantity in the context of endogenously determined product prices gives some firms the incentive to act in a contrarian manner so that they may produce (and invest) less when others produce more (leading to lower prices), and vice versa. This leads to several interesting predictions, a key one being the observed variation in industry level heterogeneity of hedging decisions.

## **2.2 Theories Regarding Interest Rate Risk**

Interest rate risk affects assets through changes in the value of investment opportunities, through its impact on borrowing capacity, intermediate to both of which is the effect on any tax shield. It affects liabilities through changes in the value of debt, and through its effect on the variability of interest payments and thus earnings. The earliest efforts to understand interest rate risks for firms were made from the point of view of asset pricing models, i.e. modeling interest rates as an additional factor. I don’t delve too deeply into this aspect, but some papers with early findings are

discussed below in Section 3.

Other papers were interested in the individual markets for various types of credit arrangements, and also in their interaction with monetary policy. Campbell (1978) develops a demand-supply model for what he terms lines of credit and revolving credit agreements. Lines of credit are described as short-term (less than one year) fee-free commitments to lend up to a maximum amount at a predetermined rate, while revolving credit agreements are longer term variable rate lending commitments that incorporate a fee for unused borrowing capacity. The objectives of both the bank and the borrower are assumed to be expected utility maximization. The stream of literature that follows from this also recognizes that in providing a fixed rate line of credit, the bank is not only insuring the borrower's cash demands, but also his interest rate risk. The initial development of interest rate risk management was naturally targeted towards financial bodies such as lenders (banks) or insurance companies, whose assets and liabilities suffer from timing mismatches and actual cash-flow risk in the form of variable costs of borrowing and return on assets. Santomero (1983) addresses the question of "Fixed versus variable rate loans" from the point of view of a bank making a lending decision. Other papers that address interest rate risk for a financial intermediary include Morgan and Smith (1987) and Morgan, Shome and Smith (1988). One of the interesting implications of these papers is that they show that a perfect hedge (known as immunization in this case) matching assets and liabilities is most likely not the optimal outcome in such a model, and that there is a residual risk that is borne optimally by the firm.

Why is interest rate risk special? In theory, Froot, Scharfstein, and Stein (1993) and others provide us with an optimal hedge ratio for any risk with relation to the cash flows of the firm. In practice, however, Faulkender (2005) points out the issues with hedging debt related interest rate exposures. Supposing a firm's cash flow is negatively correlated with interest rates, what it needs in order to hedge its cash flows is the ability to pay a low (decreasing) rate when rates are high, and a high (increasing) rate when rates are low. Such an instrument would be an inverted version of a floating rate swap that is unknown to me to exist in popular usage. Fixing rates would only neutralize the interest rate effect on financial flows altogether, a solution most modern theories of hedging would reject. Apart from that, fixed rate debt could also lead to borrowing constraints in low interest rate states, or a higher cost for the option of refinancing. Thus, we need a model in which the investor faces interest rate risk from both fixed and variable rate borrowing. Santomero, for instance, addresses the floating rate risk for the involved parties, ignoring the presence of fixed rate risk in

the sense that I will show in Section 4 below.

The interest rate risk management literature has been preoccupied with explaining the widespread and large scale use of interest rate swaps as a so-called hedging instrument. There is an institutional argument for the existence of swaps that involves a reduction in the cost of borrowing long-term for firms in the following manner. Firms may have to pay high premia for long-term debt due to asymmetric information, but the low credit risk in swaps means that they can obtain more agreeable terms by borrowing short-term and swapping the floating rate payments for a fixed rate using a long-term swap. These papers effectively ignore the repricing and refinancing risk from such a strategy that can be considerable. The other set of papers specify the particular kinds of firms that may benefit from a floating-to-fixed rate swap as described above, and a paper by Titman (1992) very neatly sums up the main arguments. While ignoring the use of fixed-to-floating rate swaps (which would amount to the synthetic creation of pre-existing long-term floaters), we can see that firms that for any reason expect their credit spread to fall in the future would prefer to borrow short-term until they can benefit from such an improvement. However, to avoid the risk of variable earnings from interest rate fluctuations, they would also lock in a fixed rate and effectively create a long-term loan, albeit with variable refinancing terms and opportunities in the short-term.

This discussion clearly leads to an aspect of interest rate risk that has been addressed extensively in the literature, albeit through a different lens. This is the question of the choice between short-term and long-term debt. See, for instance, Diamond (1991) or Ericsson (2000). In addition, the transaction-induced need for financial flexibility studied in Kahl, Shivdasani, and Wang (2008) is also a variant of the arguments that effectively emphasize the confounding of interest rate risk and financing/investment risk. It is also useful to note that rollover and repricing risks may equally arise from uncertainty about the firm's prospects or from external market phenomena such as overall liquidity in the economy.<sup>5</sup>

## 2.3 How to Manage Risk?

Here, we are thinking of risk management in the context of the whole firm that abstracts from the vast amount of work done on traditional forms of risk management such as operational and safety procedures or insurance against liability, catastrophes

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<sup>5</sup>The categorization of such risks is an open question as they do not necessarily affect all firms equally. Are the liquidity shocks generating interest rate risk, or is this "systemic" liquidity a kind of market factor by itself?

and other extreme events.

First let us consider a setting where the uncertainty is in the demand/price of the producer's output. This is true for commodities in particular, where both spot and financial markets exist for the product. Specifically referring to agricultural output, McKinnon (1967) and an exchange between Poole (1970) and McKinnon (1971) helps develop the basis for a risk management strategy involving both financial hedging and inventories. In this case, since the farmer is also the sole shareholder in his firm, and since his collateral is valued lower in bad times, there is a natural case for risk management. An important contribution of these papers is to set up an argument for the cash-flow stabilization effects of holding a buffer stock (of product and/or cash) in addition to selling forward the output once costs are known. This latter paper also sets the challenge for future researchers to find a dynamically optimal inventory holding policy given the stochastic variation of output quantities and prices. A mathematically similar problem is later addressed by Zeldes (1989a,b) in the context of the consumption choices of a household. The recognition of the fact that derivatives are not the sole means of risk-management can already be traced to these papers.

The assumption of complete or perfect markets comes with a costless hedging environment, which would imply that hedging carried out under the assumption of risk aversion a la Stulz (1984) would be complete hedging. In such a case, there is no question of determining a hedge ratio. The question of optimal hedge ratios arises when we are concerned with a particular objective function like that in Froot, Scharfstein and Stein (1993), whose hedging goal is to ensure the across-state matching of internally available funds and investment opportunities. Froot et al. propose hedge ratios for specific cases in addition to their general derivation. This is interesting because, in a static setting, it suggests that the results of typical buffer-stock, stable-inventory, or target-cash-level type models might not necessarily be the outcome of an optimal hedging strategy of the kind they pursue. Acharya, Almeida, and Campello (2007) in fact show that firms may retain different combinations of cash and debt capacity based on their investment-needs risk. i.e. A firm that expects the size of its optimal future investment to be much greater than its borrowing capacity in the future will retain more cash to hedge against the possibility of facing a binding borrowing limit.

Consider also the question of choice of instrument for hedging. Froot et al. show that in certain cases non-linear instruments would be superior to linear hedging instruments to design a more flexible hedging strategy. However, from the point of view of derivatives pricing theory, if one were attempting to eliminate volatility in the price of

one's output, the perfectly riskless/costless hedge would be a forward contract setting the future price at the arbitrage-free discounted price of the product. Alternatively, an at-the-money put option would involve an initial payout in exchange for insurance against a fall in the price of the underlying, but would still leave possible room for gain if the price of the product were to rise by more than the insurance premium. However, the realized price from selling the good must be seen in this latter case as the market price less the option premium, which could in fact be below the forward price. This is important because the risk-management implications differ in the manner in which inter-state transfers of wealth are being generated. In fact, Albuquerque (2007) shows that even with identical proportional transaction costs, the forward contract is a superior alternative to the option contract when hedging the output price. Although this does not contradict the Froot et al. finding, it does challenge a widely held belief that option-like instruments are better at hedging against downside risk. Such a view must be adjusted for the ex-ante inter-state transfer involved in paying an option premium. In fact, since non-linear contracts resemble insurance, the optimal extent of their use is addressed in Smith (1968). In this paper, he develops an optimal trade-off theory between the cost of hedging certain losses and the cost of not hedging them. Finally, Stulz(1984) implies that maximum hedging costs outside shareholders nothing, whereas any transaction involves transferring wealth from one state of the world to another. Thus, though it may be costless in the sense of a zero net value, an agent with state dependent preferences may gain or lose from this transaction.

To summarize, we need to determine which sources of risk to manage, how much exposure is optimal, and how one is to adjust one's exposure (operationally, through financial instruments or by using the services of a professional insurer). The theories suggest that a firm should only hedge risks that lead to destroyed value due to inefficiency (bankruptcy cost) or market frictions (suboptimal investment from asymmetric information or incentive misalignment). The optimal hedge ratio depends on the variable being modeled (cash flow, share value, or firm value), and the correlation of the risk factor with this ratio. There is no clear evidence, however, whether financial derivatives are the only way to hedge risks. For instances, so-called natural hedges (such as borrowing in the currency of a foreign subsidiary) are popular partly because they are considered less costly, though no evidence to that effect exists to my knowledge. In addition, as shown in the empirical section below, studies have found several different approaches toward risk management in industry that may or may not rely on derivatives usage. Finally, there is the question of the design of contracts. While derivatives are very flexible, their complexity might in practice introduce greater risks

that the hedger fails to model. Consider, for instance, the experience of municipalities all over the world that have faced disastrous consequences from basis risk related to swap contracts.<sup>6</sup>

## 3 Modeling Interest Rate Risk

### 3.1 Digression - A Wishlist Approach

In an ideal setting, we need to consider the risk management choices of the firm in general equilibrium. See, for example, Dréze (1985), where he shows that the preferences of the majority shareholders of the firm can be reflected in the financing policy of the firm, not only through the stock market or the voting/decision making apparatus, but through both in equilibrium. He also agrees, though, that a risk-neutral firm would behave as though risk-averse if it faced liquidity constraints. Thus, there is a tension along the modeling continuum, from a very complicated level to settling for partial equilibrium or evaluating a single marginal trade-off. What happens if we simultaneously incorporate some of the essential elements that the literature has recognized as being relevant in the need for and practice of risk management. The role of shareholders, managers and bondholders is, for instance, explored in Morellec and Smith (2007). They find that incorporating the agency issues between shareholders and managers would lead to optimal hedging decisions for firms both from the point of view of underinvestment and overinvestment. In other words, not only firms at risk of financial distress or lost investment opportunities (due to debt signalling problems), but also firms with large stable cash flows would optimally engage in hedging activity. We can thus see that shareholders would have a preference for higher debt due to outcomes in terms of tax and investment discipline, but would choose to reduce risk to avoid value destruction from financial distress, or to secure lower borrowing costs. Bondholders would charge a lower premium if risk-shifting behaviour could be contracted away, but in some cases firms may themselves choose to reduce riskiness of assets due to distress costs (Purnanandam 2008). This is because, if there is a risk of deadweight loss, all agents would agree (after financing and contracts are in place) to practise risk management when distress is not impending. Managers (typically underdiversified) are unable to hedge their exposure to the firm's risk, though they

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<sup>6</sup>This is because they borrowed at municipal bond market rates, but entered into swaps based on LIBOR.



may like to.<sup>7</sup> Thus, they would have an incentive to manage risk. The sensitivities of the manager's wealth to the firm's stock price and volatility have been used to study the manager's risk taking incentives by, among others, Rogers (2002) and Chava and Purnanandam (2007). However, given that compensation contracts are endogenously determined, and the manager is not a risk-neutral entity, it is not easy to assume that the Black-Scholes vega would directly apply to the manager's utility maximization problem in a linear fashion. Also, when the manager exercises options or receives other performance based compensation, he exposes himself to taxes - a trade-off that has not yet been explored in the literature. This particular trade-off may be relevant because managers cannot directly smooth out personal taxes, and they often face a highly convex tax schedule themselves. At the same time, there is a risk and utility loss from deferring compensation.

The following features of models or stylized descriptions, based on work in corporate risk management ought to be taken into account. Shareholders, in general, would prefer higher leverage due to the tax shield, and would be willing to reduce risk in order to secure more debt. However, they must weigh this against other effects. Firstly, financial distress causes a reduction in a firm's value due to strategic outcomes in the competitive product space. The trigger for financial distress may be low cash flows or an exogenous fall in the firm's value below a certain threshold. A firm would then be expected to bear more risk if it is very far from such a threshold or very close to it, but not in interim states. Secondly, the cost of borrowing external funds may be higher than the opportunity cost of internally generated reserves. The high cost of external funds may, in turn, be exacerbated if the firm faces constraints due to a poor mismatch between profitable states of the world and those with investment opportunities. Similarly, investment opportunities arise due to product market related factors and represent potentially valuable real options, but they may not materialize due to unavailability of internal funds or the relative cost of external financing assuming it's available. In either case, the availability of internal funds at certain times may help alleviate potential loss of firm value. Based on the interaction (read co-movement) of such states of the world with cyclical or countercyclical variation in the firm's operations or cash balances, we can determine if entering financial contracts on any market variable may impact the outcomes. It is clear that more than one aspect of the firm (revenues, costs, financial value in terms of future prospects) may be affected

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<sup>7</sup>Recent evidence to the contrary has been presented in terms of CEO participation in OTC derivatives transactions, but it seems to be restricted.

by variations in a market variable such as the short rate.<sup>8</sup> For interest rates, there is not only a business cycle association that may variously affect firms based on their particular industry, but also transaction risk in terms of interest costs of debt.

In the next subsection, I propose a more simple framework that would help to identify the salient features of interest rate risk for nonfinancial firms, and place it in the context of existing risk management theory.

### **3.2 A Simple Adaptable Approach to Characterizing Interest Rate Risk**

I outline and discuss below a simple model from Oberoi (2010). The objective is to characterize the nature of interest rate risk faced by a firm when it borrows money for investment. In order to properly incorporate existing theories into a model of interest rate risk management, we first need to simplify the channel through which interest rates affect the firm. One way to do it is to consider the effect of interest rates on a major aspect of the firm - its leverage from debt and its cost of debt. The other way in which we account for interest rate risk is to allow for correlation between interest rate and cash flow states. I do this in a form borrowed from Acharya, Almeida and Campello (2007). In the setup below, we will allow for an exogenous cost of financial distress as well as financing constraints. Together, these would proxy for several alternative explanations, both exogenously assuming risk aversion and endogenously ascribing it to a risk-neutral firm.

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<sup>8</sup>It is obvious, for example, from models of international asset pricing, that the value of a firm with no foreign sales (or direct inputs) is affected by exchange rate risk in a globalized economy.

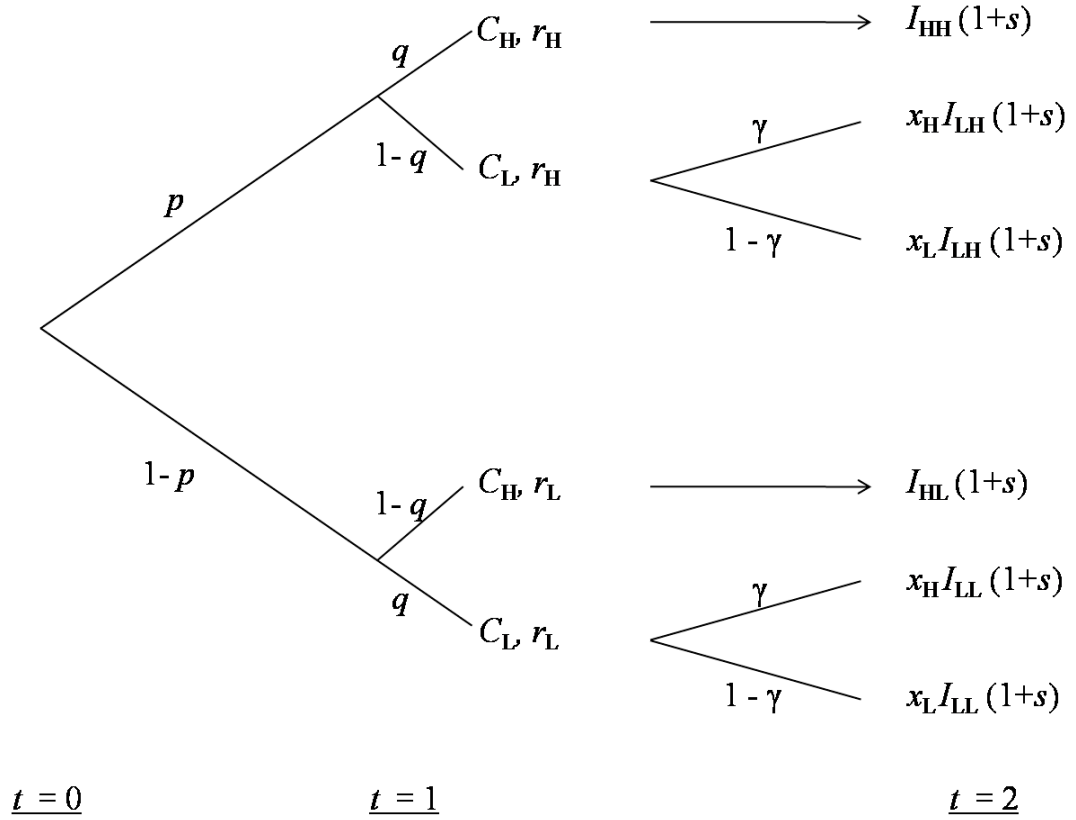


Figure 1: There are three dates in the model. The initial debt is taken up at  $t = 0$ .  $p$  is the probability of a high interest rate  $r_H$ , while  $q$  is the probability of a high cash flow  $C_H$  when the interest rate is high, or a low cash flow when the interest rate is low. The subscripts on investment  $I_{LH}$  reflect a low cash flow and high interest rate, respectively, at  $t = 1$ .  $x_H$  and  $x_L$  are factors that represent the possible reduction in expected investment return due to financial distress in the low cash flow states.

Figure 1: Tree showing dates in the model

### 3.2.1 Assumptions

There are three dates in the model (see Fig. 1). At  $t = 0$ , the firm takes up a project with uncertain cash flows and partly finances it with debt with face value  $d$  on which it must pay coupons at  $t = 1, 2$ . The debt is repaid at  $t = 2$ . At  $t = 1$ , the firm receives a high or low cash flow  $C_H$  or  $C_L$  respectively. Also, the one-period risk-free interest rate either rises to  $r_H$  or falls to  $r_L$ . Cash flows and interest rates are correlated - to model this as simply as possible, I rely on an approach used by Acharya, Almeida and Campello (2007) whereby the probability of a high cash flow in the low interest rate state mirrors that of a low cash flow in a high interest rate state. The

precise nature of this correlation would, in practice, be crucial to risk management policymakers. This is because it would determine whether the interest rate risk on variable rate liabilities is enhanced or dampened by co-movement with operating cash flows. Consider for example a firm borrowing at variable interest rates and whose operating earnings (through market demand, for instance) are negatively correlated with the level of the interest rate. Such a firm, if it has variable rate liabilities, will face the double challenge of lower cash flows and higher interest costs when rates go up. Also, at  $t = 1$ , the firm has an opportunity to reinvest its residual cash flow (after paying the debt coupon) in the project to earn a positive NPV return  $s$ , such that it is always optimal for the firm to invest. The firm may additionally borrow to finance its total investment  $I_{**}$ , where the first subscript is for the cash flow state and the second is for the interest rate. The cash flow at  $t = 2$  depends on the state at  $t = 1$  as follows. As a major simplification, I assume there is no further uncertainty in high cash flow states. In low cash flow states, however, the expected return is multiplied by a factor  $\bar{x} = \gamma x_H + (1 - \gamma) x_L$ . We may assume that  $\bar{x} = 1$  in the simplest case, but it cannot exceed 1.  $x_L$  is assumed to be low enough to bankrupt the firm, while  $x_H$  is such that (at a minimum) the bondholder recovers her entire repayment.

I make some further simplifying assumptions, the first of which is that the existing debt has absolute priority over any new debt issued (for instance, at  $t = 1$ ). This is a simplified way of modeling the presence of covenants that would not allow management or shareholders to take on additional risk that would unduly endanger the value of debt due to investors.

As stated above, coupons are paid on debt at both  $t = 1$  and  $t = 2$ . If the debt is at a fixed rate, the coupon is the same in both periods. The coupon on the debt issued at  $t = 1$  is the riskless rate on that date. The existence of default risk still implies that the debt is not issued at par. The restriction on financing comes in the form of limited pledgability of assets (again, see Acharya, Almeida and Campello 2007). Only a proportion  $\lambda$  of current and future cash flows may be pledged to the lender, limiting the total face value of debt available. This limit ought to be endogenously determined, but for our purposes, as long as one agrees it is reasonable to assume that it is less than 1, we can assume it to be exogenous. Below, I discuss some of the implications of this deliberately stylized model.

### 3.2.2 Implications

Consider first an exogenously determined debt with face value  $d$  that the firm has issued at time 0. As stated earlier, we consider only the set of cases where  $d$  remains

riskless (in the sense that final cash flows exceed repayments) in the high cash flow states.<sup>9</sup> If the firm issues only fixed rate debt at a rate  $r_0$ , such that  $r_L < r_0 < r_H$ , the time 0 value of debt based on no further borrowing would be given by:

$$\begin{aligned}
D_0^F = & pq \left( \frac{dr_0}{1+r_0} + \frac{d+dr_0}{(1+r_0)(1+r_H)} \right) + p(1-q) \left( \frac{dr_0}{1+r_0} + \gamma \frac{d+dr_0}{(1+r_0)(1+r_H)} \right) \\
& + p(1-q) \left( \frac{dr_0}{1+r_0} + (1-\gamma) \underbrace{\min \left( \frac{d+dr_0}{(1+r_0)(1+r_H)}, x_L I_{LH} (1+s) \right)}_{\text{possible default}} \right) \\
& + (1-p)(1-q) \left( \frac{dr_0}{1+r_0} + \frac{d+dr_0}{(1+r_0)(1+r_L)} \right) \\
& + (1-p)q \left( \frac{dr_0}{1+r_0} + \gamma \frac{d+dr_0}{(1+r_0)(1+r_L)} \right) \\
& + (1-p)q \left( \frac{dr_0}{1+r_0} + (1-\gamma) \underbrace{\min \left( \frac{d+dr_0}{(1+r_0)(1+r_L)}, x_L I_{LL} (1+s) \right)}_{\text{possible default}} \right)
\end{aligned}$$

with productivity parameters:

$$\begin{aligned}
(\gamma x_H + (1-\gamma) x_L) (1+s) & \geq 1+r_H \\
\gamma x_H + (1-\gamma) x_L & \in (0, 1]; \\
x_L & \in (0, x_H)
\end{aligned}$$

Also, given that any investment at time 1 promises a higher expected return than the riskless discount rate, we can conclude that the risk-neutral agent will invest the maximum available funds at time 1. Thus,  $I_{**}$  will always be  $C_* - dr_0$  in any state  $*$ , and we don't need to calculate  $I$  for the above comparison.

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<sup>9</sup>Here, we are ignoring the leverage limit  $\lambda$  as the purpose of the analysis is only to show the interest rate risk from two different types of loans.  $\lambda$  will be incorporated in later calculations.

Simplifying this expression leads to

$$\begin{aligned}
D_0^F &= \frac{dr_0}{1+r_0} + \frac{d}{1+r_H} (pq + p(1-q)\gamma) \\
&\quad + \frac{d}{1+r_L} ((1-p)(1-q) + (1-p)q\gamma) \\
&\quad + p(1-q)(1-\gamma) \min\left(\frac{d}{1+r_H}, x_L I_{LH}(1+s)\right) \\
&\quad + (1-p)q(1-\gamma) \min\left(\frac{d}{1+r_L}, x_L I_{LL}(1+s)\right) \\
D_0^F &= \frac{dr_0}{1+r_0} + \frac{pqd}{1+r_H} + \frac{(1-p)(1-q)d}{1+r_L} \\
&\quad + p(1-q) \min\left(\frac{d}{1+r_H}, \gamma \frac{d}{1+r_H} + (1-\gamma)x_L I_{LH}(1+s)\right) \\
&\quad + (1-p)q \min\left(\frac{d}{1+r_L}, \gamma \frac{d}{1+r_L} + (1-\gamma)x_L I_{LL}(1+s)\right)
\end{aligned} \tag{1}$$

If the firm had taken only a floating rate loan, the loan's market value at time 0 would similarly be given by

$$\begin{aligned}
D_0^{FL} &= \frac{dr_0}{1+r_0} + \frac{d(pq + (1-p)(1-q))}{1+r_0} \\
&\quad + p(1-q) \min\left(\frac{d}{1+r_0}, \gamma \frac{d}{1+r_0} + (1-\gamma)x_L I_{LH}(1+s)\right) \\
&\quad + (1-p)q \min\left(\frac{d}{1+r_0}, \gamma \frac{d}{1+r_0} + (1-\gamma)x_L I_{LL}(1+s)\right)
\end{aligned} \tag{2}$$

Comparing expressions in (1) and (2), we can see that the *value* of the floating rate debt depends on default probabilities, but is *not* sensitive to future realizations of the interest rate, whereas the fixed rate debt is in fact subject to both interest rate and default risk.

Consider now the cash-flows to the shareholders in the firm. For our comparisons, we can make the further simplifying assumption that the low cash flow state at time 2 is a default state in that it doesn't cover the debt repayment completely. In such a case, a firm that has borrowed at a fixed rate expects to receive the following cash flows at time 2:

$$\begin{aligned}
& [pq + (1 - p)(1 - q)](C_H - dr_0)(1 + s) \\
& + \gamma[p(1 - q) + (1 - p)q]x_H(C_L - dr_0)(1 + s) \\
& - (1 + \gamma)d(1 + r_0)
\end{aligned}$$

The cash-flows to floating-rate borrowers would be

$$\begin{aligned}
& pq[(C_H - dr_0)(1 + s) - d(1 + r_H)] \\
& + (1 - p)(1 - q)[(C_H - dr_0)(1 + s) - d(1 + r_L)] + \\
& \gamma p(1 - q)[x_H(C_L - dr_0)(1 + s) - d(1 + r_H)] \\
& + \gamma(1 - p)q[x_H(C_L - dr_0)(1 + s) - d(1 + r_L)]
\end{aligned}$$

In this case, the cash flows to shareholders in the case of fixed rate debt depend on default probabilities and the underlying operating uncertainty, but are not affected by interest rate changes. However, floating rate borrowers are affected adversely, particularly in the state with low cash flows and high interest rates coinciding. A richer model would allow us to study two states more closely and separately - the low cash flow, low interest rate regime that affects fixed rate borrowers harshly and the low cash flow, high interest rate regime that hurts floating rate borrowers.

Given the unlimited potential for returns from investing at time 1, we now consider the possibility that the firm may increase its investment by borrowing an additional amount (there is no repayment option to reduce time 0 debt balances at time 1). We know that the firm may not commit more than a proportion  $\lambda$  of its cash balances and expected cash flows as collateral. Hence, in each of the four states at time 1, the maximum (and in this case optimal) amount of borrowing would be given by (when initial debt is fixed).

$$d_1^{HH} = \frac{\lambda((B_1^{HH} + C_H - dr_0)(1 + s) - d(1 + r_0))}{1 + r_H}$$

However, since there is no further uncertainty,

$$B_1^{HH} = d_1^{HH} \tag{3}$$

$$\text{and } d_1^{HH} = \frac{\lambda((C_H - dr_0)(1 + s) - d(1 + r_0))}{1 + r_H - \lambda(1 + s)} \tag{4}$$

In the case of a low cash flow, we need to solve the following system of equations

to find the value of borrowing possible

$$d_1^{LH} = \frac{\lambda ((B_1^{LH} + (C_L - dr_0)) (1 + s) (\gamma x_H + (1 - \gamma) x_L) - d(1 + r_0))}{1 + r_H} \quad (5)$$

$$B_1^{LH} = \gamma d_1^{LH} + \frac{(1 - \gamma) \min \{d_1^{LH} (1 + r_H), (B_1^{LH} + (C_L - dr_0)) (1 + s) x_L - d(1 + r_0)\}}{1 + r_H} \quad (6)$$

The solution to this is

$$B_1^{LH} = \frac{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_0)}{(1 + r_H) - (1 + s) \bar{X}}$$

where  $\bar{x} = \gamma x_H + (1 - \gamma) x_L$  and  $\bar{X} = \gamma \lambda \bar{x} + (1 - \gamma) x_L$ . For the calculations, please see the appendix. The calculations in the case of low cash flows mirror those for high cash flows, and we have:

$$d_1^{HL} = \frac{\lambda ((B_1^{HL} + C_H - dr_0) (1 + s) - d(1 + r_0))}{1 + r_L} \quad (7)$$

$$B_1^{HL} = d_1^{HL} \quad (8)$$

$$d_1^{HL} = \frac{\lambda ((C_H - dr_0) (1 + s) - d(1 + r_0))}{1 + r_L - \lambda (1 + s)} \quad (9)$$

and

$$d_1^{LL} = \frac{\lambda \{ (B_1^{LL} + C_L - dr_0) (1 + s) (\gamma x_H + (1 - \gamma) x_L) - d(1 + r_0) \}}{1 + r_L} \quad (10)$$

$$B_1^{LL} = \gamma d_1^{LL} + \frac{(1 - \gamma) \min \{d_1^{LL} (1 + r_L), (B_1^{LL} + C_L - dr_0) (1 + s) x_L - d(1 + r_0)\}}{1 + r_L} \quad (11)$$

the solution to which is

An interesting comparison at this point is the cost of debt ( $d_1/B_1$ ) in the low cash flow states when interest rates are high or low (the calculations are in the appendix). We can find that

$$\frac{d_1^{LH}}{B_1^{LH}} - \frac{d_1^{LL}}{B_1^{LL}} = \left( \frac{1}{1 + r_H} - \frac{1}{1 + r_L} \right) \frac{(1 + r_0) (1 + s) (\bar{X} - d\lambda \bar{x})}{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_0)}$$



which implies that the cost of new debt for a fixed rate borrower in the low interest rate state is *higher* than when interest rates are high. On the other hand, when we consider the same comparison in the case of a firm holding floating rate debt, we find that the difference in the cost of debt is positively related to  $(r_H - r_L)$ . For the complete calculations including those of the case of floating rate debt, please see the appendix.

Taking into account the additional issue of debt  $d_1$  at time 1, we can now recalculate the value of time 0 debt. The fixed rate debt would be valued as:

$$D_0^F = \frac{dr_0}{1+r_0} + \frac{pqd}{1+r_H} + \frac{(1-p)(1-q)d}{1+r_L} \quad (12)$$

$$+ p(1-q) \min \left( \frac{d}{1+r_H}, \gamma \frac{d}{1+r_H} + (1-\gamma) \lambda x_H I_{LH}^* (1+s) \right)$$

$$+ (1-p)q \min \left( \frac{d_0}{1+r_L}, \gamma \frac{d}{1+r_L} + (1-\gamma) \lambda x_L I_{LL}^* (1+s) \right)$$

:

If the debt were issued at a floating rate,

$$D_0^{FL} = \frac{dr_0}{1+r_0} + \frac{d[pq + (1-p)(1-q)]}{1+r_0} \quad (13)$$

$$+ p(1-q) \min \left( \frac{d}{1+r_0}, \gamma \frac{d}{1+r_0} + (1-\gamma) \lambda x_H I_{LH}^* (1+s) \right)$$

$$+ (1-p)q \min \left( \frac{d_0}{1+r_0}, \gamma \frac{d}{1+r_0} + (1-\gamma) \lambda x_L I_{LL}^* (1+s) \right)$$

where  $I^*$  is now determined optimally through the backward solution process described above.

In this setting, we have made a significant simplifying assumption in the form of a symmetric state of distress (low cash flows) for both high and low interest rate environments. Thus, it may not be obvious how the trade-off between fixed and floating rates works for the firm to maximize its NPV. The response to this lies in the assumed correlation between cash flows and interest rates, which is a function of  $q$ . When  $q = 1$ , the correlation between cash flows and interest rates is perfect, and using floating rate debt would clearly be optimal from the point of view of minimizing risk. On the other hand, when  $q = 0$ , high cash flows only arise when interest rates are low and vice versa. In this setting, using fixed rate debt would mitigate the potential

financing constraint at time 1.<sup>10</sup>

### 3.2.3 Incorporating Other Existing Theories in the Framework

The above stylized model considers limited pledgability of cash flows as a source of imperfection in the market. Under this assumption, I demonstrate the risks and constraints imposed by borrowing both at fixed and floating rates. I also showed that even in the presence of a 'money-printing' investment opportunity that is known for sure, the effect of the interest rate risk is not altered. Limited pledgability arises from the presence of agency costs. These same agency costs can be alternatively modelled as causing external finance to be more costly and to have a convex cost structure. This approach is taken in Froot, Scharfstein, and Stein. In order to optimize for costly external finance in the absence of limited pledgability, the new constraint on output would require that  $I(1 + s)$  is replaced by a function  $f(I)$  such that  $f'(I) > 0$  and  $f''(I) < 0$ , as in a Cobb-Douglas function, for example. Other approaches, such as Purnanandam's, involve the imposition of a financial distress cost. In my model, that would be reflected by  $x_H < 1$ , implying that  $\bar{x} < 1$  as well. In such a case, it would be necessary to retain the limited pledgability condition. Alternatively, one would allow uncertainty to remain in both high and low cash flow states. The result would be exactly the same as described above, as long as  $x_L$  is such that default occurs. The models that rely on risk aversion would require that the objective function of the firm be concave in NPV, rather than linear, as is the case defined above.

## 4 Empirical Findings on Corporate Risk Management

Despite the difficulty in testing risk management theories, several attempts have been made to test them and also to discriminate between them. These have been complemented by both descriptive and comparative case studies. I will list only a very limited subset of these to highlight the fact that there is still a significant lack of convincing evidence in favour of a single theory to the detriment of others. Before going forward, however, it is important to make a key distinction about the most

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<sup>10</sup>Though not considered in this setup, the reverse rate contract (pay a high rate when rates are low and vice versa) would be the perfect cash flow hedge not taking into account further borrowing needs. Although inverse floaters are known to exist in the collateralized debt market, they are usually issued as part of a larger portfolio, whereby they are designed to cancel the yield on the regular components.

controversial source of evidence (or the lack of it) from the empirical research on risk management practices of firms.

## 4.1 Comment on Derivatives as a Proxy for Hedging

The large and growing size of transaction activity in the derivatives markets is a well-known phenomenon, and academic interest in new forms of contracts, their valuation and usefulness is also evident. However, the use of derivatives contracts has over time become synonymous with hedging although it is apparent to any casual observer that derivatives by their very nature may serve just as well to enhance exposures to risks as to reduce them. Yet, the difficulty in observing the underlying exposures of a firm and separating them from its hedging activities is exacerbated by the poor quality of disclosures made by firms (or required of them). To confound matters further, firms have an incentive to use hedge accounting for their derivatives exposures whether they are truly hedging or not. The fact that the use of off-balance sheet derivatives (simply a 1 – 0 decision) has been considered an acceptable proxy for the practice of hedging has caused two effects.

First, there has been a great deal of attention paid to reasons for the use of derivatives (which, from a risk management perspective, appears to be like focussing on the method rather than the objective). As a qualification, in cases where the risk is not fully characterized for a firm, this may help to build that picture. This is particularly true for interest rates, where authors have been greatly concerned about explaining the pervasion of specific types of contracts rather than about addressing the overall problem of risk management. The papers listed in earlier sections address the question of fixed rate or floating rate lending commitments, other forms of forward contracts, and swap contracts. In fact, they are careful to emphasize their point of entry into the analysis. See, for example, Visvanathan (1998) who asks the question "Who uses interest rate swaps?" and then attempts to discriminate in a cross-sectional sample between the various risk management theories predicated on floating-to-fixed rate swap usage.

The second, and more troubling, effect arises from the fact that new evidence is building up that suggests derivatives usage is a misleading proxy for hedging behaviour.<sup>11</sup> This places in question the results of studies that rely on this one variable to test risk management theories. It could be argued that different types of derivatives may be more or less amenable to being interpreted as exclusively hedging instruments

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<sup>11</sup>See, for example, Bodnar, Hayt and Marston (1998) or Faulkender (2005).

in corporate practice. Once disclosed, speculative foreign exchange positions should be typically difficult to disguise as hedges. Similarly, a cap, collar or interest rate lock contract may be viewed mainly as insurance. Corporations sometimes disclose short positions in floors incorporated in debt, which would be difficult to accept as hedges unless one considers them as alternatives to putability of the debt. Opposing swaps can be reported as hedging interest costs or the value of debt respectively. Despite the range of instruments, unfortunately it is still only a question of degree that distinguishes these instruments as hedges or speculative bets.

Several studies also look at the extent of derivative usage by considering the total size of open contracts for a given firm. Unfortunately, the notional value of derivatives used by a firm is often not linked to the *extent* of hedging or more specifically the net exposure from derivative positions. This is because firms typically do not buy and sell over the counter derivatives, but take offsetting positions when they wish to cancel open exposures. Graham and Rogers (2002) and Rogers (2002) address this by using net exposures, which is essential for any exercise to be valid.<sup>12</sup>

Also, Guay and Kothari (2003) consider the effect of a three standard deviation unfavourable move based on the total notional value of firms' derivative positions, and find that such changes are not likely to cause significant hardship in general. Bali, Hume, and Martell (2007) use leverage and total nominal value of interest rate derivatives in the firm in addition to measure on foreign exchange and commodity price risk exposures to determine if derivatives usage contributes to risk aversion, but find no evidence to support this. Of course, the caveat is that there are several well publicised cases of firms getting into trouble because of derivative usage, e.g. Procter and Gamble in 1995 and Metalgesellschaft in 1998.

Finally, Peterson and Thiagarajan (2000) show with the help of a comparative study of two firms that similar firms may have different opportunity sets and strategies for hedging similar exposures. All in all, the simple use of derivatives dealings, or even of their total value, to relate to risk management activity is unlikely to be informative.

## 4.2 Theories Tested and Overall Findings

Effect of taxes and optimal capital structure, especially cash or liquidity management, are the first set of variables controlled for in tests attempting to explain hedging policies of firms. Nance, Smith, and Smithson (1993) and Mian (1996) were early

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<sup>12</sup>Otherwise, a firm that heavily speculates by building up successive opposing positions would appear to be the most active in risk management.

cross-sectional studies that found mixed evidence - the first finding in favour of an investment opportunities motive for hedging (but not a debt ratio-induced distress motive), and the latter again finding no differences between derivatives users and non-users. Judge (2006) provides evidence on derivative usage and other hedging techniques used by firms in the UK. He finds that there is more evidence of financial distress as a motive for hedging and hypothesizes that it may be due to differences in the bankruptcy codes of UK and US.

The effect of convex tax schedules on firms' hedging choices is explored in Graham and Rogers (2002). Geczy, Minton, and Schrand (1997) examine the use of currency derivatives and find some evidence suggesting that firms use these instruments to hedge currency exposures. Haushalter (2000) examines the use of derivatives in the oil and gas industry and finds evidence that firms are more likely to use derivatives if they are financially constrained. The latter two studies also find evidence of size being a determinant of hedging activity, suggesting economies of scale in derivatives use.

Manager centric studies are based on managerial risk-taking incentives, and signalling theories. Schrand and Unal (1998) find that managers who are granted options are likely to increase total risk in the firm, albeit in a way that the core business risk is increased and the market risk (interest rate risk) is reduced. Rogers (2002) estimates the CEO's delta and vega for use as a measure of CEO risk-taking incentives. As this measure is directly linked to an observed (equilibrium) compensation scheme, it would make sense to simultaneously observe the riskiness of the firm's equity. However, Rogers uses it to shed light on the persistent debate about whether derivatives are indeed used for hedging (reducing risk) by firms. When he finds a negative correlation between CEO's risk-taking incentives and the level of derivatives usage in the firm, he concludes that derivatives are indeed used for reducing risk. In an apparently contradictory finding, Chava and Purnanandam (2008) incorporate the incentives of both the CEO and the CFO in attempting to explain the choice of fixed or floating rate debt. They conclude that firms where CFOs have an incentive to increase risk issue more floating rate debt. As I show below, however, it is not clear that floating rate debt is necessarily more risky (at least in an environment with stationary inflation).

Aretz and Bartram (2009) is a recent survey of empirical evidence on the value of hedging activity. Once again, while the lack of a consensus on the topic becomes clear, the common thread arising from many of the papers supports the idea that financial hedging should not be viewed in isolation, and should be evaluated taking

into account the overall interlinked decisions of the firm which are often simultaneous. Overlooking this integrated perspective in empirical tests would risk biased findings due to endogeneity.

### **4.3 Interest Rate Risk**

The original studies of interest rate sensitivity and risk took the form of attempts to identify interest rates as a factor in asset pricing equations. Martin and Keown (1977) investigate interest rate sensitivity in the context of a two-factor asset pricing model and find supportive evidence for financial industry and public utility firms. However, one might argue that this is like finding evidence of oil price sensitivity in the returns of oil firms, which would not necessarily be surprising. Subsequently, several studies have found evidence of heterogeneous stock market reaction to monetary policy shocks, the most recent of which is Ehrmann and Fratzscher (2004). Empirical studies have found that small firms, those with more information asymmetry, and those dependent on banks for financing, are affected the most by interest rate increases. This appears to be consistent with the notion that potentially constrained firms would be more affected by interest rate increases. However, work on the actual management of interest rate risk in non-financial corporations has been confounded with other aspects of borrowing related risk. For instance, the trade-offs between cash and debt, or between short-term and long-term borrowing, all incorporate an element of interest rate risk. However, the focus of such studies (as described above in Section 2) has been on the repricing and rollover risks of debt with respect to information asymmetry. The distinguishing element here is the distinction between risk caused by the changes in government policy and the changes in the credit spreads of the firms due to other information about the firm's prospects. The spread is the rate of interest in excess of the risk-free rate that is paid by the firm and is associated with its credit risk. Changes in the credit risk of the firm would be the focus of information based models that focus on (a part of the) repricing and rollover risk, whereas such models abstract away from underlying movements in the market or policy interest rate itself. This latter domain has been reserved for financial institutions, and is thus outside the scope of the current survey.

### **4.3.1 Interest Rate Risk Management - Forward Borrowing Contracts, Swaps, and Borrowing Term Choices**

As discussed in this paper, empirical evidence in favour of the existing risk management theories would be even harder to come by in the context of stochastic interest rates. Faulkender (2005) studies a sample of chemical industry firms' debt issuances over a four year period in the 1990s. He adjusts for the disclosure of any new swap positions by allocating them to the new debt issues. Although such an allocation might be problematic for reasons discussed in Section 3.1, it is significantly better than ignoring the swaps. He finds in this paper that managers may be choosing whether to issue fixed or floating rate debt according to the slope of the interest rate yield curve at the time. From a cash flow hedging sense, which is what Faulkender is testing for, this is a clear display of myopic behaviour. On the other hand, Baker, Greenwood and Wurgler (2002) find evidence consistent with the idea that the corporate sector as a whole may be successfully timing debt issuances to take advantage of mean-reverting interest rates. Christoffersen, Nain and Oberoi (2009) distinguish firms based on how actively they change the proportion of the two types of debt over an eleven-year period. Yet, they find no evidence that firms are hedging the sensitivity of their cash flows to interest rates or that either type are likely to anticipate changes in monetary policy. This appears to suggest that firms are not successful at either hedging or speculating, despite actively varying their exposures.

Related to the Chava and Purnanandam (2007) study, Beatty, Chen, and Zhang (2009) report that banks typically require constrained borrowers to enter into fixed-rate swaps as a condition of lending them money. This is rather puzzling, as the optimality of such a decision is not very clear in a dynamic setting.

## **5 Avenues for Further Research**

In this review, I have identified some of the areas that require further investigation. The first, given the biased attention to this topic in the literature, is the link between derivatives usage and risk management. The second is the use of dynamic models to consider the various interlinked relationships. In terms of interest rate risk, efforts to properly measure it and define it for nonfinancial firms would help us get closer to finding ways to manage it. Also, once we have a good measure of risk management activity, we can consider its effect on firm value and efficiency. One of the advantages of risk management is (according to many of the theoretical models) its definition. By

this, I mean that risk management is defined as an adjustment (typically downwards) of the variance of the firm's investment returns through choices over technology and other mechanisms. The use of financial risk management could therefore be observed ex-post, which is an advantage in finance where several models rely on expected values of variables that are then proxied by past averages. Thus, empirically, the ex-post measurement of risk management is simply the outcome. The only question that arises is that of the counterfactual. Can we determine what the reference point is with respect to the realized level of risk?

## 6 Conclusion

One motivation for this study is the state of current practice in interest rate management. A large variety of derivative and debt instruments is available to a corporate treasury manager. In fact, a search of the Internet for "interest rate management" leads to a long list of web sites of financial institutions offering advice on the use of interest rate derivative instruments such as swaps, caps, floors, and collars. However, at the risk of being corrected by a complete scientific review, I would venture to say that a greater emphasis is based on how a firm may benefit from holding 'correct' views on the direction of interest rates. Unfortunately, there is typically no distinction drawn between superior private information and publicly accepted wisdom about the future of monetary policy (which one would expect is priced into any derivative contract one can devise). Thus, though the latter type of information does not necessarily promise a profit, it is considered reason enough to take financial positions based on such views. At the same time, there is often advice such as recommendations for collars when firms experience an abnormal increase in debt (e.g., due to an acquisition). On the other hand, typical advice would be of the type: 'If you perceive a risk of rates rising in the long term, but are confident of low rates persisting in the medium term, you may enter into a forward starting swap.' This type of approach implies either that firms treat the cost of debt as an operationally important objective in itself, or that a clear understanding of interest rate risk (and hence, of instruments that would properly hedge it), is still lacking.

The model developed above attempts to describe the unique nature of interest rate risk for the firm (as it affects both assets and liabilities) in the context of existing risk management theories. It is also important to note that this is not a model of derivative usage. Swap contracts in this model could be used to alter the proportion of fixed rate debt, but it is not an end in itself of this model to explain the existence of



swaps. However, it also suffers from certain obvious deficiencies. First, the lack of a fully dynamic structure restricts one to cross-sectional implications and comparative statics at best. As it is stylized and heavily simplified, it does not help us to ascertain the behaviour of firms in a wide range of alternative scenarios, such as when the firm knows its credit rating is expected to improve. This would be the question of a trade-off between short and long term debt, and not one of interest rate risk, per se. In addition, it is difficult to develop realistic guidance from this model on the optimal risk management policy to be followed by a firm. While the simplified approach to correlation between cash flows and interest rates is useful in characterizing the unique nature of interest rate risk, we need a richer understanding of the dynamic interaction between firm value, profits and interest rates to develop practical recommendations for interest rate risk management.

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# Appendix

## 1 Steps for calculating the value of a floating rate loan with no intermediate debt issuance

$$\begin{aligned}
D_0^{FL} = & pq \left( \frac{dr_0}{1+r_0} + \frac{d+dr_H}{(1+r_0)(1+r_H)} \right) + p(1-q) \left( \frac{dr_0}{1+r_0} + \gamma \frac{d+dr_H}{(1+r_0)(1+r_H)} \right) \\
& + p(1-q) \left( \frac{dr_0}{1+r_0} + (1-\gamma) \underbrace{\min \left( \frac{d+dr_H}{(1+r_0)(1+r_H)}, x_L I_{LH} (1+s) \right)}_{\text{possible default}} \right) \\
& + (1-p)(1-q) \left( \frac{dr_0}{1+r_0} + \frac{d+dr_L}{(1+r_0)(1+r_L)} \right) \\
& + (1-p)q \left( \frac{dr_0}{1+r_0} + \gamma \frac{d+dr_L}{(1+r_0)(1+r_L)} \right) \\
& + (1-p)q \left( \frac{dr_0}{1+r_0} + (1-\gamma) \underbrace{\min \left( \frac{d+dr_L}{(1+r_0)(1+r_L)}, x_L I_{LL} (1+s) \right)}_{\text{possible default}} \right)
\end{aligned}$$

$$\begin{aligned}
D_0^{FL} = & \frac{dr_0}{1+r_0} + \frac{d}{1+r_0} (pq + p(1-q)\gamma) + \frac{d}{1+r_0} ((1-p)(1-q) + (1-p)q\gamma) \\
& + p(1-q)(1-\gamma) \min \left( \frac{d}{1+r_0}, x_L I_{LH} (1+s) \right) \\
& + (1-p)q(1-\gamma) \min \left( \frac{d_0}{1+r_0}, x_L I_{LL} (1+s) \right)
\end{aligned}$$



## 2 Solutions to the simultaneous equations that solve for the market and face value of debt that can be issued at time 1

### 2.1 When initial debt is at a fixed rate

$$d_1^{LH} = \frac{\lambda ((B_1^{LH} + (C_L - dr_0)) (1 + s) \bar{x} - d(1 + r_0))}{1 + r_H}$$

$$B_1^{LH} = \gamma d_1^{LH} + (1 - \gamma) \min \left\{ d_1^{LH}, \frac{(B_1^{LH} + (C_L - dr_0)) (1 + s) x_L - d(1 + r_0)}{1 + r_H} \right\}$$

We use the following change of notation:

$B_1^{LH} + C_L - dr_0 = A$ ; Therefore,  $B_1^{LH} = A - C_L + dr_0$ . Also, denote  $\bar{x} = \gamma x_H + (1 - \gamma) x_L$ . Then,

$$d_1^{LH} = \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_0))}{1 + r_H} \quad (1)$$

$$A - C_L + dr_0 = \gamma d_1^{LH} + (1 - \gamma) \min \left\{ d_1^{LH}, \frac{A (1 + s) x_L - d(1 + r_0)}{1 + r_H} \right\} \quad (2)$$

Substituting (1) into (2),

$$A - C_L + dr_0 = \gamma \frac{\lambda A (1 + s) \bar{x} - d(1 + r_0)}{1 + r_H} + (1 - \gamma) \min \left\{ \frac{\lambda A (1 + s) \bar{x} - \lambda d(1 + r_0)}{1 + r_H}, \frac{A (1 + s) x_L - d(1 + r_0)}{1 + r_H} \right\}$$

As discussed in the paper, we consider the case where  $x_L$  is such that the debt cannot be repaid in the low state. Then, by the following steps of algebra, we have

$$d_1^{LH} = \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_0))}{1 + r_H}$$

$$A - C_L + dr_0 = \gamma \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_0))}{1 + r_H} + (1 - \gamma) \frac{A (1 + s) x_L - d(1 + r_0)}{1 + r_H}$$

$$A - C_L + dr_0 = \gamma \frac{\lambda(A(1+s)\bar{x})}{1+r_H} + (1-\gamma) \frac{A(1+s)x_L}{1+r_H} - \frac{d(1+r_0)}{1+r_H}$$

$$A - C_L + dr_0 = \frac{A(1+s)(\gamma\lambda\bar{x} + (1-\gamma)x_L)}{1+r_H} - \frac{d(1+r_0)}{1+r_H}$$

$$A - \frac{A(1+s)(\gamma\lambda\bar{x} + (1-\gamma)x_L)}{1+r_H} = C_L - dr_0 - \frac{d(1+r_0)}{1+r_H}$$

$$A = \frac{(C_L - dr_0)(1+r_H) - d(1+r_0)}{(1+r_H) - (1+s)(\gamma\lambda\bar{x} + (1-\gamma)x_L)}$$

Substituting back  $A$ ,

$$B_1^{LH} + C_L - dr_0 = \frac{(C_L - dr_0)(1+r_H) - d(1+r_0)}{(1+r_H) - (1+s)(\gamma\lambda\bar{x} + (1-\gamma)x_L)}$$

Also, let

$$\gamma\lambda\bar{x} + (1-\gamma)x_L = \bar{X}$$

and we can write

$$B_1^{LH} = \frac{(C_L - dr_0)(1+r_H) - d(1+r_0)}{(1+r_H) - (1+s)\bar{X}} - C_L + dr_0$$

or

$$B_1^{LH} = \frac{(C_L - dr_0)(1+s)\bar{X} - d(1+r_0)}{(1+r_H) - (1+s)\bar{X}}$$

*Calculating the cost of new debt Issued at time 1*

Given that

$$d_1^{LH} = \frac{\lambda((B_1^{LH} + (C_L - dr_0))(1+s)\bar{x} - d(1+r_0))}{1+r_H}$$

and dividing both sides by  $B_1^{LH}$  we get:

$$\frac{d_1^{LH}}{B_1^{LH}} = \frac{\lambda\left(\left(1 + \frac{(C_L - dr_0)}{B_1^{LH}}\right)(1+s)\bar{x} - \frac{d(1+r_0)}{B_1^{LH}}\right)}{1+r_H}$$

$$\frac{d_1^{LH}}{B_1^{LH}} = \frac{\lambda(1+s)\bar{x}}{1+r_H} + \frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_0))}{B_1^{LH}(1+r_H)}$$

Using the expression for  $B_1^{LH}$ ,

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \frac{\lambda(1+s)\bar{x}}{1+r_H} \\ &+ \frac{(\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_0)))((1+r_H) - (1+s)\bar{X})}{(1+r_H)((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))} \end{aligned}$$

Thus

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \frac{\lambda(1+s)\bar{x}}{1+r_H} + \frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_0))}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))} \\ &+ \frac{(d\lambda r_0(1+s)\bar{x} + (1+r_0) - \lambda C_L(1+s)\bar{x})}{(1+r_H)((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))} (1+s)\bar{X} \end{aligned}$$

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_0))}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))} + \\ &+ \frac{(1+s)}{1+r_H} \left( \lambda\bar{x} + \frac{(1+r_0) - \lambda(1+s)\bar{x}(C_L - dr_0)}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))} \bar{X} \right) \end{aligned}$$

Denoting by  $M$  the first term where there is no interaction between  $r_H$  or  $r_L$  and  $r_0$ ,

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \underbrace{\frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_0))}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_0))}}_{\text{denote by } M} + \\ &\frac{(1+s)}{1+r_H} \left( \frac{(C_L - dr_0)(1+s)\bar{X}\lambda\bar{x} - d(1+r_0)\lambda\bar{x} - \lambda(1+s)\bar{x}(C_L - dr_0)\bar{X}}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_0)} \right) \\ &+ \frac{(1+s)}{1+r_H} \left( \frac{(1+r_0)\bar{X}}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_0)} \right) \\ \\ \frac{d_1^{LH}}{B_1^{LH}} &= M + \frac{(1+s)}{1+r_H} \left( \frac{(1+r_0)\bar{X} - d(1+r_0)\lambda\bar{x}}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_0)} \right) \\ \\ \frac{d_1^{LH}}{B_1^{LH}} &= M + \frac{1+s}{1+r_H} \left( \frac{(1+r_0)(\bar{X} - d\lambda\bar{x})}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_0)} \right) \end{aligned}$$

For the  $HL$  state, again there is no default risk and we can get

$$\begin{aligned}
d_1^{HL} &= \frac{\lambda ((B_1^{HL} + C_H - dr_0) (1 + s) - d(1 + r_0))}{1 + r_L} \\
B_1^{HL} &= d_1^{HL} \\
d_1^{HL} &= \frac{\lambda ((C_H - dr_0) (1 + s) - d(1 + r_0))}{1 + r_L - \lambda (1 + s)}
\end{aligned}$$

The  $LL$  state is similar to the  $LH$  state, and we can get

$$\begin{aligned}
d_1^{LL} &= \frac{\lambda \{ (B_1^{LL} + C_L - dr_0) (1 + s) (\gamma x_H + (1 - \gamma) x_L) - d(1 + r_0) \}}{1 + r_L} \\
B_1^{LL} &= \gamma d_1^{LL} + \frac{(1 - \gamma) \min \{ d_1^{LL} (1 + r_L), (B_1^{LL} + C_L - dr_0) (1 + s) x_L - d(1 + r_0) \}}{1 + r_L}
\end{aligned}$$

or

$$\frac{d_1^{LL}}{B_1^{LL}} = M + \frac{1 + s}{1 + r_L} \left( \frac{(1 + r_0) (\bar{X} - d\lambda\bar{x})}{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_0)} \right)$$

Comparing the ratios  $\frac{d_1}{B_1}$  in the two states, we find

$$\frac{d_1^{LH}}{B_1^{LH}} - \frac{d_1^{LL}}{B_1^{LL}} = \left( \frac{1}{1 + r_H} - \frac{1}{1 + r_L} \right) \frac{(1 + r_0) (1 + s) (\bar{X} - d\lambda\bar{x})}{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_0)}$$

## 2.2 The Case when Initial Debt is at a Floating Rate

The calculations are parallel to the case of fixed rates, and are provided below:

$$\begin{aligned}
d_1^{HH} &= \frac{\lambda ((B_1^{HH} + C_H - dr_0) (1 + s) - d(1 + r_H))}{1 + r_H} \\
B_1^{HH} &= d_1^{HH} \\
d_1^{HH} &= \frac{\lambda ((C_H - dr_0) (1 + s) - d(1 + r_H))}{1 + r_H - \lambda (1 + s)}
\end{aligned}$$

$$\begin{aligned}
d_1^{LH} &= \frac{\lambda ((B_1^{LH} + (C_L - dr_0)) (1 + s) (\gamma x_H + (1 - \gamma) x_L) - d(1 + r_H))}{1 + r_H} \\
B_1^{LH} &= \gamma d_1^{LH} + \frac{(1 - \gamma) \min \{ d_1^{LH} (1 + r_H), (B_1^{LH} + (C_L - dr_0)) (1 + s) x_L - d(1 + r_H) \}}{1 + r_H}
\end{aligned}$$

or:

$$d_1^{LH} = \frac{\lambda ((B_1^{LH} + (C_L - dr_0)) (1 + s) \bar{x} - d(1 + r_H))}{1 + r_H}$$

$$B_1^{LH} = \gamma d_1^{LH} + (1 - \gamma) \min \left\{ d_1^{LH}, \frac{(B_1^{LH} + (C_L - dr_0)) (1 + s) x_L - d(1 + r_H)}{1 + r_H} \right\}$$

Change of notations:

$$B_1^{LH} + C_L - dr_0 = A$$

$$B_1^{LH} = A - C_L + dr_0$$

$$\bar{x} = \gamma x_H + (1 - \gamma) x_L$$

$$d_1^{LH} = \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_H))}{1 + r_H}$$

$$A - C_L + dr_0 = \gamma d_1^{LH} + (1 - \gamma) \min \left\{ d_1^{LH}, \frac{A (1 + s) x_L - d(1 + r_H)}{1 + r_H} \right\}$$

Substituting, we get

$$A - C_L + dr_0 = \gamma \frac{\lambda A (1 + s) \bar{x} - d(1 + r_H)}{1 + r_H} + (1 - \gamma) \min \left\{ \frac{\lambda A (1 + s) \bar{x} - \lambda d(1 + r_H)}{1 + r_H}, \frac{A (1 + s) x_L - d(1 + r_H)}{1 + r_H} \right\}$$

Again assuming a default in the  $x_L$  state

$$d_1^{LH} = \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_H))}{1 + r_H}$$

$$A - C_L + dr_0 = \gamma \frac{\lambda (A (1 + s) \bar{x} - d(1 + r_H))}{1 + r_H} + (1 - \gamma) \frac{A (1 + s) x_L - d(1 + r_H)}{1 + r_H}$$

$$A = \frac{(C_L - dr_0 - d) ((1 + r_H))}{(1 + r_H) - (1 + s) (\gamma \lambda \bar{x} + (1 - \gamma) x_L)}$$

which gives us

$$B_1^{LH} + C_L - dr_0 = \frac{(C_L - dr_0 - d)(1 + r_H)}{(1 + r_H) - (1 + s)(\gamma\lambda\bar{x} + (1 - \gamma)x_L)}$$

Further, using the earlier notation for  $\bar{X}$

$$B_1^{LH} = \frac{(C_L - dr_0 - d)(1 + r_H)}{(1 + r_H) - (1 + s)\bar{X}} - C_L + dr_0$$

$$B_1^{LH} = \frac{(C_L - dr_0)((1 + r_H) - (1 + r_H) + (1 + s)\bar{X})}{(1 + r_H) - (1 + s)\bar{X}} - \frac{d(1 + r_H)}{(1 + r_H) - (1 + s)\bar{X}}$$

or

$$B_1^{LH} = \frac{(C_L - dr_0)(1 + s)\bar{X} - d(1 + r_H)}{(1 + r_H) - (1 + s)\bar{X}}$$

For the  $HL$  state:

$$\begin{aligned} d_1^{HL} &= \frac{\lambda((B_1^{HL} + C_H - dr_0)(1 + s) - d(1 + r_L))}{1 + r_L} \\ B_1^{HL} &= d_1^{HL} \\ d_1^{HL} &= \frac{\lambda((C_H - dr_0)(1 + s) - d(1 + r_L))}{1 + r_L - \lambda(1 + s)} \end{aligned}$$

and the  $LL$  state:

$$\begin{aligned} d_1^{LL} &= \frac{\lambda\{(B_1^{LL} + C_L - dr_0)(1 + s)(\gamma x_H + (1 - \gamma)x_L) - d(1 + r_L)\}}{1 + r_L} \\ B_1^{LL} &= \frac{\gamma d_1^{LL}(1 + r_L) + (1 - \gamma)\min\{d_1^{LL}(1 + r_L), (B_1^{LL} + C_L - dr_0)(1 + s)x_L - d(1 + r_L)\}}{1 + r_L} \end{aligned}$$

Once again, the comparison for  $\frac{d_1^{LH}}{B_1^{LH}}$  and  $\frac{d_1^{LL}}{B_1^{LL}}$  is as follows

$$d_1^{LH} = \frac{\lambda((B_1^{LH} + (C_L - dr_0))(1 + s)\bar{x} - d(1 + r_H))}{1 + r_H}$$

and dividing both sides by  $B_1^{LH}$  we get:

$$\frac{d_1^{LH}}{B_1^{LH}} = \frac{\lambda\left(\left(1 + \frac{(C_L - dr_0)}{B_1^{LH}}\right)(1 + s)\bar{x} - \frac{d(1 + r_H)}{B_1^{LH}}\right)}{1 + r_H}$$

Thus:

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \frac{\lambda(1+s)\bar{x}}{1+r_H} + \frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_H))}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_H))} \\ &\quad + \frac{(d\lambda r_0(1+s)\bar{x} + (1+r_H) - \lambda C_L(1+s)\bar{x})}{(1+r_H)((C_L - dr_0)(1+s)\bar{X} - d(1+r_H))} (1+s)\bar{X} \end{aligned}$$

$$\begin{aligned} \frac{d_1^{LH}}{B_1^{LH}} &= \underbrace{\frac{\lambda C_L(1+s)\bar{x} - d(\lambda r_0(1+s)\bar{x} + (1+r_H))}{((C_L - dr_0)(1+s)\bar{X} - d(1+r_H))}}_{\text{denote by } M_{LH}} + \\ &\quad \frac{(1+s)}{1+r_H} \left( \frac{(C_L - dr_0)(1+s)\bar{X}\lambda\bar{x} - d(1+r_H)\lambda\bar{x} - \lambda(1+s)\bar{x}(C_L - dr_0)\bar{X}}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_H)} \right) \\ &\quad + \frac{(1+s)}{1+r_H} \left( \frac{(1+r_H)\bar{X}}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_H)} \right) \end{aligned}$$

$$\frac{d_1^{LH}}{B_1^{LH}} = M_{LH} + \frac{(\bar{X} - d\lambda\bar{x})(1+s)}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_H)}$$

where

$$M_{LH} = \frac{\lambda(C_L - dr_0)(1+s)\bar{x} - d(1+r_H)}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_H)}$$

and:

$$\frac{d_1^{LL}}{B_1^{LL}} = M_{LL} + \frac{(\bar{X} - d\lambda\bar{x})(1+s)}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_L)}$$

where

$$M_{LL} = \frac{\lambda(C_L - dr_0)(1+s)\bar{x} - d(1+r_L)}{(C_L - dr_0)(1+s)\bar{X} - d(1+r_L)}$$

Then, we have

$$\begin{aligned}
& \frac{d_1^{LH}}{B_1^{LH}} - \frac{d_1^{LL}}{B_1^{LL}} \\
= & \frac{\lambda (C_L - dr_0) (1 + s) \bar{x} - d(1 + r_H) + (\bar{X} - d\lambda\bar{x}) (1 + s)}{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_H)} \\
& - \frac{\lambda (C_L - dr_0) (1 + s) \bar{x} - d(1 + r_L) + (\bar{X} - d\lambda\bar{x}) (1 + s)}{(C_L - dr_0) (1 + s) \bar{X} - d(1 + r_L)} \\
= & \frac{[\lambda (C_L - dr_0) (1 + s) \bar{x} + (\bar{X} - d\lambda\bar{x}) (1 + s)] d (r_H - r_L)}{((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_H)) ((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_L))} \\
& - \frac{d (C_L - dr_0) (1 + s) \bar{X} (r_H - r_L)}{((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_H)) ((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_L))} \\
= & \frac{\{ (\bar{X} - d\lambda\bar{x}) - (\bar{X} - \lambda\bar{x}) (C_L - dr_0) \} d (r_H - r_L) (1 + s)}{((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_H)) ((C_L - dr_0) (1 + s) \bar{X} - d(1 + r_L))}
\end{aligned}$$



## 2. Selection of empirical papers and their findings

Year	Authors	Brief description	Type(s) of Exposure Hedged	Findings
1977	Martin and Keown	Test whether monthly stock returns of public utilities and financial institutions display interest rate sensitivity in a market model setup.	Interest rate	Stock returns of such firms support an additional factor.
1993	Nance, Smith and Smithson	Study 169 responses from surveyed Fortune 500 firms on the use of off-balance sheet hedging instruments in 1986	Any	Find support for economies of scale, tax convexity, growth options, costs of financial distress as predictors of hedging activity
1996	Mian	Studies the financial year 1992 reports of 3022 firms, with 543 disclosing derivative use for hedging purposes.	Any	Larger firms more likely to hedge with derivatives, no support for financial distress motives, and only weak or mixed evidence for other theories of risk management.
1996	Tufano	Studies 50 gold mining firms with a view to examining overall hedging activity.	Commodity (own gold output)	Incentives of managers and shorter tenure of CFOs are significant in determining hedging activity, but contradictory evidence on agency costs.
1997	Geczy, Minton and Schrand	Currency derivative usage of 372 nonfinancial Fortune 500 firms in 1990.	Currency	Further support for economies of scale, but also find support for underinvestment costs theory a la Froot, Scharfstein and Stein (1993).
1998	Visvanathan	Studies swap usage of 410 nonfinancial S&P 500 firms to distinguish between asymmetric information and risk management theories.	Interest rate	Finds support for expectations of financial distress leading to use of fixed rate swaps to alter maturity structure of debt.
1998	Bodnar, Hayt and Marston	Extensive and detailed survey of firms' risk management policies	All market prices	Suggests a greater than previously assumed proportion of managers rely on their views of future market movements to enter into 'hedging' positions.
1998	Schrand and Unal	Study change in risk management profiles of recently converted thrift institutions.	Interest rate and credit	Find that an increase in interest rate risk management is a way to shift the exposures according to the capability of firms and take on more credit risk.
2000	Petersen and Thiagarajan	Case study/ comparison of two firms with different hedging strategies.	Commodity (own gold output)	Both firms manage risks, though one uses no derivatives - clear evidence of need for another proxy for hedging activity.

Year	Authors	Brief description	Type(s) of Exposure Hedged	Findings
2000	Haushalter	Hedging by 100 oil and gas producers from 1992 to 1994.	Commodity (own oil and gas output)	Apart from scale and financial leverage, another determinant of extensive derivative use is the availability of instruments with low basis risk (underlying with closely matched price movements with price of firm's output)
2002	Graham and Rogers	442 randomly sampled firms with ex-ante interest rate or currency risk in 1994.	Currency and/or interest rate	Tax convexity does not appear to influence hedging activity, but the ability to increase leverage and hence the value of the tax shield does. Also find support for managers' delta being related to hedging.
2002	Rogers	Notional value of derivatives holdings of 569 firms from 1994 10-K filings is modeled in a simultaneous equation with managers' incentives.	Currency and/or interest rate	Managers' risk-taking incentives are negatively related to derivatives usage - interpreted as support for derivatives being a good proxy for risk management.
2003	Guay and Kothari	Study the extent of derivatives usage by 234 large nonfinancial firms in 1997	Currency, interest rate, and commodity	The effect of a combined three standard-deviation shock in all underlyings for open derivatives positions is not likely to cause a major impact on the health of the firms.
2005	Faulkender	Studies 275 debt fundings of chemical industry firms between 1994 and 1999, of which 30 were swapped to alter their original exposure to determine the choice of exposure.	Interest rate	Finds that the choice of fixed and floating rate exposures is not sensitive to cash-flow betas on interest rates, but mostly explained by myopic reactions to the slope of the term structure.
2006	Judge	Annual reports of 412 UK nonfinancial firms combined with survey responses from 186 firms.	Currency and interest rate	Expected costs of financial distress are a major factor in risk management decisions for UK firms.
2007	Chava and Purnanandam	Mainly 313 firms that provide information on CEO and CFO compensation for fiscal year 1997.	Interest rate	Assuming floating rate debt is riskier, CFO's delta and vega are key to explaining the mix of fixed and floating rate debt in a firm.

<b>Year</b>	<b>Authors</b>	<b>Brief description</b>	<b>Type(s) of Exposure Hedged</b>	<b>Findings</b>
2007	Acharya, Almeida and Campello	Margin between cash retention and debt repayment	Any	Firms that are more likely to be financially constrained hold cash rather than retain debt capacity, and vice versa
2008	Purnanandam	Hedging activity of a large cross-section of firms from 1997.	Currency and commodity	Support for theoretical prediction that expected costs of financial distress and hedging activity are related through a U-shaped function, contradicting market-timing arguments.
2009	Christoffersen, Nain and Obreroi	Detailed netted out swap and debt exposures of 82 non-financial firms over 11 years	Interest rate	Firms with least theoretical exposure to interest rate are most active in varying exposure, suggesting timing attempts. Yet, there is no evidence of superior timing skills or long-term advantage from guessing correctly.
2010	Beatty, Chen and Zhang	2355 loan origination contracts, of which 262 contain mandatory derivative use and 697 use derivatives voluntarily	Interest rate	Firms that credibly commit to hedge floating rate risk by fixing rates enjoy reduced agency costs and lower cost of funds

## The Next Chapter

In the survey above, I highlighted that there is still a lack of clear consensus about empirical support for various risk management theories. I also demonstrated the unique nature of the risk management problem arising from variation in interest rates. To jointly address these questions, the first step must be to collect a better dataset that would help examine the practices and performance of firms over a reasonably long period. This is the objective of the next paper, in which we will clearly show how the usage of derivatives is a misleading proxy for risk management activity. We seek to distinguish hedging activity from speculation, with or without the use of derivatives, and explore its implications for non-financial firms exposed to interest rate risk from their debt.

# 3

## Interest Rate Shocks and Corporate Risk Management

Co-authored with  
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# 1 Introduction

The International Swaps and Derivatives Association (2008) reports that, globally, the notional amounts of total interest rate derivatives (including cross-currency swaps) outstanding increased from \$3.45 trillion in 1990 to \$63 trillion at the end of 2000 and then to \$464.7 trillion in the first half of 2008. Given the drastic increase in the use of derivatives, much of the theory in corporate risk management attempts to identify conditions under which corporate risk-management is value enhancing. Theory suggests that risk-management may enhance shareholder value in the presence of financial distress costs or agency costs, or when a firm faces convex tax schedules. Empirical research finds mixed and inconclusive evidence in support of existing theory.<sup>1</sup> A common explanation is that derivatives usage, which is the most common empirical proxy for hedging, does not necessarily capture hedging.

In the 1998 CIBC Wharton survey, about half the firms reported that they sometimes allowed their market views to affect the timing of their hedges and the size of their hedges.<sup>2</sup> Faulkender (2005) provides evidence that firms may use derivatives for speculating rather than hedging. He finds that the final interest rate exposures of newly issued debt securities are largely driven by the slope of the yield curve at the time of the debt issue.

Another reason why derivatives may not be a good empirical proxy for hedging is that firm need not rely on derivatives to reduce or increase interest rate exposure. Firms often manage interest rate exposure by issuing and retiring debt with a chosen exposure to interest rate movements.

Anecdotal evidence also suggests that some firms follow a policy of hedging exposure to interest rates while others use derivatives to reduce cost of capital by timing the yield curve. For example, Honeywell International explicitly acknowledges that it uses interest derivatives to reduce its cost of capital. Quoting from its 1998 financial statements – “(the) Company issues both fixed and variable rate debt and uses interest rate swaps to manage the Company’s exposure to interest rate movements and reduce borrowing costs.” In contrast, Genuine Parts Company claims to use interest derivatives primarily to reduce exposure to interest rates by converting floating rate

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<sup>1</sup>For risk-management theories, see Stulz (1984), Smith and Stulz (1985), Froot, Scharfstein and Stein (1993), DeMarzo and Duffie (1991, 1995), Breeden and Viswanathan (1998), Leland (1998) and Morellec and Smith (2007). For empirical findings, see Nance, Smith and Smithson (1993), Dolde (1995), Mian (1996), Tufano (1996), Geczy, Minton and Schrand (1997), Schrand and Unal (1998), Haushalter (2000), Graham and Rogers (2002), and Knopf, Nam and Thornton (2002). For evidence from a case study, see Brown (2001).

<sup>2</sup>See Bodnar, Hayt and Marston (1998)

exposure to fixed rates.<sup>3</sup>

Due to scarcity of detailed derivatives usage data, we understand relatively little about why some firms hedge interest rate risk while other firms speculate with derivatives to reduce their cost of capital. We understand even less about firms' ability at market timing.<sup>4</sup> In this paper, we use hand-collected data on interest rate derivatives and debt exposures and attempt to improve our understanding of these issues.

We identify firms that are more likely to be speculators and distinguish them from those that are less active in interest rate management. We then ask a number of questions that have remained unanswered in the corporate risk-management literature. First, do firms actively adjust interest rate exposures to take advantage of changes in interest rates? Second, how often do firms correctly anticipate changes in the interest rates? Third, can one predict which firms are likely to be good at correctly anticipating shocks to interest rates, or are correct and incorrect decisions random? Finally, if firms do correctly anticipate the shock to interest rates (even if by accident) what advantages if any does this give them relative to firms that took incorrect positions prior to an interest rate shock?

To address these questions, we use data on interest rate exposure of debt for a randomly selected sample of 100 S&P 500 firms from the years 1990 to 2000. The interest rate exposure is measured after taking into account the effect of derivatives usage. For each firm, we aggregate the exposures generated by all the interest rate derivatives instruments outstanding in a given year to determine whether the net effect of the instruments is to convert fixed rate to floating rate or vice-versa. We then adjust the proportion of fixed rate debt to total debt for the net effect of the swap positions. Thus, for each firm we calculate the proportion of fixed rate debt to total debt net of swap positions for each of the 11 years. The variation in this proportion of net fixed rate debt is used to determine whether a firm is an active interest rate manager or not. Our premise is that firms attempting to pre-empt changes in interest rates in order to reduce the cost of capital will change their fixed-to-floating exposure more often than firms that wish to minimize exchange rate exposure. Therefore, for each firm, we calculate the standard deviation of the proportion of net fixed debt over the 11 years in the sample. Firms whose standard deviation of net fixed rate debt (as a proportion of total debt) exceeds the median standard deviation for the cross-section are considered to be *Active* managers of interest rate exposures. After dropping some

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<sup>3</sup>See page 4 of Exhibit 13 of the year 2000 financial report

<sup>4</sup>Although Faulkender (2005) finds evidence that firms attempt to time the yield curve, the focus of that paper is not to evaluate how well the firms do in predicting changes in interest rate policy.

firms for the sample for reasons discussed in detail in Section 4, we have a final sample of 41 *Active* and 41 *Less Active* firms.

The notion of activity as an indicator of cost-minimizing behavior as opposed to risk management behavior is central to our analysis. Chava and Purnanandam (2005) analyze the choice of fixed or floating rate debt for a cross-section of firms, and find that the vega of CFOs' compensation schemes is positively related to the proportion of floating rate debt. This is interpreted as consistent with risk-taking by CFOs who have incentives to increase risk. However, it is not clear that floating rate debt is riskier than fixed rate debt for all firms at all times. Guedes and Thompson (1995) present a case for firms signaling their quality by choosing to take on the riskier debt contract based on the relation between variability of expected inflation and expected real rates. However, this does not take into account the supply side dynamic in terms of banks' exposures to interest rates during the period of their sample. Although we do not have a benchmark for the optimal mix of fixed and floating rate debt for a firm, it is difficult to perceive a high degree of variation over time in this ratio to prompt annual changes to the mix. As we are able to look at the firms' choices over a period of time, we expect firms that vary their interest rate mix significantly to be more likely to be attempting to time the market rather than maintain a safe ratio of fixed and floating rate debt. Accordingly, our tests begin by attempting to analyse this distinction in level of activity among firms.

First, we examine whether Active firms are different from the other firms. According to existing theory, financial distress and agency costs create incentives for firms to hedge. Thus, theory predicts that firms in the less active group (who are not as likely to be speculating) face higher financial distress costs or agency costs. We use leverage and quick ratio as proxies for financial distress and market-to-book and research and development (R&D) expense as proxies for agency costs and find that Active firms are not only smaller, but also have higher market-to-book ratios than less active firms. Thus, even though we distinguish between hedgers and possible speculators, the finding on market-to-book ratios appears to be contradictory to existing risk-management theory. We do find, however, that operating cash flows of firms in the Active category are significantly less sensitive to changes in interest rates than firms in the less active category. Faulkender (2005) uses the sensitivity of cash-flows to interest rates of firms as an indicator of their incentive to hedge. Our finding thus suggests that firms (as a group) whose underlying business is more exposed to interest rates are not active in varying their debt exposures as much, which could be considered consistent with hedging behavior. In contrast, firms that face low ex-ante exposure to interest rates



appear more likely to take on the added risk of speculating by actively varying their mix of fixed and floating rate debt.

Next we examine whether firms correctly anticipated the interest rate shocks. For example, in 1990 when rates were high but falling, Avery Dennison, a manufacturer of pressure sensitive materials, was holding swaps that had fixed rates on \$100 million of debt. The firm continued to hold floating to fixed rate swaps throughout 1991 despite the steady decline in interest rates. However, in 1992 and 1993, when interest rates seem to have bottomed out, the firm reversed its position by taking on \$150 million worth of fixed to floating rate swaps, while replacing maturing debt with fixed rate debt. Unfortunately for the firm, interest increased sharply through 1994 and the firm found itself on the wrong end of the interest rate shock yet again relative to not having reversed the swaps. In 1995, Avery Dennison wound up its swaps positions and did not use swaps again in our sample period.<sup>5</sup> However, it continued to remain active in varying the proportion of fixed rate debt it carried. Despite large variations in the proportion of its fixed rate debt that speak of attempts to time the market, over four monetary policy shocks identified below in this paper, its exposure moved in the correct direction two times, giving it a 50% success rate. Examples of this type motivate us to examine whether firms, in general, are able to anticipate interest rate movements.

We identify four episodes during the 1990s when interest rates underwent a significant change and examine changes in firms' net interest rate mix as of the fiscal year-end preceding the interest rate shock. We divide firms into two groups depending on how often the change in position made prior to an interest rate shock was profitable ex-post. We find that the sample is evenly split between firms that made mostly correct choices and firms that mostly made wrong choices. By mostly correct, we mean that the changes to exposure in the year prior to the shock was profitable ex-post 3 or 4 times out of 4. Those that were correct only 0 or 1 times out of 4 are considered mostly wrong, and those that were write 2 out of 4 times are labelled half correct. Given the split we can conclude that, on average, firms in our sample are not skilled at predicting interest rate movements and taking advantage of interest rate changes. Yet, many regularly and significantly alter their mix of fixed and floating rate debt.

Given our results that do not support existing risk management motives, and do not reflect (on average) any market timing skills, one possible explanation for the high level of activity in altering the mix of exposures is that some firms are better at

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<sup>5</sup>See Appendix 1 for an example of the description of swap positions by Avery Dennison.

timing than others. We should then be able to see some differences (for example in valuation) between the firms separated as being Mostly Correct and Half Correct or Mostly Wrong. This classification is based on their decisions before the four shocks discussed in Section 2, allowing us to compare the firms' average characteristics over an eleven-year horizon. We find no significant evidence of differences between the two groups of firms. However, we also look at the firms in the year immediately following each shock. This time, we classify the firms as being Right only based on their decision in that particular instance, implying the same firm could be classified as being Right in one year and Wrong in another. Given that the implications in terms of saved interest costs are obvious, and that guessing correctly consistently doesn't appear to offer any long-term advantage, we want to test whether there is any real advantage to those who guess correctly. We find that, in the year following a shock, the Right firms had better performance than the others in terms of operational profitability as well. In order to investigate if any channel exists through which these two outcomes are related, we break down the operational performance into revenue improvement and cost reduction. We find that it is the cost dimension that is the source of better profitability changes for the correct firms. These results are consistent with a scenario where firms seek to time the market, but also make consistent decisions on other aspects of the business such as inventory management or labour cost. Should they have guessed right, they will report better performance on multiple fronts.

The rest of the paper consists of a discussion of the importance of the 1990s as a sample period (in Sections 2 and 3), a description of the data (in Section 4) followed by analysis and results (in Section 5). Section 6 concludes.

## **2 The Monetary Policy Environment and Interest Rate Shocks in the 1990s**

In this section, we briefly describe the monetary policy environment in the 1990s and identify four different interest rate shocks that will facilitate our analysis of corporate interest rate risk management below.

Most corporate debt contracts are based on the LIBOR (London Inter-Bank Offer Rate). Before entering into a description of the monetary policy environment it is, therefore, important to first check if monetary policy shocks had a sufficiently direct bearing on the value of corporate swap contracts through commensurate changes in LIBOR. To this end we plot the intended Fed Funds rates along with the LIBOR

rate in Figure 1. They can be seen to move quite closely together during the sample period. The sample correlation between LIBOR and the intended Fed Funds rate is 0.99 during the period shown in Figure 1.

The 1990s was an eventful and interesting decade in terms of interest rate movements and policies: There were at least four distinct and sustained, credit tightening or easing periods. We identify the following four interest rate shocks.

## **2.1 Interest Rate Shock 1: The 1992 Continued Easing**

Our sample period begins in 1990, when the Fed Funds Target Rate started to gradually come off its peak in 1989, and was just over 8%. Midway through the year, as the recession began in conjunction with the first Gulf War, the Fed lowered the interest rate slightly (see Figure 2). It stepped up the pace of decreases only halfway through the recession and continued well into the second half of 1992, ending up with a near zero real interest rate in early 1993. The recession ended in March 1991 according to the NBER, but the unemployment rate actually rose sharply in the period after the recession, arguably because the Fed had initially been slow to respond. The reason for the Fed's initial hesitation in aggressively easing credit had been the presence of inflationary pressures in part due to factors related with the war. This suggests that, under Alan Greenspan, the Fed's priority was to contain inflation while not hesitating to offer stimulus in the face of unemployment as long as inflation was in check.

## **2.2 Interest Rate Shock 2: The 1994 Tightening**

The next major move in our interest rate sample came on February 4 1994, after almost eighteen months at a very low rate. This move was in anticipation of increased inflationary expectations, and the FOMC decided to explain its pre-emptive action to the public immediately after its meeting for the first time. On May 17 1994, when the discount rate (not the Fed Funds Target) was increased by 50 bps, an explanatory statement was also issued. Even more information was available in the statement of August 16 1994, when for the first time the exact magnitude of increase in the Fed Funds Target of 50 bps was stated by implication. The following increase of 75 bps on November 15 1994 was similarly announced. By July 6 1995, when the FOMC eased its policy for the first time after sustained increases, the statement explicitly referred to both the current and the new target rates.

## 2.3 Interest Rate Shock 3: The 1999 Tightening

The next economic shock came in 1998 in the form of the Russian debt crisis and its ensuing effects on LTCM and US markets in general. While decreasing rates, the Fed was careful to emphasize its fundamental commitment to low inflation and this was repeated for future decreases as well. The decrease of September 29, 1998 would have been very difficult to anticipate due to the Fed's tendency to smooth interest rates and its "policy inertia" (Piazzesi 2005) implying further gradual increases at first.<sup>6</sup> However, the series of reductions that followed due to this 'external shock' were abruptly reversed on June 30 1999. We consider this the third significant period in our sample, when rates increased by 175 b.p. over nine months. The first 7 of the 8 scheduled meetings in 2000 were followed by statements reflecting inflationary risks, though rates were increased only three times (in February, March and May).

Rasche and Thornton (2002) test whether the market was surprised by the announcements.<sup>7</sup> They find that the market was not surprised when the Fed left interest rates untouched. Further, when the FOMC reversed their view completely towards dangers of "economic weakness" on December 19 2000, the futures market had already anticipated this in mid-December. The Fed went on to decrease the rate by 50 bp on January 3 2001, well before the scheduled meeting.

## 2.4 Interest Rate Shock 4: The 2001 Easing

The abrupt change in 2001, where the Fed began to aggressively decrease interest rates following a sudden and absolute reversal in its outlook is our fourth "shock". This time, with inflation appearing to be under control, the Fed decided to take advantage of its flexibility to counter the slowdown (Greenspan, 2004). They moved even before the recession began, having reduced a full percentage point in less than two months. By the end of 2001, the rate was a full 500 bps lower.

Rasche and Thornton (2003) argue that the market is unable to anticipate far enough ahead (more than six months) what the interest rate will be. This is consistent with Swanson's (2006) argument that while the understanding of the Fed's policy reactions to economic news might have improved, the ability to forecast the underlying economic variables themselves (GDP, etc.) is still limited. Yet, the futures

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<sup>6</sup>Note that it is pointed out above that the FOMC statement in March 1997 appears to have attempted to reduce the probability of further increases by implication through carefully chosen language, possibly due to such an expectation.

<sup>7</sup>They use the Poole and Rasche (2003) measure of FOMC meeting surprises based on the Fed funds futures market, whereby a significant post-announcement jump ( $>5$  b.p.) implies a surprise.

market does anticipate FOMC moves on occasion. Though the evidence suggests that improvements in their forecasts are mainly due to increased FOMC transparency, it is difficult to ascertain whether certain types of firms are more sensitive to the information about the real economy that they gather in the course of doing business. Clearly, this additional information might help them condition publicly available information to their advantage.

Figure 2 displays the history of the intended Fed Funds rate over the period 1990-2001 as in Figure 1, but it now has the two NBER recessions shaded as well as our four interest rate shocks circled.

Interest rates steadily and steeply declined starting in 1990 until the middle of 1992, and then stayed low for over one year before the FOMC made its first public announcement in 1994 indicating a tightening bias. Following this, rates steadily rose for a year, then adjusted slightly and made another significant move upwards at the end of 1999, only to sharply reverse direction after 2000. As discussed above we will focus on the years ending in December of 1991, 1993, 1998 and 2000 respectively. For the year following these dates, it would have been profitable to have had an increased floating rate exposure in 1992 and 2001 and an increased fixed rate exposure in 1994 and 1999. This is true when we are considering the exposure on debt, and the reverse would be true for exposure to swaps that have investments as their underlying (and for which we adjust).<sup>8</sup>

Figure 3 provides an alternative justification of the choice of shocks. The markers on the graph represent the 6-9 month old forecasts in light grey and the 9-12 month old forecasts in black. The forecasts are matched in time with the quarter for which the forecasts were intended. We do not have forecast data prior to 1993. Nevertheless, it is interesting to note that the forecasts seem to consistently lag the realizations during the three interest rate shocks for which we have forecasts, namely the 1994 and the 1999 tightening as well as the 2001 easing.

### 3 The Regulatory Framework for Reporting on Derivatives Use

In this section we give a brief overview of the reporting requirements regarding derivatives use in the 1990s.

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<sup>8</sup>Please note that we refer to swaps rather than interest rate instruments although we do account for forwards/futures and caps or floors where the implications are clear – this is because swaps are by far the predominant instrument used by the firms for interest rate management.

In December 1989, the Federal Accounting Standards Board (FASB) issued the Statement of Financial Accounting Standards No. 104 (FAS104) that amended FAS95 (November 1987) to allow for hedge based accounting classification as long as the accounting policy was disclosed. Hedge-based accounting classification refers to the practice of assigning derivatives based cash flows to the same category as an identifiable underlying. Under the original FAS95, such transactions were required to be classified according to the nature of the cash flows, and not under the headings of the items being hedged. The Statement was made effective for financial years ending after June 15, 1990.

FAS95 was followed by FAS105 in March 1990 which was entitled: Disclosure of Information about Financial Instruments with Off-Balance-Sheet Risk and Financial Instruments with Concentrations of Credit Risks. FAS105 was introduced as a first step toward a general system of reporting financial instruments whose usage and variety was steadily increasing. It required fuller disclosure by corporations about their off-balance sheet financial transactions that included the notional principal accompanied by information/discussions about the applicable market and credit risk.<sup>9</sup> FAS105 was also applicable for financial years ending after June 15, 1990 and has since been superseded by a series of other statements beginning with FAS107 (Disclosures about Fair Value of Financial Instruments) that was issued in December 1991. FAS107 mainly had the impact of extending and generalising the applicability of FAS105 and it was applicable for financial years ending after December 15, 1992.<sup>10</sup>

In October 1994, the FASB issued FAS119: Disclosure about Derivative Financial Instruments and Fair Value of Financial Instruments, which would be effective for financial statements ending December 15, 1994 (see footnote 11). This statement extended the applicability of disclosure requirements to instruments that did not have market risk, required identification of instruments held for trading purposes, and specified further classification of instruments, while “encouraging” but not requiring increased quantitative disclosures. Thus, during the period beginning in 1990, companies disclosed relatively more information about their actual derivatives positions in the footnotes to their annual financial statements.

The propensity to provide quantitative and transparent information about the ac-

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<sup>9</sup> “...applies to all financial instruments with off-balance-sheet risk of accounting loss and all financial instruments with concentrations of credit risk. . .” with some exceptions that are not relevant to this current paper (FAS105, 1990). Note that, in the “nature and terms”, companies were not absolutely required to disclose the specific positions if they included a discussion on the credit and market risk and the cash requirements, along with accounting policies.

<sup>10</sup>For entities with assets below \$150 million, the date was December 15, 1995.

tual positions in swaps was reduced after 1999, when FAS133 (Accounting for Derivative Instruments and Hedging Activities) was initially set to come into effect. FAS133 was deferred by a year to 2000 under FAS137. FAS133 and subsequent statements laid down rules for an accounting treatment of derivatives that incorporated them into the balance sheet (and earnings statements). They also removed the emphasis on provision of specific position information in the footnotes as long as risk management methods and accounting policies were clearly enunciated. Thus, the period offering distinct information on the companies' derivative transactions ended around 2000.

## 4 Data on Derivative Use and Debt Exposures from Corporate Filings

Having surveyed the interest rate environment and the disclosure requirements on derivatives use in the 1990s we are now ready to describe our derivative data collection methodology.

In order to construct our sample, we randomly picked a company from the S&P 500 index, and checked to see if there was a history of annual financial statements available for it in the 1990s through a combination of Mergent Online which provides EDGAR SEC filings data typically starting with the fiscal year 1994, as well as Lexis-Nexis for the earlier years. If not, then we randomly drew another company. In this manner, we collected data on 100 companies for the financial years 1990 through 2000. As discussed above, the choice of this period is dictated by the creation of a window in time when corporate disclosures on derivative usage were more informative.

### 4.1 Derivative Position Data

The data we collected includes the types of derivatives used by the company in a given year, with detailed information on interest rate derivatives. We searched the financial footnotes through the use of multiple search terms in addition to looking for certain sections of the footnotes manually to ensure detailed and accurate data.<sup>11</sup> Our initial experience showed that searching for standard terms such as “swap”, “cap”, “futures”, “forward”, “floor”, “collar”, and “hedg” was not sufficient as companies often use terms such as “interest rate protection agreement” and “interest rate exchange agreement”. In order to ensure completeness, we read the sections that referred to fair

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<sup>11</sup>The practical arrangements for collecting the data are described further in Appendix 2.

value disclosures, risk management, off-balance sheet instruments, and debt. When companies mention the hedging of investments as one of their reasons for using interest rate derivatives, we also read the section on investments.

We classified interest rate instruments as either changing the firm’s exposure from floating rates to fixed rates or vice versa. By floating to fixed, we imply an instrument that changes the interest rate exposure from a US Dollar denominated (and thus US monetary-policy sensitive) floating rate such as USD LIBOR to a fixed US dollar rate, directly or indirectly. The exposure is always seen from the point of view of a liability, so that an increase in interest rates is a negative development for a firm with floating rate exposure and a positive development if you have fixed rates instead. Similarly, a reduction in interest rates is good if you have floating rates and bad if you have fixed rates.<sup>12</sup> We ignored the use of cross-currency swaps when they were being used to hedge foreign exchange exposure unless they were clearly shown to have an effect that would fit them into one of our two main categories, viz. floating to fixed and fixed to floating.

The level and clarity of the disclosures vary significantly across companies. Some companies report individual contracts, since swaps are usually on large sums and are not very frequent. Other companies only provide aggregate level information on the notional and fair values and the direction of the swaps (fixed to floating or vice versa). This latter format is sufficient for our purposes as long as the underlying item(s), whose exposure is being “hedged,” are delineated. We merely need it to be clear that underlying items are either liabilities or assets, and not a combination of both.

Effectively, the data gives us a snapshot at the end of each year as to whether companies were taking on more fixed rate or floating rate exposure on their debt through derivatives. After collecting detailed information about all the instruments in the disclosures, we aggregated the exposures generated by derivatives into floating to fixed or fixed to floating. Where the disclosures were not sufficiently clear or we were not confident that we were obtaining a clear picture of the companies’ positions, we dropped those companies from our sample. As a result, we have a final sample containing 82 firms over the eleven-year period. Some had to be dropped because they had no significant debt over the period.

Table 1 and Figure 4 summarize the derivative usage statistics of firms in the sample by year. The first three columns in Table 1 refer to companies’ disclosure

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<sup>12</sup>When rates fall, the fair value of fixed rate debt increases while that of a swap converting floating to fixed rates falls.



about using any type of derivative. The number of companies making an informative disclosure is provided, followed by the number (and percentage) of firms among those disclosing that actually used a derivative instrument in the given year. The next three columns repeat this exercise for firms that use any interest rate derivatives, reporting the number of firms and their proportion among all disclosing firms and those that use derivatives. On average, around 80% of firms in our sample were using derivatives in a particular year and around 70% of derivative users were using interest rate derivatives. The final three columns in Table 1 present the number of firms using swaps, and show that almost all interest rate derivative users in a given year were using swaps. Figure 4 presents the same information graphically. Visually, there appears to be a pattern in usage of interest rate derivatives over the period that is not as pronounced for all derivatives and that might be linked to the interest rate movements.

It is important to note that the actual makeup of derivative users varies from year to year, implying that a larger proportion of companies used derivatives at some point over the eleven-year period. Also, several companies stated that they used derivatives while at the same time stating that they had no open positions for more than two successive annual statements. Further, Faulkender (2005) presents evidence that firms are minimizing their short term interest costs when they decide on the kind of exposure for newly issued debt. Similarly, several firms state in their footnotes that they explicitly wish to reduce the cost of debt. This approach would imply that swaps are taken on for short periods and reversed regularly.<sup>13</sup> Yet, the initial duration of typical swap contracts in our sample tends to be in line with the long-term debt, which is longer even than the tightening and loosening cycles for monetary policy. In addition, there is no consistent pattern among firms whereby they would all be changing their exposure regularly in a particular direction. In the cases where the firms change the direction regularly, we have again no evidence of a directional pattern as the firms are quite evenly divided in terms of the positions they take. Thus, we need to study how well firms anticipate the changes in the regimes, how they react to the changes, and what they do during periods of flat rates when there may be more uncertainty. These observations point to the potential usefulness of a sample that covers a longer period of time and also of checking for actual exposures as opposed to standard statements in the annual reports indicating the possibility of taking up derivative contracts.<sup>14</sup>

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<sup>13</sup>If this were not true, merely the minimizing of short-term costs would not be consistent with rational behavior and we would need other reasons for the managers to severely sacrifice the future for very short-term gains.

<sup>14</sup>Some of the corporate statements are taken verbatim from FASB guidelines such as FAS 105,

## 4.2 Debt Data

Although we set out originally to analyze the derivatives activity of the firms around shock dates, we found that in the area of debt, there was enough flexibility available to firms to alter their interest rate cycle exposures without requiring them to enter into any derivative contracts. As a result, we focused on the final exposure of the firm by taking the proportion of fixed rate debt of the firm and adjusting it by the net effect of swaps. The debt data was manually collected in the same way as the derivatives data.

## 4.3 Interest Rate Data

While the position data helps us look at what types of firms actively manage interest rate exposure, we need interest rate data to use this information in the context of their interaction with monetary policy. Specifically, we need to identify points when interest rates underwent a significant change or the direction of monetary policy was shifted from one of tightening to one of loosening credit or vice versa. To this end we use the four interest rate shocks defined in Section 2. We then use these periods to evaluate the performance of firms' interest rate management and also the impact of monetary policy shocks on firms' subsequent performance.

## 4.4 Firm Characteristics

Based on existing theories on why firms hedge, we collect data from Compustat on market value, sales, leverage, liquidity, research and development, and profitability measures including cash flow margins and return on assets. The data are collected for the years 1989 through 2001 and are summarized in Table 2, with the pair-wise correlations in Table 3. Market value (mv) is calculated as the product of common shares outstanding in millions (csho) and share price at the close of the fiscal year (prcc\_f) in the industrial annual Compustat file. Similarly, we have sales (sale) and total assets (at), leverage is total liabilities (long term debt – dltd, plus debt in current liabilities - dlc) divided by total assets, while research and development expenditure (xrd) is normalized by sales. For liquidity, we define the variable quick ratio as cash plus short term investments (che) divided by current liabilities (lct). Cash flow margins are calculated as operating income before depreciation (oibdp) divided by sales, and return on assets as income before extraordinary items (ib) divided by total assets.

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paragraph 45.

Market-to-book ratios are calculated as (Total assets minus common equity – ceq, plus market value) divided by total assets. Finally, we also have the ratios Cost of goods sold (cogs) and Sales, General and Administrative Expense (xsga) both normalized by sales.

Thus, our three main sources of data are the financial statement footnotes for derivative and debt position disclosures, the Federal Reserve for interest rates, and Compustat for balance sheet and income statement variables. In the next section, we report the analyses conducted.

## 5 Analysis and Results

In this section, we attempt to classify firms as active interest rate managers versus less active managers and examine whether there are any observable differences between the two types of firms. We also examine how good firms are at correctly anticipating interest rate shocks. Finally, we test whether correctly anticipating interest rate shocks confers a competitive advantage to a firm.

### 5.1 Interest Rate Management and Firm Characteristics

We begin by classifying firms into two sets of categories depending on the variability of the interest rate exposure choices of the firm, and on how well the firms did at anticipating the four interest rate shocks identified above. We first calculate the proportion of fixed rate debt to total debt for all firms for all years. We then calculate for each firm the standard deviation of this ratio and sort the companies according to this ratio. Those companies whose standard deviation of the proportion of fixed rate debt exceeds the median standard deviation are classified as Active, and the others are then Less Active. By splitting the sample this way in half, we allow the data to dictate the criterion as there is no guidance on what would be considered as more active interest rate management. We also considered the range of the proportion of fixed rate debt over the eleven-year sample as a classification criterion. The overlap in categories based on the two criteria is 93%, so we elected to use standard deviations as the classification criterion. In an alternate dimension, we break down the firms into Mostly Correct and Half Correct or Mostly Wrong. In order to split them so, we count the number of times the firms changed the proportion of fixed rate exposures in the profitable direction before the four shocks. Those that had a proportion of profitable positions at more than 50% were classified as Mostly Correct. Similarly, Half Correct

and Mostly Wrong had a success rate of 50% or less. Table 4 lists the categories and the averages (over the entire period) of their characteristics which include sales, market value, leverage, quick ratio, research and development expenditure, cash flow margins, return on assets, market to book ratios, cost of goods sold, and sales, general and administrative (S, G & A) expenses.

Of the 82 firms, equal numbers are classified as Active and Less Active by design, while 25 firms fall under the Mostly Correct category. Of the 25 Mostly Correct firms, 13 are also Active, while 28 of the 57 Half Correct or Mostly Wrong are classified as Active. This suggests that Active firms were just as likely to be wrong or right in adjusting their interest rate exposures in anticipation of the four shocks. This point is also clear from the lack of correlation between the two measures in Table 3.

In the last two columns of Table 4, we report the differences in the average firm characteristics between the two selected pairs of categories, viz. Active vs. Less Active, and Mostly Correct vs. Half Correct or Mostly Wrong. We find that Active firms are smaller, have lower leverage and higher market-to-book ratios than Less Active firms. There is no highly significant difference between Mostly Correct firms and their counterparts except that their asset turnover appears to be higher, and in a related sense, both S, G & A and R & D expense ratios appear to be lower.

The results of the basic univariate comparisons seem to indicate that the average characteristics of firms are quite similar in the various categories, except that firms with higher growth potential (smaller with higher market to book ratios) are more active in managing interest rate exposure. In results not reported here, when we look purely at interest rate derivative usage, we find that larger firms, those with higher leverage and higher market to book ratios tend to be higher users of interest rate derivatives. This observation offers a cautionary point on the interpretation of derivatives usage as a proxy for hedging in the case of interest rate risk. At the least, our evidence on growth opportunities seems to be contrary to what we would expect from hedging arguments. This is not surprising given that 35% of firms explicitly listed cost reduction as a motive for interest rate management in their financial statements.

Next, to consider the firm characteristics in a multivariate setting, we run cross-sectional probit regressions. To avoid losing observations, we follow a common practice by assigning a value of 0 where no research and development expenditure is provided by the firms (according to the Compustat database).

In Table 5, we present two probit regressions. In the first, the dependent variable is 1 if the firm is classified as Active, and 0 otherwise. In the second, we set the dependent variable equal to 1 if the firm is Mostly Correct (and thus 0 if it is Half Correct or

Mostly Wrong). The regressors include all the firm characteristics (we drop market value and total assets in favour of sales as a “size” variable), and dummies breaking down the sample by the alternate classification criterion in each case. We use robust standard errors and report the p-values below the estimates. The estimates reported are not the raw estimates, but the marginal effects estimated at the mean of the variables. In the case of the dummy variables, the marginal effect is the change in the dependant variable for a discrete change from 0 to 1 of the regressor. Lower size and higher growth opportunities are associated with a higher probability of the firm being Active. There is some evidence that Active firms are slightly less likely to be Mostly Correct, or Mostly Correct are slightly less likely to be Active. This is an important point to consider if Active firms were indeed those that were trying to time the market.

The multivariate regressions also provide conflicting evidence for risk management theory. Active firms have higher market to book ratios than Less Active firms, but Mostly Correct firms do not. Firms are more likely to follow a less active approach to interest rate management when they have higher sales and lower market to book ratios, while those that have lower leverage are more likely to be active in adjusting interest rate exposures. Although higher leverage would be associated with higher interest rate risk, it would be consistent with both types of firms – those seeking to reduce interest costs, and those with less active and more consistent exposures that appear more like hedging than speculation. These findings could be seen as consistent with the notion that active interest rate management is less likely to be for hedging purposes.

## 5.2 Cash Flow Sensitivities

In addition to the indirect model-based variables used to test for hedging incentives above, there is also the direct question of whether firms’ cash flows are sensitive to interest rate changes. Faulkender (2005) uses sensitivity of cash flows to interest rates estimated from a quarterly regression on a firm-by-firm basis for this purpose. The cash flow measure he uses is operating income before depreciation normalized by book assets, while the interest rate is LIBOR. He uses data from five years preceding the date of debt issuance. Purnanandam (2008) suggests that a firm-by-firm regression presents a very noisy estimate of this sensitivity, and thus estimates a single sensitivity measure for all firms in a particular industry instead. In this paper, we are interested in knowing whether there is any difference between the Active and Less Active groups

in terms of their cash flows' sensitivity to interest rates. Thus, we adopt a slightly different approach by grouping all firms into a single panel regression, using data over all the quarters from January 1989 through December 2001. The dependant variable is cash flows/book assets as in earlier papers, regressed on its own lag, LIBOR, a dummy for the Active group, and its interaction with LIBOR to estimate the slope differences.<sup>15</sup> To account for firm-specific characteristics in a simple way, we also use a fixed-effects specification for the regression. The regression results are presented in Table 6 for the following two specifications (fixed effects and random effects).

$$CF_{it} = \beta_{0,i} + \beta_1 CF_{i,t-1} + \beta_2 LIBOR_t + \beta_3 Active_i * LIBOR_t + u_{it}$$

Since the mean cash flow dummy would lead to collinearity in the fixed effects regression, this specification provides us with estimates only of the difference between the sensitivities of the cash flows of the Active group with that of the Less Active group. Thus, we also run a random effects regression specified as

$$CF_{it} = \beta_0 + \beta_1 CF_{i,t-1} + \beta_2 LIBOR_t + \beta_3 Active_i + \beta_4 Active_i * LIBOR_t + \alpha_i + u_{it}$$

which we estimate by the Feasible Generalized Least Squares method. In both cases, we estimate robust standard errors, and we find that the Less Active firms have lower cash flows and higher sensitivity of cash flows to interest rates than Active firms. If cash flow sensitivity is a predictor of hedging activity, as theory would guide us to conclude, we should find the opposite result. Alternatively, if a high level of activity is associated with hedging and not speculation, then we should find the opposite result. This can only lead us to question the idea that firms that are actively changing their exposures are doing so out of a hedging motive. Given the finding from Table 5 that Active firms are not really likely to be Mostly Correct, this raises serious questions about the motives for such high levels of variation in interest rate exposures.

### 5.3 Policy Shock Analysis

We now consider the impact on firms of having adjusted their exposure in the correct direction in the years preceding the shocks, at the end of 1991, 1993, 1998, and 2000. We classify such a firm-year as being Right, and therefore, the others as being Wrong.

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<sup>15</sup>We also use cash flows/sales for robustness, and find that the main finding about differences between groups holds for this alternative specification.

In December 1991, the rates had been falling continuously and at a steep rate for two years, and had come down from 8.25% to 4% already. However, the FOMC policy stance was not publicly known and the rates continued to fall for a further year before bottoming out. At the end of 1993, in fact in February 1994, the Federal Reserve announced their intention to target a higher interest rate for the first time, and this was followed by a sustained increase of approximately 3 percentage points over the course of 1994. In contrast to such large changes, the rate increase in 1999 was less than a percentage point, and the rate kept increasing to 6.5%, when at the end of 2000, there was a sudden and sharp reversal downward. If companies are able to anticipate policy, they may not be able to adjust their debt exposures directly, but they can adjust their swap exposures to reduce their cost of debt. In Table 7A, we report a shock-wise breakdown of the percentage of firms that had adjusted their total interest rate exposure on debt in a profitable direction before the shock arrived. In Table 7B we break down the number of times that Active (or Less Active) firms were also Right (or Wrong). Active firms were more often Right, and Less Active firms were more often Wrong, but the difference is small.

The earlier part of the analysis was whether there were any characteristics recognized in the standard theory that would help predict which types of firms are more or less successful at anticipating changes in interest rate policy. The question we ask in this analysis is whether anticipating these changes makes any real difference to the performance of firms. In order to look at this, we compare the percentage change in size and changes in leverage, along with the same proxies for liquidity and profitability as before, and looking slightly ahead of ourselves, the changes in cost ratios.

In Table 8 we group together the observations from 1991-92, 1993-94, 1998-99, and 2000-01 and then classify the firm-years based on whether they were Right or Wrong on the relevant date. Unadjusted, the size of the total group of firms on average increased in these four shock years, and the size of the two groups separately also increased with a higher percentage for those that were Right. However, when we consider the differences between the groups, we find limited significance, mainly that the Right group benefited from an increase in profitability and a decrease in the S, G & A expense ratio as compared to the Wrong group. From this part of the analysis, it appears that companies that had wrong exposures fared worse than others in terms of their profitability ratios, but there was not other major significant change. Noting that the cash flow margin outcome does not directly lead from the financial benefit of having anticipated interest rate changes, we focus on cash flow margins in a multivariate setting below.

The initial finding of a post-shock impact on profitability of the firms with the Right firms doing better than the Wrong ones is puzzling because it is not a mechanical effect. In order to understand what conferred this advantage, we hypothesized that the firms that anticipate the direction of interest rate changes might also be taking other actions that are consistent with their expectations, leading to savings or other improved operating performance. This is why we also include cost ratios to consider whether some business decisions made the firms more efficient relative to their Wrong peers. The fact that the difference between groups in the change in the S, G & A expense ratio is significantly negative suggests some support for this hypothesis. In a multivariate setting, when we regress the change in cash flow margin on lagged characteristics and dummies for Active, Mostly Correct or Right, only the dummy for Right is significant with a coefficient equal to one percentage point (not presented here). We cannot, however, directly regress the change in cash flow margins on change in cost of goods sold ratio and change in S, G & A expense ratio. Although the S, G & A expense ratio has very low correlation with cash flow margin (see Table 3), putting all three together in this form would lead to collinearity by definition. Thus, in order to understand the source of operating advantage to the Right firms, we regress only interactions of these two terms with the Right dummy on cash flow margins. In Table 9, we report how this leads to an insignificant estimate for the Right dummy itself, thus offering further support to our hypothesis that managers that correctly adjusted their exposures also took other decisions consistent with their beliefs that would lead to improvements in operating profits relative to those who were Wrong.

## 6 Summary and Conclusions

In the paper, we have controlled for a wide range of firm specific variables and found that size, leverage, and existing derivatives programs (e.g. use of currency derivatives) are positively related to a firm's decision to use interest rate derivatives. This finding is consistent with existing literature. However, when we take into account the overall interest rate exposure of the firm (exposure from debt netted by exposure from swaps), we find that firms that display a higher variability in their interest rate exposures are not necessarily derivative users. In fact, in mixed support of risk management theory, we find that the more active firms are likely to be smaller and less leveraged than their less active counterparts, and are also likely to have higher growth prospects (as proxied by market to book ratios). This finding is in line with previous literature that suggests that the use of derivatives is not necessarily a sign of hedging behavior



and that firms manage interest rate exposures for reasons other than to manage risk (Faulkender 2005). Further, we find that those firms that were more often successful in their anticipation of interest rate shocks over the entire period were almost as likely to belong to the Active or Less Active categories.

While still drawing a parallel with risk management theory, we step away from the use of derivatives or the exposure from derivative positions as an indicator of hedging behavior. We are careful to label the firms as active or less active interest rate managers, but the parallels with profit seeking behavior are arguably present. As a result, we may still need to consider holdings of insiders, industry performance, and distance to default of firms to provide a more complete treatment to risk management theory.<sup>16</sup> We could also consider the effect of tax non-linearity, if any, on hedging incentives. Finally, Froot, Scharfstein and Stein (1993) show that internal cash flow variability could have effects on investment, and this has led to the use of cash flow sensitivity to interest rates as a measure of hedging performance. We would need to consider a duration-based measure to directly account for interest rate risk rather than rely on any specific hypothetical objective for risk management.

Note, however, that these considerations only apply to questions of whether firms are hedging or speculating. They do not affect the results related to the success in predicting shocks, nor the differences in the impact of interest rate exposure choices. On these questions, we have used our unique dataset to observe the behavior of firms over a longer period of time and in the case of both upward and downward shocks in interest rates. Here, our main conclusion is that it is difficult to predict the type of firm that will be successful in choosing exposures, but that those firms that do guess right might display other signs of superior management in the form of consistent decisions that lead to improved operating performance over their peers in the face of a shock. Overall, this paper brings into question the usefulness of active interest rate management, especially when presented by firms as a device to reduce borrowing costs.

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<sup>16</sup>Theoretical justifications for these variables could be drawn from, for holdings of insiders, Stulz (1984), for industry performance, Breeden and Viswanathan (1998), DeMarzo and Duffie (1995), and for distance to default, Smith and Stulz (1985).

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# Appendix

## 1 Sample Footnotes

Avery Dennison – Jan 01, 1994

“The Company enters into interest rate swap agreements and collars to reduce the impact of changes in interest rates on its short- and long-term variable rate borrowings. Interest paid or received on interest rate swap agreements is recognized as an adjustment to interest expense.

During 1993, the Company entered into five 2-year interest rate swap agreements for an aggregate of \$100 million under which it will pay interest based on LIBOR (the weighted average rate at year end was 3.4 percent). The Company will receive interest at a weighted average rate of 4.1 percent.

During 1992, the Company entered into two 3-year interest rate swap agreements for an aggregate of \$50 million under which it will pay interest based on LIBOR (the weighted average rate at year end was 3.4 percent). The Company will receive interest at a weighted average rate of 6.4 percent. The Company also entered into a \$50 million 3-year interest rate swap agreement under which it will pay interest at a rate of 9.4 percent. The Company will receive interest based on LIBOR (the weighted average rate at year end was 3.4 percent).

During 1990, the Company entered into four 5-year interest rate swap agreements for an aggregate of \$100 million under which it will pay a weighted average rate of 9.0 percent. The Company will receive interest based on LIBOR (the weighted average rate at year end was 3.5 percent). The fair value of all interest rate swap agreements at the end of 1993 was estimated by obtaining dealer quotes and was a net liability of approximately \$13 million.

During 1989, the Company entered into two agreements with a domestic bank which effectively set interest rate limits on \$35 million of the Company’s short-term borrowings. The interest rate collars, which were effective June 1989, limit the interest rate to a range of 7 to 11 percent through June 1994. The fair value of these agreements at the end of 1993 was estimated based on dealer quotes and was a net liability of approximately \$1 million.”

## 2 Data Collection Procedures

Undergraduate students were selected to collect the data as much for their finance or accounting background as for their ability to read and correctly interpret long, winding or complicated sentences. The selected students were then provided a refresher on the types of derivatives used by corporations and how to classify and distinguish those with similar terms. This classification was filtered as we moved along and came across the use of basis swaps and commodity swaps, for instance.

During the actual coding process, the first task for each student was to take the randomly selected firms in sequence and check if there was a public record of financial statements available for the sample period in question. As the EDGAR filings are available only after 1994, we first relied on an old set of CDs containing monthly digests of financial results until we discovered that annual reports/10K filings were also available through the Lexis-Nexis database system.

The lack of a precise standard for corporate statements implied we had to learn over the course of data collection and improve our processes.<sup>1</sup> To achieve this, when initially starting with reports from the early years, we began with as wide a search as possible, reading the entire sections on debt, investments, financial instruments, and using wide search terms such as “interest”, “interest rate”, “risk”, and “hedg” apart from the standard terms like “swap”. The students entering the data were supervised or supported so that any questions they may have were immediately answered. Initially, at least two students worked independently on the same company, and their files were compared to ensure standardization. There was also an intermediate confirmation procedure in place so that they could cross-check their interpretation of disclosures with their neighbor as they worked together. The resulting sharing of observations led to a rapid learning process about where in the notes to look and how to record the data. Also, a student would work on one company at a time, taking advantage of any continuity in the reporting and cross-checking occasional typos with the following or previous years’ reports.

Despite all these checks and balances, the awkward and non-standard use of terminology and differences in emphasis on disclosure by firms led to challenges for slotting all the information into clear categories. Thus, where information was reported differ-

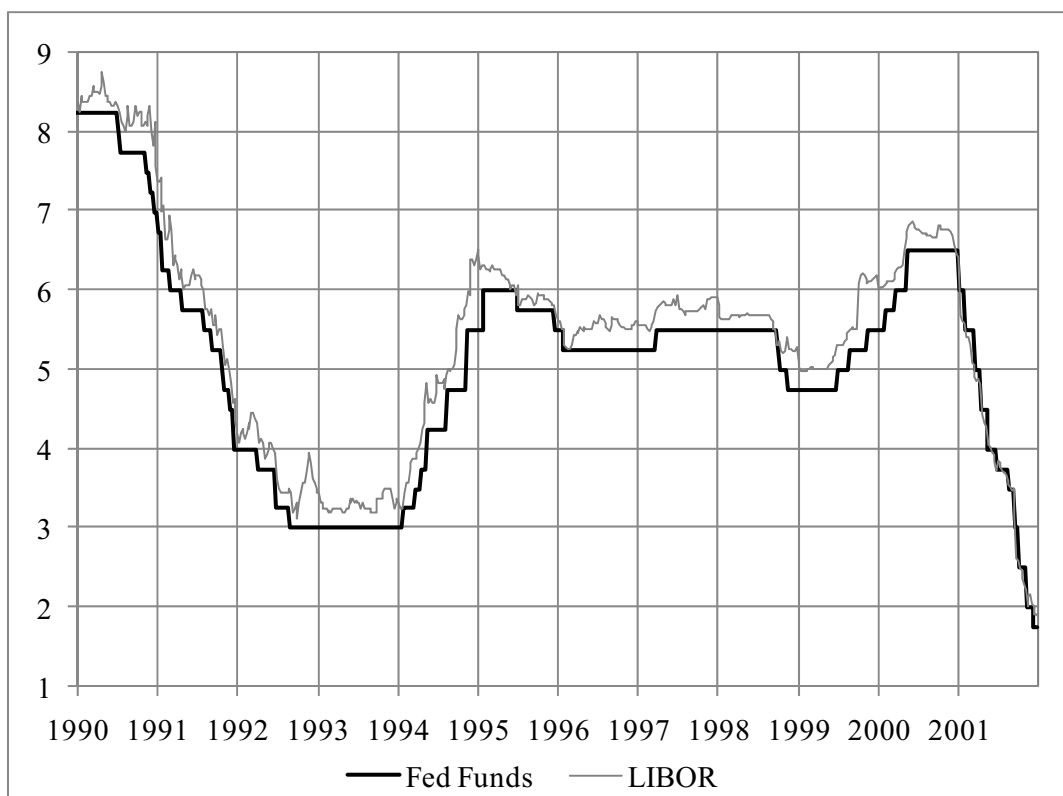
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<sup>1</sup>A study by Roger Merritt of Fitch (the rating agency) on the hedge accounting practices of 57 companies with more than USD 1 trillion of debt found the quality of disclosure to be very varied and lacking in clarity. Inconsistent and inadequate disclosure is a persistent problem related to accounting for derivatives, and thus the window of data we collect is a very useful snapshot of corporate risk management activities.

ently, students were required to insert a new column and record the data as originally classified by the company, and incorporating a “remarks” column if necessary. Simultaneously as these reports were prepared, we also attempted to retain a standard format for the data classifications, ultimately compiling all the firms into a standard coded database containing the key pieces of data with separate room for recording any remarks that were needed.

In the case of debt data, although much the same procedure was used, we also checked the balance sheet when information on short-term debt was not separately provided in the notes. Classification of exposures on debt data often involved reading forward and backwards in years to where the terms of debt issues were properly reported as being at fixed or floating interest rates. Some companies report debt interest rates after the effect of swaps, and this was taken into account to avoid double counting the effect of swaps while combining the two sets of data.

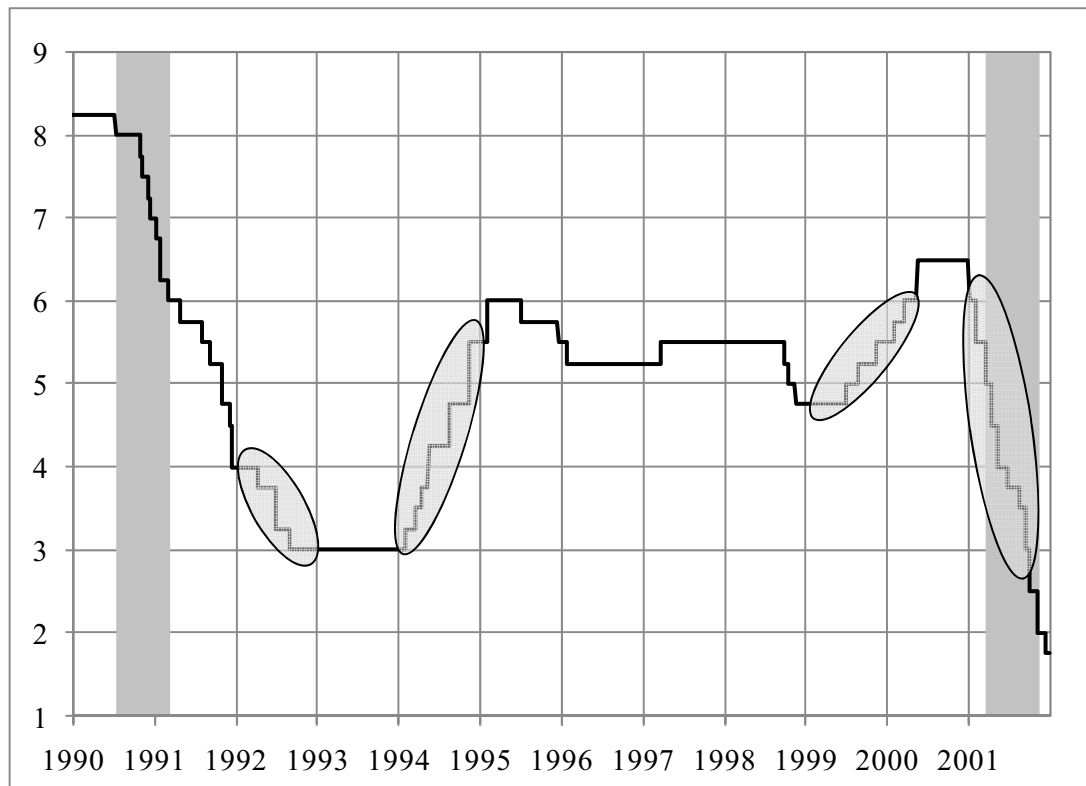
**Figure 1: Weekly Intended Fed Funds and LIBOR Rates (Percent).**



Notes to Figure: We plot the intended Fed Funds rate and the LIBOR rate on every Friday during 1990 through 2001.

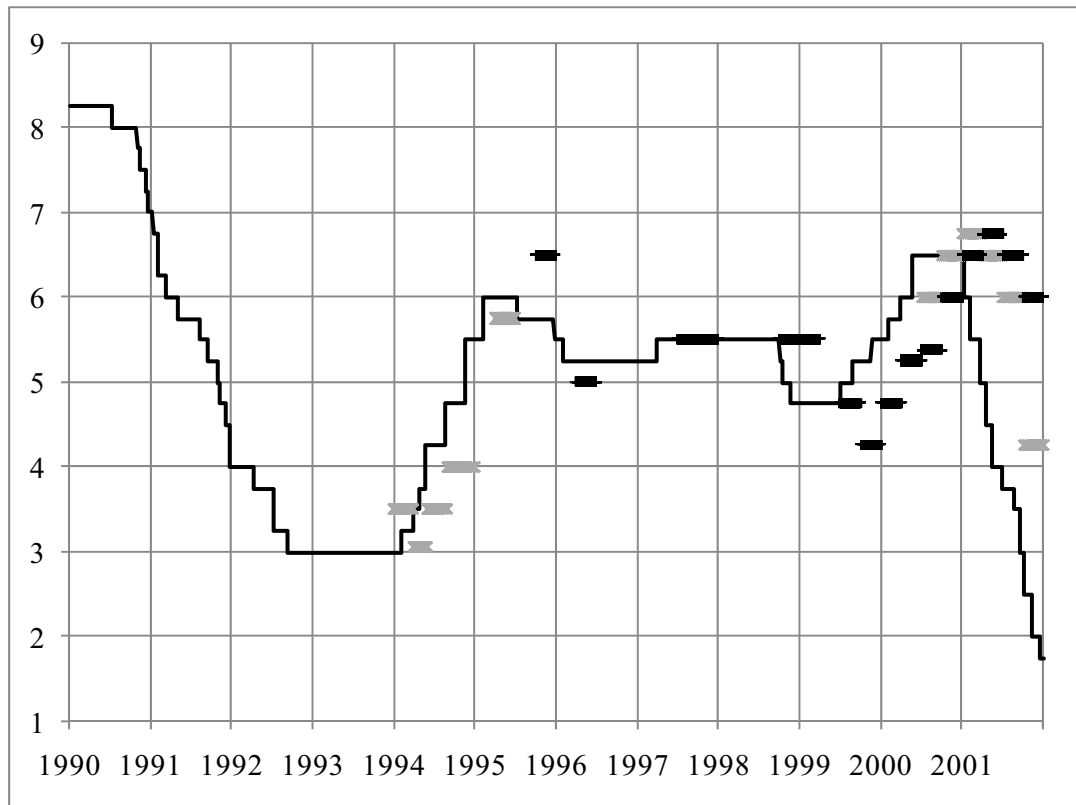


**Figure 2: Intended Fed Funds Rate, NBER Recessions, and Interest Rate Shocks**



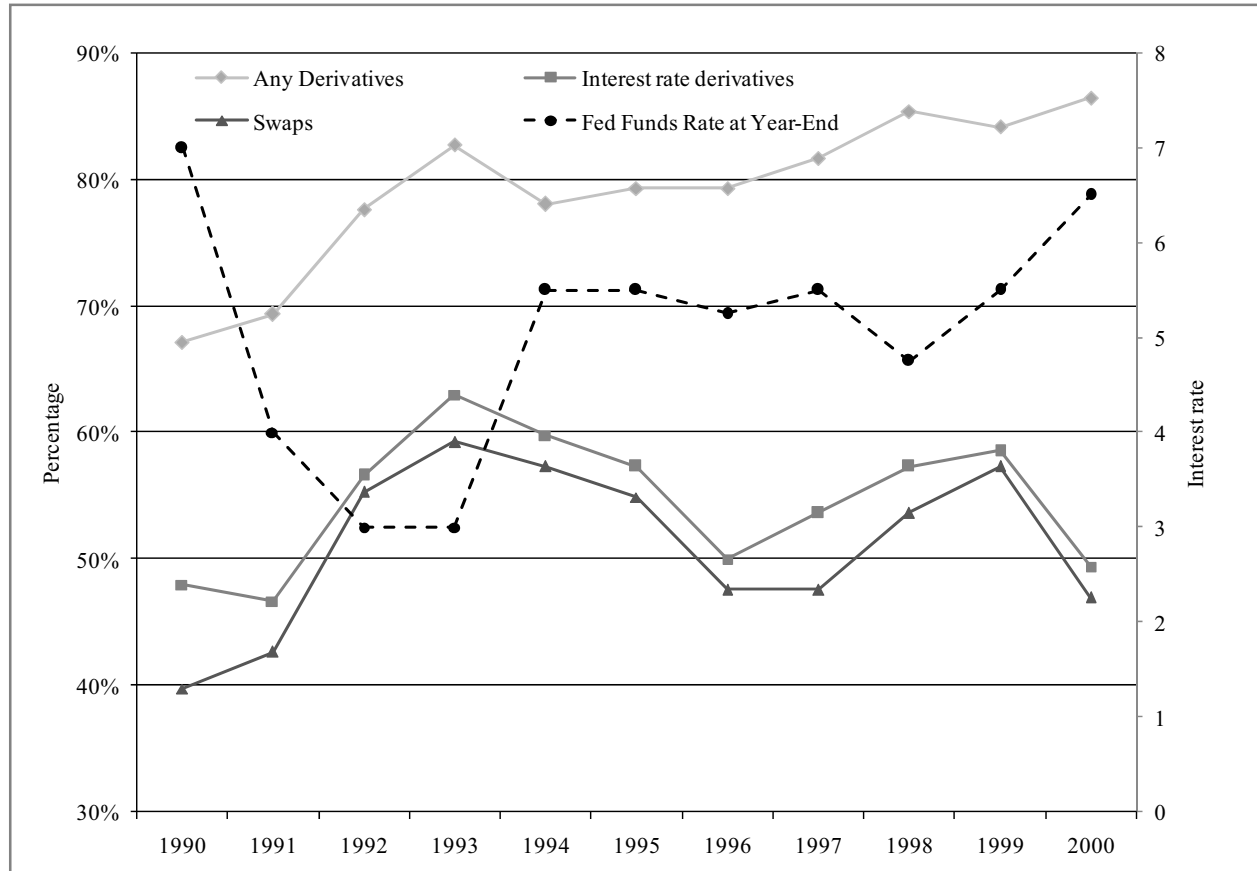
Notes to Figure: We plot the intended Fed Funds rate with the NBER recessions imposed as shaded areas. We also encircle the four interest rate shocks identified in Section 2.

**Figure 3: Consensus Survey Forecasts and Fed Funds Rate Realizations**



Notes to Figure: We plot the intended Fed Funds rate (solid line) along with consensus forecasts from economist surveys from Bloomberg. The forecasts are plotted on the date matching the relevant Fed Funds rate realization. The light markers denote forecasts made 6-9 months prior, and the dark markers denote forecasts made 9-12 months prior. The forecast data begins in 1993.

**Figure 4: Firm Use of Derivatives (Percent)**



Notes to Figure: The bars show the corporate use in percent of swaps, interest rate derivatives, and any kind of derivative as extracted from the annual reports. The dashed line denotes the Fed Funds rate at year-end.

**Table 1: Corporate Derivatives Use**

	Companies reporting	Companies using derivatives	Percentage	Companies using interest rate derivatives	Proportion of total	Proportion of derivative users	Companies using swaps	Proportion of total	Proportion of interest rate derivative users
1990	73	49	67%	35	48%	71%	29	40%	83%
1991	75	52	69%	35	47%	67%	32	43%	91%
1992	76	59	78%	43	57%	73%	42	55%	98%
1993	81	67	83%	51	63%	76%	48	59%	94%
1994	82	64	78%	49	60%	77%	47	57%	96%
1995	82	65	79%	47	57%	72%	45	55%	96%
1996	82	65	79%	41	50%	63%	39	48%	95%
1997	82	67	82%	44	54%	66%	39	48%	89%
1998	82	70	85%	47	57%	67%	44	54%	94%
1999	82	69	84%	48	59%	70%	47	57%	98%
2000	81	70	86%	40	49%	57%	38	47%	95%
Total	878	697		480			450		

Notes to Table: We summarize the derivative use by year of the firms in our sample. A firm is only counted as using derivatives if it has open exposures at the end of the particular year. The last three columns refer to companies that specifically stated using swaps.

**Table 2: Descriptive Statistics on Firm Characteristics**

Variable	N	Mean	Std. Dev.	Min.	Max.
Sales	82	9641	9924	340	54268
Total assets	82	10181	9868	732	56640
Market value of Equity	82	14261	19943	1053	96431
Leverage	82	0.283	0.118	0.060	0.618
Quick ratio	79	0.423	1.554	0.014	13.78
R & D expense ratio	82	0.026	0.041	0.000	0.214
Cash flow margin	82	0.197	0.111	0.036	0.637
Return on assets	82	0.061	0.041	-0.002	0.187
Asset turnover	82	1.079	0.611	0.175	3.857
Market to book ratio	82	2.073	1.101	1.023	8.021
Cost of Goods Sold	82	0.617	0.168	0.106	0.921
Sales, General & Admin Expense	72	0.215	0.116	0.030	0.526

Notes to Table: We summarize the firm characteristics used in our analysis. Sales is item “sale” from the Compustat Industrial Annual file, Total Assets is “at”, while Market Value is defined as the product of common shares outstanding in millions (csho) and share price at the close of the fiscal year (prcc\_f). Leverage is total liabilities/total assets calculated as the sum of “dltt” and “dlc”, divided by “at”. Research and development expense ratio is computed as “xrd” divided by sales. Quick ratio is defined as cash and short term investments (che) divided by current liabilities (lct). Cash flow margins are calculated as operating income before depreciation (oibdp) divided by sales, return on assets as income before extraordinary items (ib) divided by total assets, market to book ratio as the sum of total assets less common equity (ceq) and market value of equity together divided by total assets. The two cost ratios are Cost of goods sold (cogs) and S, G & A expense (xsga), each divided by sales.

**Table 3: Correlations of Firm Characteristics**

	Sales	Total assets	Mkt. value of Equity	Leverage	Quick ratio	R & D expense	Cash flow margin	Return on assets	Asset turnover	Market to book	Active (by s.d.)	Active (by range)
<b>Total assets</b>	<b>0.85</b>	<b>1</b>										
<i>significance</i>	0.000											
<i>N</i>	82	82										
<b>Market value of Equity</b>	<b>0.59</b>	<b>0.65</b>	<b>1</b>									
<i>significance</i>	0.000	0.000										
<i>N</i>	82	82	82									
<b>Leverage</b>	<b>-0.18</b>	<b>-0.04</b>	<b>-0.32</b>	<b>1</b>								
<i>significance</i>	0.103	0.748	0.003									
<i>N</i>	82	82	82	82								
<b>Quick ratio</b>	<b>-0.13</b>	<b>-0.11</b>	<b>-0.01</b>	<b>0.26</b>	<b>1</b>							
<i>significance</i>	0.248	0.332	0.898	0.023								
<i>N</i>	79	79	79	79	79							
<b>R &amp; D expense ratio</b>	<b>0.02</b>	<b>0.04</b>	<b>0.40</b>	<b>-0.48</b>	<b>0.05</b>	<b>1</b>						
<i>significance</i>	0.885	0.750	0.000	0.000	0.642							
<i>N</i>	82	82	82	82	79	82						
<b>Cash flow margin</b>	<b>-0.23</b>	<b>0.04</b>	<b>0.21</b>	<b>0.18</b>	<b>0.44</b>	<b>0.16</b>	<b>1</b>					
<i>significance</i>	0.034	0.731	0.059	0.101	0.000	0.147						
<i>N</i>	82	82	82	82	79	82	82					
<b>Return on assets</b>	<b>0.04</b>	<b>-0.03</b>	<b>0.52</b>	<b>-0.39</b>	<b>0.04</b>	<b>0.36</b>	<b>0.31</b>	<b>1</b>				
<i>significance</i>	0.723	0.795	0.000	0.000	0.731	0.001	0.005					
<i>N</i>	82	82	82	82	79	82	82	82				
<b>Asset turnover</b>	<b>0.26</b>	<b>-0.19</b>	<b>-0.06</b>	<b>-0.35</b>	<b>-0.19</b>	<b>-0.12</b>	<b>-0.64</b>	<b>0.17</b>	<b>1</b>			
<i>significance</i>	0.019	0.095	0.597	0.002	0.090	0.296	0.000	0.138				
<i>N</i>	82	82	82	82	79	82	82	82	82			
<b>Market to book ratio</b>	<b>-0.02</b>	<b>-0.08</b>	<b>0.51</b>	<b>-0.34</b>	<b>0.07</b>	<b>0.56</b>	<b>0.30</b>	<b>0.83</b>	<b>0.11</b>	<b>1</b>		
<i>significance</i>	0.853	0.470	0.000	0.002	0.518	0.000	0.006	0.000	0.317			
<i>N</i>	82	82	82	82	79	82	82	82	82	82		
<b>Active (by s.d.)</b>	<b>-0.33</b>	<b>-0.35</b>	<b>-0.06</b>	<b>-0.23</b>	<b>0.14</b>	<b>0.02</b>	<b>0.05</b>	<b>0.20</b>	<b>0.14</b>	<b>0.22</b>	<b>1</b>	
<i>significance</i>	0.003	0.001	0.612	0.034	0.233	0.834	0.672	0.077	0.220	0.043		
<i>N</i>	82	82	82	82	79	82	82	82	82	82	82	
<b>Active (by range)</b>	<b>-0.29</b>	<b>-0.30</b>	<b>-0.01</b>	<b>-0.17</b>	<b>0.14</b>	<b>0.14</b>	<b>-0.02</b>	<b>0.23</b>	<b>0.13</b>	<b>0.29</b>	<b>0.85</b>	<b>1</b>
<i>significance</i>	0.007	0.006	0.950	0.127	0.221	0.202	0.833	0.040	0.227	0.008	0.000	
<i>N</i>	82	82	82	82	79	82	82	82	82	82	82	82
<b>Mostly Correct</b>	<b>-0.02</b>	<b>-0.17</b>	<b>-0.05</b>	<b>0.02</b>	<b>0.16</b>	<b>-0.18</b>	<b>0.06</b>	<b>0.11</b>	<b>0.24</b>	<b>0.05</b>	<b>0.03</b>	<b>-0.03</b>
<i>significance</i>	0.828	0.116	0.653	0.888	0.163	0.114	0.621	0.337	0.027	0.686	0.813	0.813
<i>N</i>	82	82	82	82	79	82	82	82	82	82	82	82

Notes to Table: We report the sample correlations between the firm characteristic variables. Please see Table 2 for definitions of these variables. *N* denotes the number of observations in each case. The significance of the correlation coefficients is reported below each estimate.

**Table 4: Activeness and Firm Characteristics**

	N	I All	II Active	III Less Active	IV Mostly Correct	V Half Correct + Mostly Wrong	II-III	IV-V
Sales	82	9641 <i>Mean</i> <i>Median</i>	6413 4535	12868 8678	9278 6776	9800 5462	-6455 (0.003)	-522 (0.818)
Total assets	82	10181 <i>Mean</i> <i>Median</i>	6749 4030	13613 11786	7593 5085	11316 6598	-6864 (0.001)	-3723 (0.059)
Market value of Equity	82	14261 <i>Mean</i> <i>Median</i>	13134 6135	15387 8700	12752 7413	14922 7346	-2252 (0.612)	-2170 (0.652)
Leverage	82	0.283 <i>Mean</i> <i>Median</i>	0.255 0.239	0.310 0.312	0.286 0.237	0.282 0.289	-0.055 (0.034)	0.004 (0.899)
Quick ratio	79	0.423 <i>Mean</i> <i>Median</i>	0.625 0.169	0.205 0.116	0.783 0.148	0.256 0.156	0.419 (0.219)	0.527 (0.345)
R & D expense ratio	82	0.026 <i>Mean</i> <i>Median</i>	0.027 0.006	0.025 0.009	0.015 0.000	0.031 0.009	0.002 (0.834)	-0.016 (0.053)
Cash flow margin	82	0.197 <i>Mean</i> <i>Median</i>	0.202 0.169	0.192 0.173	0.206 0.164	0.193 0.173	0.010 (0.672)	0.013 (0.696)
Return on assets	82	0.061 <i>Mean</i> <i>Median</i>	0.069 0.059	0.053 0.043	0.068 0.058	0.058 0.042	0.016 (0.077)	0.009 (0.321)
Asset turnover	82	1.079 <i>Mean</i> <i>Median</i>	1.162 1.073	0.996 0.937	1.303 1.198	0.981 0.932	0.166 (0.220)	0.323 (0.085)
Market to book ratio	82	2.073 <i>Mean</i> <i>Median</i>	2.318 2.053	1.828 1.536	2.148 1.947	2.040 1.641	0.491 (0.043)	0.108 (0.641)
Cost of Goods Sold	82	0.617 <i>Mean</i> <i>Median</i>	0.610 0.620	0.623 0.642	0.615 0.635	0.618 0.623	-0.013 (0.722)	-0.003 (0.9478)
S, G & A Expense	72	0.215 <i>Mean</i> <i>Median</i>	0.216 0.217	0.215 0.182	0.182 0.180	0.233 0.232	0.002 (0.952)	-0.051 (0.0561)
N		82	41	41	25	57		

Notes to Table: We report the mean (with medians in square brackets below) firm characteristic values for the different categories of firms based on their interest rate exposure variability and success in anticipating the four major shocks in interest rates. “Active” firms have a standard deviation of the proportion of fixed rate debt (over the 11-year sample) that exceeds the median standard deviation. Those firms that did not change the proportion of fixed rate debt in the wrong direction more than 50% of the time for the four shocks (see Figure 2) are labeled “Mostly Correct”, and those with 50% or less success “Half Correct or Mostly Wrong”. The last two columns to the right contain differences between selected categories with the p-values of t-tests in parentheses below.

**Table 5: Probit Regression of Activeness and of Success Rate on Firm Characteristics**

	Active = 1, else 0	Mostly Correct = 1, else 0
Sales	-0.00005	-0.000009
<i>p-value</i>	0.000	0.27
Leverage	-3.02	-0.398
<i>p-value</i>	0.003	0.64
Quick ratio	0.230	0.254
<i>p-value</i>	0.196	0.163
R & D expense ratio	-5.13	-4.98
<i>p-value</i>	0.095	0.067
Cash flow margin	-20.35	-38.90
<i>p-value</i>	0.38	0.238
Return on assets	-3.27	0.159
<i>p-value</i>	0.317	0.957
Asset turnover	0.125	0.369
<i>p-value</i>	0.544	0.058
Market to book ratio	0.349	0.017
<i>p-value</i>	0.03	0.879
Cost of Goods Sold	-20.51	-40.95
<i>p-value</i>	0.376	0.214
S, G & A Expense	-22.64	-42.18
<i>p-value</i>	0.329	0.201
Mostly Correct*	-0.323	
<i>p-value</i>	0.053	
Active*		-0.253
<i>p-value</i>		0.095
<i>N</i>	69	69
Pseudo R <sup>2</sup>	0.3794	0.2372

Notes to Table: We report probit regression analysis based on the average characteristics of the firms over the entire sample period. Please see Table 2 for a description of the variables.

Estimates reported are the marginal effects estimated at the mean of the explanatory variables.

Light shading denotes significance at the 10% level and medium shading at the 5% level, and dark shading at the 1% level.



**Table 6: Cash Flow Sensitivity Regressions**

	Random Effects	Fixed Effects
Constant	0.867 0.000	2.127 0.000
Lag	0.709 0.000	0.469 0.000
LIBOR	0.046 0.039	0.077 0.000
Active	0.611 0.003	
Active*LIBOR	-0.067 0.051	-0.089 0.005
No. of observations	3637	3637
No. of groups	81	81
R <sup>2</sup>		
Within	0.2528	0.25
Between	0.9838	0.88
Overall	0.5531	0.50
Joint test	1130.67	83.62
Joint test statistic	Wald(4)	F(3,3553)
Prob>chi <sup>2</sup>	0.0000	0.0000

Notes to Table: We estimate the sensitivity of firm cash flows to interest rates, based on the whether the firms are classified as Active interest rate managers. The dependent variable is operating income before depreciation divided by book assets. The data frequency is quarterly in a panel format, with a dummy for Active and its interaction term with LIBOR used to determine, if on average, the cash flows and their sensitivities to interest rates are different from the Less Active group. p-values are provided below the estimates, which are almost all significant at the 5% level.

**Table 7A: Yearwise Performance**

Year	N	Right
1991	82	36.6%
1993	82	58.5%
1998	82	52.4%
2000	82	54.9%
Total	328	50.6%

Notes to Table: Percentage of firms that changed their interest rate exposure in the profitable direction in the four shock years

**Table 7B: Activeness and Being Right**

		Right		
		0	1	Total
Active	0	86	78	164
	1	76	88	164
Total		162	166	328

Notes to Table: We document the overlap in number of firm-year observations between those that were classified as Active (1) or Less Active (0) and those that were Right (1) or Wrong (0) at the time of each of the four shocks.

**Table 8: Policy Shock Exposure Comparisons. Right versus Wrong**

	% $\Delta$ Sales	% $\Delta$ Total Assets	% $\Delta$ Market Value of Equity	$\Delta$ Leverage	$\Delta$ Quick ratio	$\Delta$ R & D	$\Delta$ Cash flow margin	$\Delta$ Return on Assets	$\Delta$ Asset turnover	$\Delta$ Market to Book ratio	$\Delta$ Cost of Goods Sold	$\Delta$ S, G & A Expense
Total	0.100	0.136	0.119	-0.001	0.022	0.0003	0.0006	0.003	-0.024	-0.062	0.001	-0.001
Right	0.116	0.149	0.151	-0.004	0.001	-0.0008	0.0045	0.008	-0.020	-0.074	-0.0002	-0.004
Wrong	0.083	0.122	0.087	0.002	0.044	0.0013	-0.0033	-0.002	-0.029	-0.049	0.002	0.003
Right-Wrong	0.033	0.027	0.065	-0.006	-0.043	-0.0021	0.0078	0.010	0.009	-0.024	-0.002	-0.006

Notes to Table: We conduct univariate comparisons across the firms that were Right at the time of the shock versus those that were not. We report the change (pre-shock year to post-shock year) in size, leverage, quick ratio, research and development, cash flow margins, as well as return on assets, asset turnover, market to book ratio, and costs. Light shading denotes significance at the 10% level and medium shading at the 5% level, and dark shading at the 1% level.

**Table 9: Post Shock Firm Performance**  
Dependant Variable: Change in Cash flow margin (percentage points)

Constant	-0.02 <i>-0.07</i>
% Change in Sales	0.605 <i>0.701</i>
Change in leverage	-3.46 <i>0.239</i>
Change in quick ratio	-0.90 <i>0.592</i>
R & D (t-1)	-10.32 <i>0.223</i>
Market to Book (t-1)	0.208 <i>0.197</i>
Change in C. O. G. S. Ratio*Right	-99.93 <i>0.000</i>
Change in S, G & A Expense Ratio*Right	-101.89 <i>0.000</i>
yr1994	-0.074 <i>0.854</i>
yr1999	-0.003 <i>0.991</i>
yr2001	-1.27 <i>0.015</i>
Right (t-1)	0.09 <i>0.770</i>
N	264.00
R <sup>2</sup>	0.555

Notes to Table: Regression explaining post-shock performance of firms based on whether they adjusted their exposures in the Right direction at the time of the interest rate shocks. P-values are provided below the estimates. Light shading denotes significance at the 10% level and medium shading at the 5% level, and dark shading at the 1% level.

## The Next Chapter

In the previous paper, despite developing a better proxy for exposure management, we cannot find conclusive evidence in favour of existing risk management theories when it comes to interest rate risk. Further, we find evidence that favours the idea that managers choose financial exposures consistent with their views on future outcomes, which is akin to speculation or profit-seeking. This activity, however, does not lead to any long-term gains, and when managers do benefit from taking a view in the short term, their operating performance improves due to their actions in cost management rather than any competitive market advantage. We also are aware of the limitation of existing theories in that they predict hedging only of cash flow exposures, while we find that lower cash flow sensitivities are in fact related to greater variability in firms' exposures. Given that we look at a firm's activity over time in order to discriminate it in the cross-section, we are aware of the unavailability of a benchmark that would help us determine what the optimal interest rate exposure should be for a firm. The next paper is an attempt to approach this problem with a reduced-form modeling approach, i.e. assuming that a firm has incentives to manage risk, what combination of fixed and floating rate debt would it choose?

# 4

## The Choice of Fixed or Variable Rate Debt for Corporate Risk Management

# 1 Introduction

How should a firm decide whether to issue debt at a fixed or variable interest rate? The economic literature has not yet provided a coherent answer to this question, even though one need only look to the large volume of open derivative contracts designed to switch the nature of interest payments between the two types, to convince oneself of its importance. These contracts, such as interest rate swaps, are essentially bets on the future cost of borrowing faced by the firm. According to the Bank for International Settlements (2010), single-currency interest rate derivatives with a notional value of 437.2 trillion dollars were outstanding at the end of June 2009. Of this, non-financial customers were counterparties in contracts with a notional value underlying of 39 trillion dollars. These latter contracts had a gross market value (the money that would actually be expected to change hands) of almost 800 billion dollars. Given these numbers, it is easy to argue that the ex-post, if not ex-ante, cost of debt would be sensitive to the choice of interest payment scheme.

Many firms issue both fixed and variable rate debt and may significantly vary the share of each type over time (Christoffersen, Nain and Oboeroi 2009). Since their introduction in response to high inflation in the 1970s, the share of long-term floating rate instruments in the markets has grown rapidly and has varied significantly. The choice of contract type is clearly an important issue for determining interest rate exposure. Yet, there appears to be no commonly stated decision rule that would either guide managers in their choice of interest rate liabilities or help us benchmark the choices of firms against an optimal policy. In this paper, I propose a theoretical approach to practically selecting the share of fixed and variable interest rate liabilities from the perspective of risk management.

Financial structure is often a significant source of risk to a firm's investors. The subject of financial leverage is arguably one of the most enduring in the attention it receives from both businesses and academics. It would not be an exaggeration to suggest that the debt structure of a firm is one of the key responsibilities of managers, given the well known trade-offs for shareholders that arise from risk-shifting incentives, tax benefits of higher debt, the risk of failure or distress, and inefficiencies from overinvestment. However, beyond leverage, there is also the question of which type of debt to issue. This question has been partially addressed in two closely linked areas of study. The first is obviously the risk management literature that concerns itself with the need for liquid assets (cash) to avoid underinvestment problems (e.g. Froot, Scharfstein, and Stein 1993). The second area is concerned with the maturity of debt

or the choice between short-term and long-term debt. Theories along this frontier are based mainly on the presence of asymmetric information about the quality of the firm's projects (Diamond 1991, Titman 1992, Ericsson 2000) or due to the financial flexibility needed during mergers and acquisitions (Kahl, Shivdasani, and Wang 2008).<sup>1</sup>

I rely on the two main themes above to motivate my approach to the subject of this paper. In terms of justifications for risk management, I look to Froot, Scharfstein, and Stein (1993), Leland (1998), and Purnanandam (2008). Froot et al. propose hedge ratios that would effectively ensure the availability of internal funds in states where investment opportunities arise for the firm. They argue that such hedging is essential due to costly external financing (where the cost of borrowing is modeled as a convex function). Leland shows that a firm may have an incentive to reduce its risk as this will in turn increase its borrowing capacity, hence allowing it to take advantage of tax shields. Purnanandam shows that a firm has an ex-post (after financing) incentive to reduce its risk due to the value destruction that arises in financial distress.<sup>2</sup> These papers imply that a concave objective function would be appropriate to describe the decision making process of a firm.

Further, with respect to cash holdings and corporate financial structure, several papers show that firms (at least partially) take a traditional buffer-stock approach to cash on hand. These include Diamond (1991), Anderson and Carverhill (2007), Faulkender and Wang (2006), Dittmar and Mahrt-Smith (2007), Acharya, Almeida, and Campello (2007), and Riddick and Whited (2009). McKinnon (1967, 1971), in a different context, argued in favour of including liquid buffers in the form of cash or inventory as a valuable risk management tool. The essential premise of this group of papers is that firms with hedging incentives due to costs of financial distress, risk aversion, or mismatched timing between investments and cash flows, would increase cash holdings or, if appropriate, retain excess borrowing capacity.

This concept has a parallel in the macroeconomics literature on household behaviour and precautionary savings that includes Zeldes (1989a, b), Deaton (1991), Carroll (1997), Cocco, Gomes and Maenhout (1999), and Gourinchas and Parker (2002), among others. An extension of this approach addresses the choice of households when they face borrowing constraints and when they must make housing decisions (a home

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<sup>1</sup>Apart from this, the maturity decision is also related to rollover and repricing risks that introduce an added layer of uncertainty about the firm's prospects. These risks, of course, could be completely caused by external market phenomena such as the variation of liquidity in the economy or technological change, and I will not be attempting to classify them here.

<sup>2</sup>Other explanations for the existence of risk management include risk aversion or career concerns of managers and agency conflict. See, for example, Stulz (1984), Smith and Stulz (1995), Breeden and Viswanathan (1998), Morellec and Smith (2007).



being an asset that is also consumed). This avenue is interesting to those concerned about interest rate risk, although it is framed in the context of inflation expectations. In particular, Campbell and Cocco (2003), deJong, Driessen and Van Hemert (2005), and Koijen, Van Hemert and Van Nieuwerburgh (2008) explore the choice between fixed rate and adjustable rate mortgages for investors in a life-cycle model.

Unlike the mortgage literature on household behaviour, there is not much empirical work available to determine the manner in which nonfinancial firms address interest rate risk. I believe the reason is that there is no articulated benchmark policy when it comes to interest rate risk. This, in turn, is because interest rate risk always has a flip side - when you hedge interest payments, you increase the variance of the *value* of debt, and vice versa.

In an effort to gain insight on the optimal proportion of fixed rate debt, my approach in this modeling exercise is to focus on that particular margin while allowing for as many stylized features as possible in a dynamic setting. First, I assume that incentives for risk management exist. I model the investor as maximising a concave function of cash flows generated from an investment over a finite period. This generates a smoothing incentive and a precautionary cash-on-hand motive, and is justified as a reduced-form strategy based on the risk management papers mentioned above. In particular, the introduction of a concave objective function is essential if risk management would add any value even if this may be only the perceived objective function for a risk-neutral entity. Second, I consider a finite-time model where a single initial investment is made and the traditional trade-off between tax benefits of debt and bankruptcy exists.<sup>3</sup> Since risk aversion is being explicitly modeled, the firm will target a stable dividend and a stable cash balance. It must determine rationally what proportion of its long-term debt will be issued at a variable rate.

Unlike the standard assumption in risk management literature about the greater riskiness of variable rate debt, I find that a firm with greater incentives to manage risk will necessarily prefer a combination of fixed and floating rate debt rather than completely fixed rate debt. The traditional view has been that variable rate debt incorporates interest rate risk, while fixed rate debt transfers interest rate risk to the lender. This is possibly due to the study of such contracts from a financial institution's perspective. However, I show that fixed rate debt also incorporates interest rate risk for the borrower, and is not optimally preferred by risk averse borrowers.

Before moving to the main dynamic model, however, I first use a two-period (three

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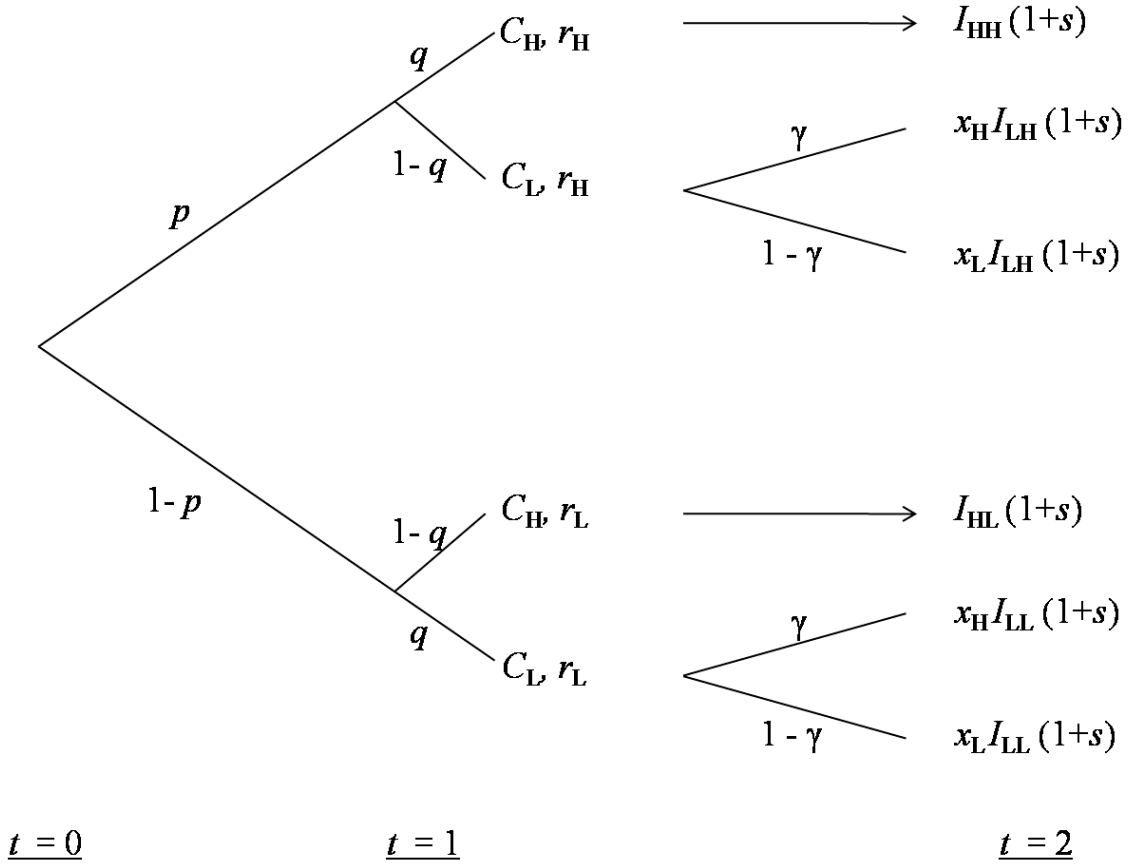
<sup>3</sup>I do not model deadweight losses from bankruptcy as this is not required given the implicit costs resulting from a concave objective function.

dates) setup to characterize the effect of interest rate risk that the firm will face in the dynamic model, and to propose some intuitive explanations for the model. In the following section, I develop the two-period example. In the third section, I describe the model in detail and then discuss the solution and the choice of parameters used in the next section. I am eventually interested in the recommendations from this model that would help explain the heterogeneous choices of firms. Thus, in section 5, I discuss some testable cross-sectional implications based on variation of the exogenous parameters in the model. I then conclude with the limitations of this model and discuss possible ways to enrich the framework in future work.

## 2 A Two-Period Trade-off Model

I outline below a simple model which helps to identify the margins where interest rate risk affects the firm. This is a flexible model because it shows that different types of frictions would lead to similar effects in terms of interest rate risk. Here, I rely on limited pledgability of cash flows (as in Acharya, Almeida and Campello 2007) as the source of market imperfection. Convex costs of borrowing combined with a concave production function would lead to the same outcomes, albeit in the states of the world where cash availability (including new borrowing) is lower than optimal investment. Alternatively, a sufficient decrease in future productivity caused by financial distress would also lead to the same outcomes. Essentially, I show here that a risk exists whether the firm borrows at a fixed rate or a floating rate. Thus, an entity which must conduct itself *as if* it were risk-averse would seek to mitigate this risk.

There are three dates in the model (see Figure 1 for the timeline). At  $t = 0$ , the firm makes an investment with uncertain cash flows, and it borrows  $d$  in order to invest. Interest rates are correlated with the cash flow generated at time 1, and affect both the cost of debt and the value of debt based on the borrowing commitments made at  $t = 0$ .



**Figure 1.** *Tree showing dates in the model.* There are three dates in the model. The initial debt is taken up at  $t = 0$ .  $p$  is the probability of a high interest rate  $r_H$ , while  $q$  is the probability of a high cash flow  $C_H$  when the interest rate is high, or a low cash flow when the interest rate is low. The subscripts on investment  $I_{LH}$  reflect a low cash flow and high interest rate, respectively, at  $t = 1$ .  $x_H$  and  $x_L$  are factors that represent the possible reduction in expected investment return due to financial distress in the low cash flow states.

The debt is repaid at  $t = 2$ . At  $t = 1$ , the firm receives a high or low cash flow  $C_H$  or  $C_L$  respectively. Also, the one-period risk-free interest rate either rises to  $r_H$  or falls to  $r_L$ . The covariance between cash flows and interest rates depends on  $q$  as follows (please see the appendix for the complete expressions):

$$\begin{aligned} \text{Cov}(C, r) &> 0 \quad \text{if } q > 0.5 \\ &< 0 \quad \text{if } q < 0.5 \end{aligned}$$

The precise nature of this correlation would, in practice, be crucial to risk management policymakers. This is because it would determine whether the interest rate risk on variable rate liabilities is enhanced or dampened by co-movement with operating

cash flows. Consider for example a firm borrowing at variable interest rates and whose operating earnings (through market demand, for instance) are negatively correlated with the level of the interest rate. Such a firm, if it has variable rate liabilities, will face the double challenge of lower cash flows and higher interest costs when rates go up.

The coupon payment on debt issued at time 0 may or may not co-vary with interest rates based on whether the debt is at a fixed rate or floating rate, while the coupon on additional time 1 debt will be at the interest rate realized at time 1. Up to this point, the risk appear to be of the standard variety that affect the free cash flows (and hence the cash balances) of the firm. However, suppose the firm has an investment opportunity for which it must borrow additionally at time 1. Then, when the realized interest rate is low, its fixed rate debt increases in value. This in turn must necessarily reduce the borrowing capacity as long as there is a limit on leverage ( $\lambda < 1$  in this case). Hence, the firm's investment is at risk in either scenario. The assumption in the model above is that the firm has an opportunity to reinvest its residual cash flow (after paying the debt coupon) at  $t = 1$  to earn a rate of return  $s$ , such that it is always optimal for the firm to invest. In the high cash flow state, there is no residual uncertainty, while in the low cash flow state the expected return is adjusted by a factor  $\bar{x} = \gamma x_H + (1 - \gamma) x_L$  such that  $\bar{x} \leq 1$  and  $x_L$  leads to default.

## 2.1 Nature of Risk

For any debt with face value  $d$  (below the leverage limit) that the firm has issued at time 0, and for an investment opportunity at time 1 that is only constrained by the maximum leverage, we can show that the relative cost of debt (face value divided by market value) for a fixed rate borrower is higher if low interest rates are realized, i.e.

$$\frac{d_1^{LH}}{B_1^{LH}} - \frac{d_1^{LL}}{B_1^{LL}} < 0$$

where the superscripts stand for the cash flow state and interest rate state in that sequence. For a floating rate borrower, the relationship is reversed. For calculations, please see the appendix.

Thus, from this simple model we can establish that the margin between the issue of fixed and floating rate debt must be concerned with two key points. First, the correlation between cash flows and interest rates would determine the degree to which one type of risk must be hedged. Second, we need to trade-off the risk of financing

constraints arising from fixed rate debt with distressed (low) cash flow states arising from floating rate debt when interest rates are low and high respectively. Clearly, a perfect hedge would not be possible in this case.

### 3 The Dynamic Model

The first question for a risk management model is the source of non-linearity in the objective function that generates a need for risk management. Such non-linearity may be introduced through information asymmetry leading to convex external financing costs, diminishing marginal returns in the production function, or value destruction due to financial distress, among other reasons. I sidestep this particular issue by opting to model the firm in a reduced form - an important simplification that will allow direct attention to be placed on the aim of this paper. We must be able to practically determine what proportion of a firm's debt should be at a fixed rate when the investor issues this debt to finance a revenue generating asset.

#### 3.1 Objective Function

We consider an investor who buys a productive asset at time 0 for a price  $V_0$ . He finances the purchase partly with his own funds, and partly with debt. The maximum he can borrow is  $\lambda V_0$ , with  $\lambda < 1$  exogenously determined.

The objective for the investor/entrepreneur is

$$\max E_0 \left[ \sum_{t=1}^T \exp \left( -\mu t - \sum_{i=1}^t r_i \right) \frac{\delta_t^{1-\gamma}}{1-\gamma} + \exp \left( -\mu (T+1) - \sum_{i=1}^{T+1} r_i \right) \frac{X_{T+1}^{1-\gamma}}{1-\gamma} \right] \quad (1)$$

where  $\delta_t$  is the periodic payout from the firm,  $X_{T+1}$  is the terminal value of the firm, or the final value of assets in hand,  $\gamma$  reflects the risk aversion assigned to the firm, and  $r_t$  is the continuous compounding analog of the short term interest rate  $R_t$ .

$$r_t = \log(1 + R_t)$$

Although the parallels are quite obvious, it is important at this point to distinguish between the objective function above, and a traditional risk-averse individual's utility function. It is the knowledge that a utility function of this form is responsible for risk-averse behaviour that leads me to adopt this as a tool that will *effectively constrain* the manager's set of decisions to comply with a policy akin to earnings smoothing.

As this is not an equilibrium model where I am endogenously determining the risk premia, discount rates and other parameters from a traditional asset pricing model, it would be wrong to think of the objective as a utility function. What I am effectively doing is allowing myself to adjust the tolerance of the firm to variations in cash flows by varying  $\gamma$ . This parameter could be linked to typical constraints in production technology or financing costs and should be thought of as a measure of the *need* for a firm to manage risk if it is to avoid a deadweight loss. In other words,  $\gamma$  is a smoothing constraint parameter.

### 3.2 Income Process

The income process is modeled as a sum of a random walk and a transitory variation. i.e. the income of the firm is stochastic, and it follows the process:

$$z_t = \log Z_t = v_t + \omega_t \quad (2)$$

$$\omega_t \sim NID(0, \sigma_\omega^2) \quad (3)$$

with  $\omega_t$  a transitory shock and  $v_t$  a persistent stochastic component such that

$$v_t = v_{t-1} + \eta_t \quad (4)$$

$$\eta_t \sim NID(0, \sigma_\eta^2) \quad (5)$$

### 3.3 Interest Rate Process

The short risk free interest rate is assumed to follow an AR(1) process. More specifically, I assume the log of the short rate follows an AR(1) process, i.e.

$$r_t = \log(1 + R_t) = \phi r_{t-1} + \epsilon_t \quad (6)$$

with  $\epsilon_t \sim NID(0, \sigma_\epsilon^2)$ .

How well this choice reflects the true data generating process for the short rate may be open to debate. While several authors have found evidence that the interest rate may be nonstationary in a typical range of rates and strongly mean reverting at relatively higher rates, Jones (2003) conducts a careful analysis to demonstrate the biases that arise from estimating such models on small samples and with the null of a stationary process to begin with. Thus, it should be just as acceptable to use this

form for the interest rate process as using a more complex form given that no single one has been established as being the correct one.

In order to rule out speculative incentives, I assume that there are no profit making opportunities from timing the issuance of debt. The mean-reverting and predictable nature of interest rates necessitates that there is a term premium added to bonds that extend beyond one period. There is also evidence that monetary policy has a certain level of inertia (Piazzesi 2005), which might require us to consider other kinds of dynamics. However, the exact dynamic would not have a major effect on this model - more important is the assumption that it is not profitable to time the market. This is because the expectations hypothesis holds. i.e. the interest rate on an  $n$ -period bond at time  $t$  is given by:

$$\begin{aligned} r_{t,n} &= \log(1 + R_{t,n}) \\ &= \frac{1}{n} \sum_{i=0}^{n-1} E_t[r_{t+i}] + \xi \end{aligned} \quad (7)$$

where  $\xi$  is a constant premium for maturity  $n$ . This assumption is the same as in Campbell and Cocco (2003) and rules out the profitability of timing the market based on short term expectations of interest rate increases or decreases as they are already priced.

### 3.4 Relation between asset value, income and interest rates

The transitory component of income from (2),  $\omega_t$ , may be correlated with innovations to the interest rate process (6) such that  $Corr(\epsilon_t, \omega_t) = \varphi$ , and the shocks to the persistent component of income from equation (4),  $\eta_t$ , are assumed to be perfectly positively correlated with innovations to the value of the productive asset whose evolution through time may now be written as:

$$v_t = \log V_t = v_{t-1} + \kappa_t \quad (8)$$

$$\kappa_t = \zeta \eta_t \quad (9)$$

One of the advantages of allowing the value to be defined in this manner is that it will reduce the number of state variables in the model. However, this does not impose an excessive cost in terms of generality due to the manner in which the income is defined with two components. Thus, as in standard finance concepts, while we expect income and value to be closely tied, there may be short-term variations in

their relationship.

### 3.5 Debt

At date 0, in order to finance an asset purchase  $V_0$ , the entrepreneur may borrow  $D_0 \leq (1 - \lambda) V_0$  with a maturity  $T + 1$ , i.e. to be repaid on date  $T + 1$ . Having borrowed money based on the asset's initial value, the firm may not further pledge its cash flows or income and must adjust to variations in the income.

#### 3.5.1 Further borrowing

The firm may borrow short-term (for one period) over the life of the project, but this borrowing is restricted so that the *total* debt after borrowing does not exceed a proportion  $\lambda$  of the value of assets at the time. This can be interpreted as follows: At the time of initial investment, the value of the asset may be ascertained either from its market price or from direct investigation, and the borrowing limit set accordingly. Over the life of the project, though, this value is important only as a predictor of the final period payoff when the residual value over the debt must be claimed by the investor. Thus, the coupon payments gain more immediate importance, and the value of the asset may not be as well monitored by outsiders. However, at the time of additional borrowing, whenever it is needed, the maximum leverage condition presses into effect again the importance of the asset's value to lenders.

#### 3.5.2 Coupon choices (fixed or floating)

A proportion  $\alpha \in (0, 1)$  of the firm's debt would be at a variable rate  $r_t + \theta$  and the remaining portion at a fixed rate  $R_t^F$  such that  $r_t^F = r_t^{T+1} + \theta$ . Here,  $\theta$  is a premium for default risk and is assumed to be constant throughout the life of the asset and  $\theta \leq \mu$ . I assume that the spread on the two types of debt is the same since it reflects firm-specific default risk. The spread for fixed rate debt may be higher when there is an embedded prepayment option in the debt contract. Since I do not allow for prepayment, this assumption is not problematic. Also,  $r_t^{T+1}$  is determined by equation (7) above.

The coupon payment on this initial loan at any time  $t$  will be

$$\begin{aligned} C_t &= D_0 \alpha (R_t + \theta) + (1 - \alpha) D_0 R_0^F \\ &= D_0 \alpha (R_t + \theta) + (1 - \alpha) C_0^F \end{aligned} \tag{10}$$



since  $R_0^F$  is fixed at issuance.

The value of the fixed portion of this debt at any time  $t$  will be

$$D_t^F = E_t \sum_{s=t+1}^{T+1} C_0^F \exp(-r_t^s(s-t) - \theta(s-t)) + D_0^F \exp(-r_t^{T+1} - \theta(T+1-t)) \quad (11)$$

I do not allow for the refinancing of fixed rate debt in this paper. If one were to incorporate a call provision in the fixed rate debt, it would require the determination of a premium based on the expected chances of calling the debt. In other words, incorporating an option in the fixed rate debt may confuse the comparison for risk management purposes between fixed and floating rate coupon choices. This is because a call provision involves paying a higher coupon in exchange for a form of insurance, and the value of this insurance would need to be compared separately with alternative forms of risk management. I am leaving to future work the question of the relative efficiency of an option based strategy for risk management (which would include caps and floors, if necessary) and the direct alternative of choosing what proportion of fixed and floating rate debt should be issued. Another reason for this is that the need for valuation of complex instruments in the options based approach would restrict the applicability of this research, which concerns a simple choice for financial managers when faced with interest rate risk.

I do not shut down all borrowing after the debt issue, however. In every period, I allow the firm to issue new debt  $B_t$  up to its borrowing limit for the immediate short term at the rate in effect on that date. This short-term debt must be repaid in the following period. However, if it is advantageous for the firm, it would simply refinance it each period (as is the usual practice with short-term borrowings).

The new total debt level on any date  $t$  after such issuances would then be

$$\begin{aligned} D_t + B_t &= D_t^F + D_0^{FL} + B_t, \\ s.t. V_t(1 - \lambda) &\geq B_t + D_t \end{aligned} \quad (12)$$

where  $D_0^{FL}$  is the (constant) value of the floating rate debt issued at time 0.

Note that the value of the floating rate debt is constant in this model. I do not incorporate changing credit quality, which has been studied separately as a source of refinancing risk or a motive for borrowing at a short maturity under asymmetric information. As stated above, the source of refinancing risk in this model is purely interest rate risk and has nothing to do with the changing qualities of the firm or the

overall supply of credit in the market.

Please note that the condition in (12) is only applicable when a firm needs to borrow. Should this condition be violated, the firm may not borrow additional funds. However, it is not forced to default.

### 3.6 Default decision

If the investor defaults, they will have to give up the asset and will remain with a proportion of the cash-on-hand. I set this proportion at 100%. Thus, if the investor defaults, they will spread the use of the default state cash-on-hand over the remaining time horizon. The investor may make a rational decision to default when the continuation value no longer exceeds the value obtained from defaulting. Thus, there is no exogenous threshold for the value of the assets at which the investor defaults. Since the innovations to the value of the asset and the permanent component of the income process are assumed to be perfectly correlated, it is not clear that the investor will wait until the final period to default if his income drops. As long as the coupons are paid, there is no trigger for default in this setup. Since the default decision is based on the expected continuation value, the investor evaluates on each date the expected value of withdrawing the cash-on-hand  $X_t$  and earning short-term risk-free returns on this cash for the remainder of the period until  $T + 1$ . In defaulting, they would default on the total debt, and not just on the fixed or floating portion. Thus, there may be states where they would continue to pay coupons on the debt even though  $V_t(1 - \lambda) < D_t$ .

### 3.7 Cash on hand

We can now write the transition equation for cash on hand  $X_t$  when there has not been a default as:

$$\begin{aligned} X_{t+1} = & (X_t - \delta_t + B_t)(1 + R_t) + (1 - \tau) Z_{t+1} \\ & - B_t - [C_{t+1} + B_t(1 + R_t)](1 - \tau) \end{aligned} \quad (13)$$

where  $\tau$  is the tax rate. When there has been a default, the equation would be:

$$X_{t+1} = (X_t - \delta_t)(1 + R_t) \quad (14)$$

### 3.7.1 Priority

The lender's priority status, though not modeled through dynamic recovery rates, is not ignored in this model. First, the cash available for dividends is after payment of coupons and repayment of short-term debt, but includes new short-term borrowing. It is clear from this that the priority for cash on a regular basis is to pay the obligations towards bondholders. However, the unavailability of sufficient short-term liquidity does not disallow the firm from borrowing additional funds (within the total leverage limit) to pay out as dividends. In fact, the only motivation for short-term borrowing is that it would smooth out dividends (which ostensibly go towards other investment opportunities). It is known that firms are typically hesitant to reduce dividends, and they would borrow in order to maintain short-term liquidity rather than reduce dividends.

At default, the firm's shareholders retain all the cash on hand, but lose control of the productive asset. Thus, instead of a percentage of assets, the lenders receive the entire value of the physical asset. This reasoning reflects the fact that managers can exercise significant control over how cash is spent. Dittmar and Mahrt-Smith (2007) explore the value of cash in the context of corporate governance, and find that the holdings of cash in poorly governed firms are not fully reflected in the value of the firm. Since I don't model agency conflict between managers and shareholders in this paper, the lower control of cash by lenders is an extension of this argument. This is a simple way to create tension between the incentives for holding cash and holding less of it from an agency perspective (also see Morellec and Smith 2007). However, due to this assumption, I do not allow default to take place in the final period, when the asset is sold and the principal repayment is due, as the value of defaulting at that stage would be obviously high.

## 3.8 Discussion

In theory, Froot, Scharfstein, and Stein (1993) and Purnanandam (2008) provide us with an optimal hedge ratio for any risk with relation to the cash flows of the firm, motivated respectively by costly financing and financial distress. In practice, however, Faulkender (2005) points out the issues with hedging debt related interest rate exposures based on the above cash-flow hedging objectives. Supposing a firm's cash flow is negatively correlated with interest rates, what it needs is the ability to pay a low (decreasing) rate when rates are high, and a high (increasing) rate when rates are low. Such an instrument would be an inverted version of a floating rate swap

that does not appear to exist in popular usage. Fixing rates would only neutralize the interest rate effect on financial flows altogether, a solution most modern theories of hedging would reject. Apart from that, fixed rate debt could also lead to borrowing constraints in low interest rate states, or a higher cost for the option of refinancing (as also seen in the model from Section 2). Thus, this model is set up so that the investor faces interest rate risk from both fixed and variable rate borrowing.

One element of risk that (*ceteris paribus*) decreases with maturity is repricing risk. In the traditional sense, this links the credit spread to the quality of a firm's projects. Hence the short-term versus long-term trade-off in the optimal maturity literature is concerned mainly with questions such as asymmetric information about future prospects. In this paper, this type of repricing risk is not incorporated, since I have assumed a constant default premium. I submit that this should not affect the decision of fixed versus floating interest rates as much as it would affect the maturity question. Although it is true that the duration for floating rate bonds does not depend on their maturity, choosing an optimal maturity is not the same as choosing an optimal mix of fixed or floating rate debt. In fact, if one divides the interest rate paid by the firm into the base market rate and the credit spread, it becomes clear that the optimal maturity (and thus repricing risk) question addresses one part of the interest cost (credit spread), while the fixed versus floating addresses the other. The 'repricing risk' we see in this model is really only related to the market interest rate being higher, and not specifically the spread component

The assumptions of the model closely follow those in Campbell and Cocco (2003) and are only adjusted to the extent necessary to study the problem of a firm that is financing a productive asset as opposed to a household that finances a mortgage and must consume residential services. We can then predict based on this papers and those on optimal capital structure such as Anderson and Carverhill (2007), that the firm maintains a precautionary balance of cash on hand. This is ostensibly to reduce the variance of periodic dividends and to retain funds for paying coupons in low cash flow states. This could also be interpreted as both an across-time and across-state hedging policy whereby new investment opportunities could be viewed as mutually exclusive and be funded through the dividends.

## 4 Solution Mechanism and Parameter Choices

Due to the number of variables in the model and its overall complexity, I follow the earlier literature in solving a discretized version of the model numerically by use

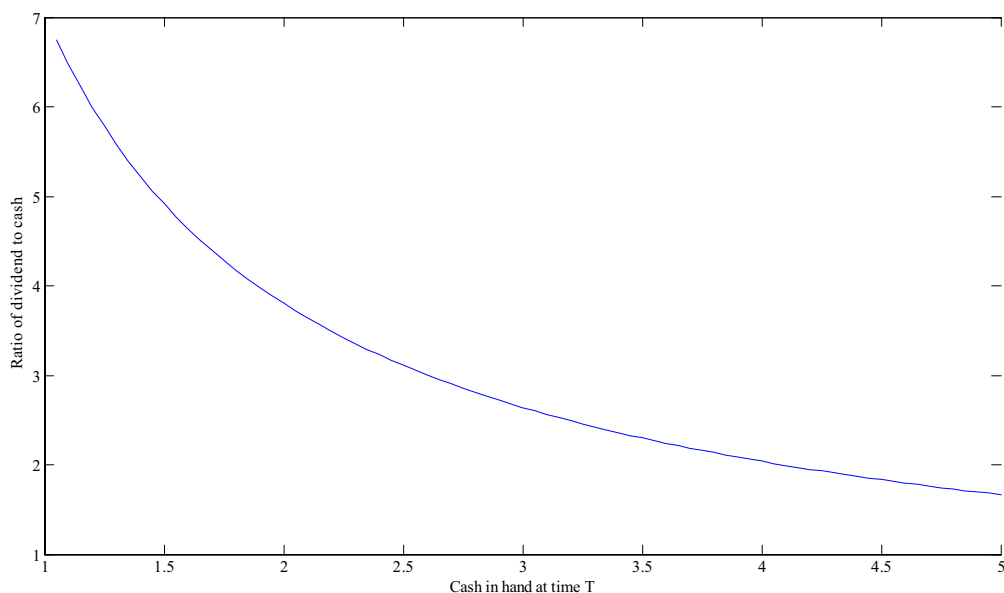
of a search algorithm that takes into account all feasible combinations of state and control variables. As the utility and value function coincide in the last period, I work backwards by estimating a policy rule at date  $T$ , then using that to determine the optimal dividend at date  $T - 1$ , and so on. In order to integrate out the two transitory shocks to income, I use two-dimensional Gauss-Hermite quadrature (Judd, 1998). Further, I approximate the interest rate process with a two-state Markov chain as in Campbell and Cocco (2003). The nominal interest rate process is assumed to have an autoregressive parameter of 0.75, generating extreme high and low interest rates of 0.19 and 0.005, respectively.

The benchmark value for  $\gamma$  is set at 3. However, since we would like to learn about cross-sectional predictions from the study as well, I estimate the model using  $\gamma$  equal 2 and 8. I set  $\mu$  at 6% in line with the oft-quoted historical equity risk premium, and choose a  $\theta$  of 2% for the firm-specific default premium. The term premium  $\xi = 1.2\%$  is based on an estimate for the past decade of the difference between 10-year swap rates and the 6-month LIBOR. If the asset were perpetually lived, a reasonable estimate of  $\zeta$  could be  $1/(\bar{r} + \mu)$ . I finally settle on  $\zeta = \ln(10)$ . By not incorporating a drift or growth term, and (without loss of generality) initializing  $V_0$  at  $\exp(\zeta)Z_0$ , I significantly simplify the selection of the gridpoints in the state space. Finally, I discretize the state space for future income through a Markov chain (Tauchen and Hussey 1991) with 7 states.

The tax rate  $\tau$  is set at 30%. I do not consider that the firm must pay taxes on interest earned every period, but this would not change the solution or the results in any useful manner.  $\lambda$  is set at 0.3, which might be considered low for a borrowing boundary, but a good representation of typical leverage. My argument is that the default premium in this model is not endogenously determined or dynamic. It is clear to see that firms that attempt to borrow from the market in times of higher risk (through leverage) would be expected to pay a higher premium than under regular conditions. Instead of explicitly modeling this cost as a convex function, I instead choose a  $\lambda$  that rules out borrowing in more difficult conditions.

For a given level of cash in hand, for a particular realization of income and for a specific realization of the interest rate among the values on the grid, I choose all permissible levels of dividend payment and short-term borrowing (which may be used to pay dividends). I calculate the value associated with these combinations of dividends and borrowing, and find the dividend that returns the maximum value. I do not use a penalty function for the maximization process, instead relying on a grid search and taking care to rule out the cases which are not possible. Thus, in some cases, when

the financing limit is breached,  $B_t$  is set at zero, and the maximum dividend payable becomes the existing cash on hand  $X_t$ . At other times, the maximum total amount available for dividends is  $X_t + B_t$ . I concurrently optimize  $B_t$  and  $\delta_t$  in such cases, in the sense that I choose the optimal  $\delta_t$  for each permissible value of  $B_t$ , and then choose the highest value of  $\delta_t$  for all permissible values of  $B_t$ . A policy rule can be found by finding a maximum for each combination of cash in hand, income realization, and interest rate realization. This procedure is iterated backwards to time 0. Please see Figure 2 for an example of the policy rule. I plotted the dividend payment as a proportion of cash in hand for a range of values at the average level of income. We can see that in the final period, conditional on no default in prior periods, the short-term borrowing can be several times the available cash in hand in many cases, so that the actual dividend is almost constant across states.

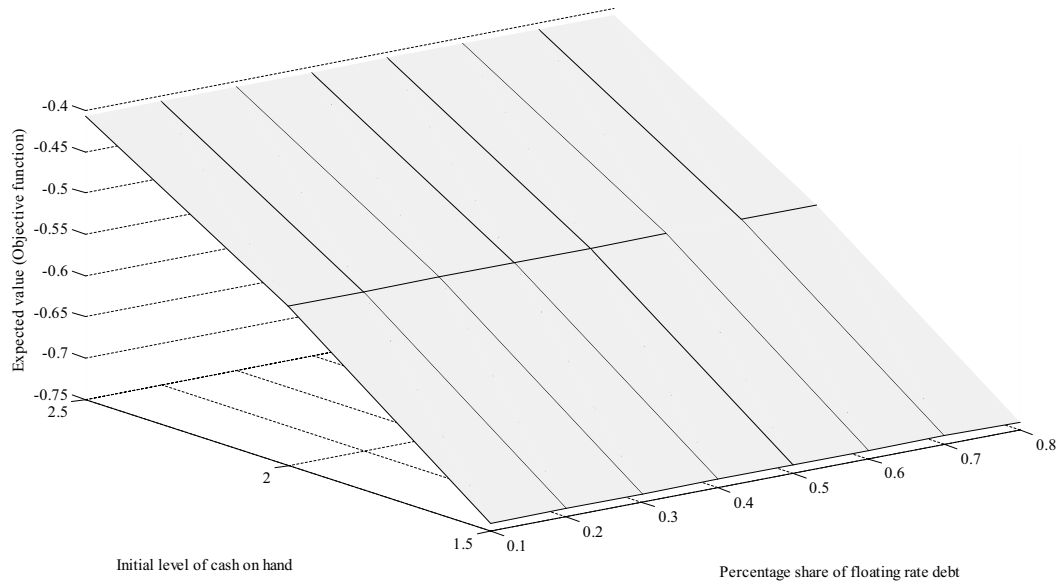


The ratio of dividends to cash on hand at time  $T$  (the penultimate date). Cash on hand is on the x-axis.

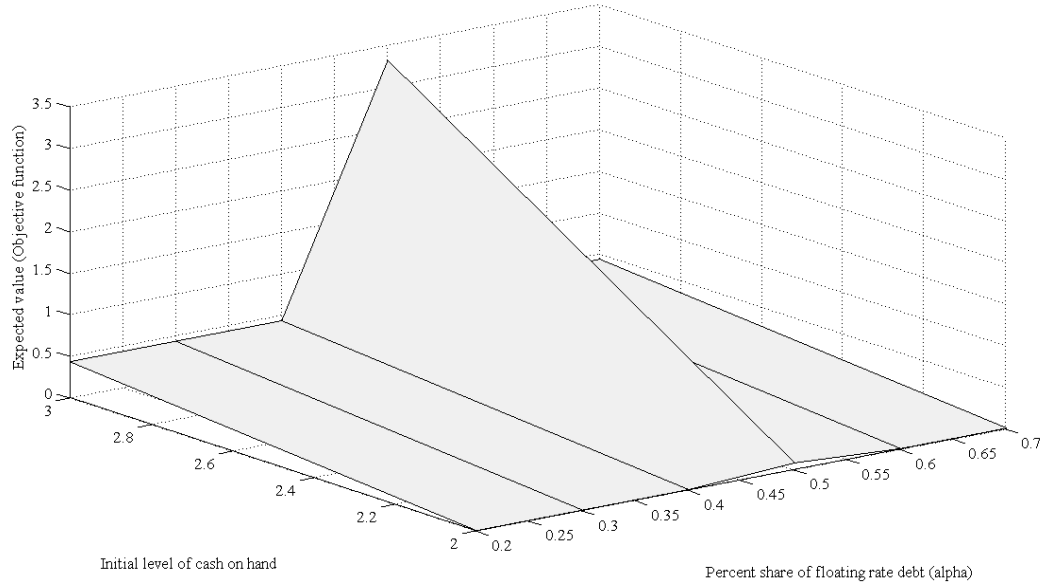
## 5 Model Predictions

The main parameter of interest, however, is the smoothing constraint  $\gamma$ . Below, I compare two objective function outcomes for various levels of  $\alpha$ . I do this by calculating what would be a value function in the sense of being the expected discounted sum of the optimal stream of future incomes modified by the smoothing parameter.

At time 0, I plot the surface of this value function with respect to combinations of intermediate levels of initial cash on hand and  $\alpha$ , the proportion of floating rate debt. In Figure 3,  $\gamma$  is 2. We can see that the firm is almost indifferent to the choice of  $\alpha$  in the intermediate range plotted, and is only sensitive to initial levels of cash on hand. I find that at both extreme levels of  $\alpha$  (closer to 0 or 1), the value function takes an extreme negative value (order of  $10^6$ ), and thus cannot include them on the same graph. This seems to show that, as long as the firm is within intermediate ranges of fixed and floating rate debt proportions, it is not significantly affected by the exact proportion. One reason for this might also be the manner in which the problem is set up on two fronts. First, short-term borrowing may also be used to exploit the tax shield of debt. Second, the interest rate process is fairly predictable and stable with low risk of scenarios such as hyperinflation.



*Objective function when  $\gamma = 2$ .* The axis on the left is cash on hand and on the right is the proportion of floating rate debt. Extreme values of  $\alpha$  both cause significantly lower values, and alter the scale of the graph.



*Objective function when  $\gamma = 8$ .* The axis on the left is cash on hand and on the right is  $\alpha$ . The objective function shows improvement from extreme values of  $\alpha$  (0 or 1) to interior values, and then at the centre again.

The findings change significantly when  $\gamma$  is set at a higher level of 8, however. Now, there is a clear improvement in the objective function as we move closer to a ratio of 0.5, or equal quantities of fixed and floating rate debt. The reason that it the maximum moves to the centre can be interpreted based on the static model in Section 2, i.e. the absence of explicitly modelled correlation between interest rates and income. Clearly, any correlation would shift the optimum away from 0.5, higher in the case of positive correlation, and lower in the case of negative correlation. Once again, the extreme proportions of fixed and floating rate debt are associated with very large negative values in this solution. I would hypothesize that the boundaries would also shift in response to correlation between income shocks and interest rate surprises.

## 5.1 Empirical Predictions

I find that for intermediate levels of initial income realizations (and thus cash on hand), there is a clear ordering whereby increases in the proportion of variable rate debt diminish the value of payoffs to the investor. However, at very low levels and very high levels of  $X$ , the ordering no longer stands. This is consistent with other findings in risk management studies. For instance, Purnanandam (2008) finds that firms would increase risk when they are closer to a default barrier.



Faulkender (2005) shows with a sample of chemical industry firms' debt issuances that they are likely to be timing the market in a display of myopic behaviour. On the other hand, Baker, Greenwood and Wurgler (2002) find evidence consistent with the idea that the corporate sector as a whole chooses the maturity of debt to minimise cost of borrowing. They imply that firms may be successfully timing debt issuances simply because of predictability from the term structure. Christoffersen, Nain and Otero (2009) distinguish firms that adjust the composition of their interest rate exposures actively over a period of time, and yet find no evidence that firms are hedging the sensitivity of their cash flows to interest rates or that they are likely to anticipate changes in monetary policy. This appears to suggest that firms are not successful at either hedging or speculating, despite actively varying their exposures. One of the limitations for tests of firms' hedging policies with respect to interest rates, however, is that , forcing us to look at time variation as a proxy for active adjustment.

One way of identifying firms that are hedging interest rate risk would be to match the implied risk aversion from their choice on the proportion of floating and fixed rate debt to the sensitivity of their earnings to earnings surprises. Admittedly, the latter metric could reflect other factors including information asymmetry, but if calibrated appropriately, the projection of the implied  $\gamma$  onto the sensitivity should also offer insights on other firm characteristics that would affect this interaction. We have seen that choosing interest rate proportions is particularly important for some firms, and may have a marginal impact on others within a range of values. Thus, the underlying sensitivity of firm value to surprises would be a key determinant of the firm's policy.

Other ways in which  $\gamma$  can be matched to firm characteristics rely on the technological and informational aspects of the firm. As it determines the concavity of the objective function, it can be associated with constraints that would affect this particular feature. From the literature, we know that this would vary across firms based on the nature of their production function (returns to scale), the time-sensitivity of investment opportunities, degree of asymmetric information affecting external financing costs, and the severity of financial distress costs. Delving further, financial distress costs might be sensitive to the specificity of capital and the degree of competition in the industry. Finding more accurate proxies for hedging needs from the point of view of correlation between cash flows and investment opportunities has been elusive due to the underlying endogeneity in the relationship between the two variables. Acharya, Almeida and Campello (2007) propose using the correlation between a firm's cash flows and an industry level proxy for investment needs such as research and development expenditure or future realized sales growth. This would help cap-

ture industry-level heterogeneity at least, though it is not clear that we would be able to rank firms' needs across industries. One way to seek empirical verification of the risk management theories listed above is thus a backwards route, i.e. to use available conditioning information on production, financing costs, growth opportunities, and informational asymmetry to establish a one-to-one relation between  $\gamma$  and  $\alpha$

Apart from  $\gamma$ , the parameters available (in the sense that they may be matched to empirical data) include  $\lambda$  (the limit on leverage),  $\sigma_\eta$  (the variance of the income process), and  $\xi$  (the correlation of transitory income shocks with interest rates). The limit on the leverage has weaker justifications for being a focus of study in this model, primarily because it is difficult to associate exogenously determined limits on particular kinds of assets.

The estimation of the relationship between operating income and interest rates has been done by Faulkender (2005) where he estimates a beta on quarterly data. Christoffersen, Nain, and Oberoi conduct a similar panel regression to reduce the noise in the estimate. Given the straightforward implication that marginally, a positive correlation between income and interest rates would lead to more variable rate debt, such a relation could also be tested. However, Christoffersen, Nain, and Oberoi find no evidence of such a relationship *on average*.

Meanwhile, a search of the Internet for “interest rate management” leads to a long list of web sites of financial institutions offering advice on the use of interest rate derivative instruments such as swaps, caps, floors, and collars. For instance, the use of collars is promoted in the case of firms that experience an abnormal increase in debt (e.g., due to an acquisition). If they perceive a risk of rates rising in the long term, but are confident of low rates persisting in the medium term, firms may also enter into forward starting swaps. The notional values on which swaps are based may also accrete or amortize, and even vary to match seasonal debt requirements. Hence, for a given debt profile, firms can engineer a wide variety of outcomes, but there is no clear idea of what their choice should be in order to reduce the risk from interest rates.

## 6 Conclusion and Further Work

Several studies have found evidence of heterogeneous stock market reaction to monetary policy shocks (Ehrmann and Fratzscher 2003). Empirical studies have found that small firms, those with more information asymmetry, and those dependent on banks for financing, are affected the most by interest rate increases. This appears to be

consistent with the notion that potentially constrained firms would be more affected by interest rate increases. In line with this, Beatty, Chen, and Zhang (2009) report that banks typically require constrained borrowers to enter into fixed-rate swaps as a condition of lending them money. These findings suggest that there is significant heterogeneity in the relative importance of the financing constraint versus the cash flow risk of making periodic payments from income. However, given the flexibility in interest rate management afforded by the variety of derivative and debt instruments available, it is possible for a firm to engineer any type of sequence of payments keeping in mind its unique repricing and rollover risks. This paper moves a step further to disentangle these two elements and offer a framework for choosing the proportion of fixed and variable debt a firm should be issuing.

When interest rates rise or fall, they have an impact on a firm's cash flows and its investment opportunities, potentially constraining its ability to make optimal investment decisions. The constraints brought on by financing limits in particular, may be mitigated by holding more cash or optimally transferring liquid assets between states with abundant capital and those where capital is needed. Of course, the effects of financial distress may be avoided mainly by lowering overall risk in the first place. Managing interest rate risk better may thus lead to a reduced need to hold cash and an increased ability to take on more risky projects.

I do not explicitly model considerations of changing credit quality or managerial incentives, but having assumed that the firm would face risk management incentives, I find a pattern for the optimal interest rate exposure for a firm given its cash flows, reserves of cash, asset value, and external information based constraints.

The setup of the model ensures that a firm has risk management incentives, and it is thus not surprising that I find in the case of interest rates that risk preferences run parallel to the general literature. However, I show that both extreme fixed rate and extreme floating rate positions are risky, and that the firm's choice is consistent with this idea. One of the limitations of the current model is that I am using a two-state Markov process to estimate the interest rate. In future work, I intend to test the implications of this model with simulations based on alternate specifications of the interest rate process that might allow for richer variation and co-variation with respect to firm cash flows.

Further, debt is often issued with in-built derivative contracts such as call or put provisions which are akin to floor and cap contracts traded with third parties. I do not consider the value of options but these could be built into the current framework quite effectively. If we are willing to remain within a reduced form setup with respect

to the *reason* for the firm choosing to smooth cash flows, the flexibility of this model could be used for a more enhanced calibration of the firm's joint choices concerning target cash levels, proportion of short-term debt, and proportion of fixed to floating rate debt required to deal with interest rate risk.

Finally, while this study addresses an important aspect of the financing choice set for a firm, it abstracts from certain aggregate features of the marketplace. Beyond the extent that factors such as liquidity and other borrowing conditions enter the equation through the interest rate, there might be more complex interactions at the aggregate level. For instance, the supply of credit and demand for credit might both be concentrated along the time dimension and cross-sectionally based on regulations or industry for instance. These conditions should not be ignored in an equilibrium sense, and it is left to future work to incorporate the effects of industry interactions on the fixed versus floating rate threshold for a standalone firm.

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## Appendix

### 1 Correlation between cash flows and interest rates in the static model

$$\bar{r} = pr_H + (1 - p)r_L$$

$$\bar{C} = (pq + (1 - p)(1 - q))C_H + (p(1 - q) + (1 - p)q)C_L$$

$$\begin{aligned} Var(C) &= (pq + (1 - p)(1 - q))(C_H - \bar{C})^2 + (p(1 - q) + (1 - p)q)(C_L - \bar{C})^2 \\ &= (C_H - C_L)^2(p + q - 2pq)(2pq - q - p + 1) \\ &= (C_H - C_L)^2\{q - q^2 + (p - p^2)(1 - 2q)^2\} \end{aligned}$$

$$\begin{aligned} Var(r) &= p(r_H - \bar{r})^2 + (1 - p)(r_L - \bar{r})^2 \\ &= p(r_H - pr_H - r_L(1 - p))^2 + (1 - p)(r_L - pr_H - r_L(1 - p))^2 \\ &= p(1 - p)(r_H - r_L)^2 \end{aligned}$$

$$\begin{aligned} Cov(C, r) &= pq(C_H - \bar{C})(r_H - \bar{r}) + p(1 - q)(C_L - \bar{C})(r_H - \bar{r}) \\ &\quad + (1 - p)(1 - q)(C_H - \bar{C})(r_L - \bar{r}) + (1 - p)q(C_L - \bar{C})(r_L - \bar{r}) \\ &= p(1 - p)(2q - 1)(r_H - r_L)(C_H - C_L) \end{aligned}$$

$$\begin{aligned} \rho &= \frac{p(1 - p)(2q - 1)(r_H - r_L)(C_H - C_L)}{\sqrt{p(r_H - r_L)^2(1 - p)(C_H - C_L)^2(p + q - 2pq)(2pq - q - p + 1)}} \\ &= \frac{p(1 - p)(2q - 1)(r_H - r_L)(C_H - C_L)}{(C_H - C_L)(r_H - r_L)\sqrt{p(1 - p)(p + q - 2pq)(2pq - q - p + 1)}} \\ &= (2q - 1)\sqrt{\frac{p - p^2}{q - q^2 + (1 - 2q)^2(p - p^2)}} \end{aligned}$$



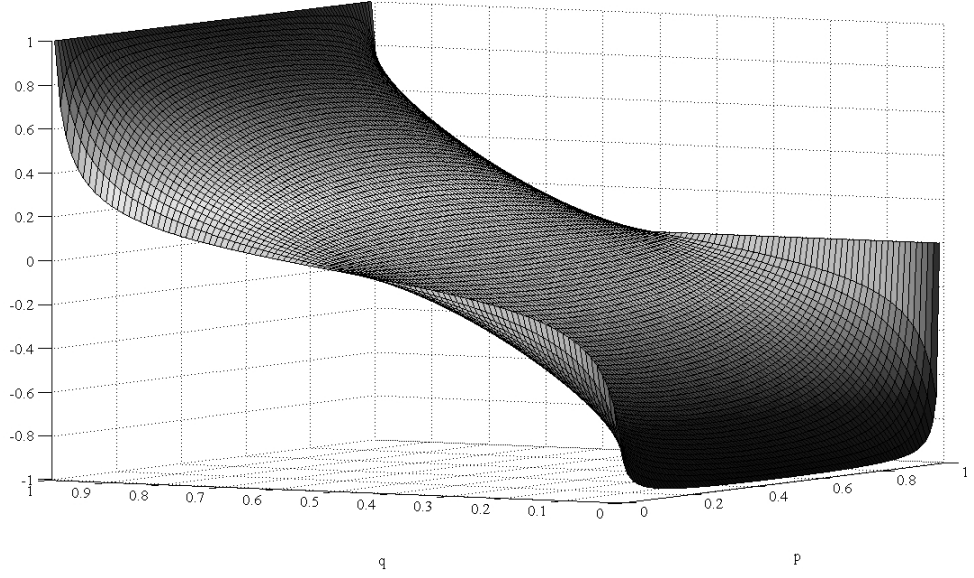


Figure A.1: Correlation between interest rates and cash flows in the static model. The correlation increases and decreases with the probability parameter  $q$ . Opposing extreme values of  $q$  and  $p$  also lead to increases in correlation, offering a rich set of alternatives.

## 2 Income Process

$$\begin{aligned}\ln Z_{t+1} &= z_{t+1} = v_{t+1} + \omega_{t+1} \\ v_{t+1} &= v_t + \eta_{t+1} \\ \therefore Z_{t+1} &= \exp(v_t + \eta_{t+1} + \omega_{t+1})\end{aligned}$$

## 3 Value process

The value of the firm at any time  $t$  is completely determined by the process  $\{v\}_{s=0}^t$  up to the starting value  $V_0$ . In the paper, I assume  $V_0 = \exp(\zeta) Z_0$ .

$$\ln V_{t+1} = v_{t+1} = v_t + \zeta \eta_{t+1}$$

We already have

$$\begin{aligned}v_t &= v_0 + \eta_1 + \eta_2 + \dots + \eta_t \\ \therefore \eta_1 + \eta_2 + \dots + \eta_t &= v_t - v_0\end{aligned}$$

Now,

$$v_{t+1} = v_0 + \zeta (\eta_1 + \eta_2 + \dots + \eta_{t+1})$$

$$\begin{aligned}
&= v_0 + \zeta (v_{t+1} - v_0) \\
\therefore V_{t+1} &= V_0 \exp(\zeta) \exp(v_t - v_0)
\end{aligned}$$

## 4 Solution Steps

If there is no default, in the final period we have:

$$\begin{aligned}
V_T(X) &= U_T + \beta E_T[V_{T+1}(X)] \\
&= \frac{\delta_T^{1-\gamma}}{1-\gamma} + \beta E_T[V_{T+1}(X)]
\end{aligned}$$

At  $T + 1$ ,

$$\begin{aligned}
\delta_{T+1} &= W_{T+1} \\
&= (W_T - \delta_T + B_T)(1 + R_{1,T+1}) + (1 - \tau) Z_{T+1} \\
&\quad + Val_{T+1} - D_0 - C_{T+1} - B_T(1 + R_{T+1}(1 - \tau))
\end{aligned}$$

Thus,

$$E_T[V_{T+1}] = \int_{R^2} \left[ \frac{\{W_T - \delta_T - (1 - \tau) C_T\}(1 + R_{1,T+1})}{+(1 - \tau) Z_T \exp(J_T) + Val_T \exp(K) - D_0} \right]^{1-\gamma} L dx_\eta dx_\omega$$

$$\begin{aligned}
J &= v_T + \sqrt{2}\sigma_\omega x_\omega + \sqrt{2}\sigma_\eta x_\eta \\
K &= \zeta \sqrt{2}\sigma_\eta x_\eta \\
L &= \frac{1}{1-\gamma} \exp(-x_\eta^2 - x_\omega^2) 2\sigma_\eta \sigma_\omega
\end{aligned}$$

Here, I am writing  $Val$  for the value of the assets  $V$ , in order to avoid confusion with the value function in the iterative procedure.

### 4.1 Degree 5 rule using 9 points

The Gauss-Hermite quadrature rule from Judd (1998) for two-dimensional integrals is reproduced here.

To calculate  $\int_{R^2} f(x) \exp(-x_1^2 - x_2^2) dx$

$$A = \frac{\pi}{2}, B = \frac{\pi}{16}, Q = \frac{\pi}{16} = B$$

$$\begin{aligned} \therefore \quad & \frac{\pi}{2} f(0,0) + \frac{\pi}{16} f(ae^1) + f(-ae^1) + f(ae^2) \\ & f(-ae^2) + \frac{\pi}{16} [f(be + be^2) + f(-be - be^2)] \end{aligned}$$

$$\text{where } a = \sqrt{2}, b = \sqrt{\frac{1}{2} + \frac{1}{2}} = 1$$

## 5 Estimating the Markov process

The matrix for estimating the two-state Markov process over time is reproduced here.

$$p^m = \begin{bmatrix} \frac{1-p_{22}+\lambda_2^m(1-p_{11})}{2-p_{11}-p_{22}} & \frac{1-p_{22}-\lambda_2^m(1-p_{22})}{2-p_{11}-p_{22}} \\ \frac{1-p_{11}-\lambda_2^m(1-p_{11})}{2-p_{11}-p_{22}} & \frac{1-p_{11}+\lambda_2^m(1-p_{22})}{2-p_{11}-p_{22}} \end{bmatrix}$$

$$\lambda_1 = 1, \lambda_2 = p_{11} + p_{22} - 1$$

# 5

## Summary and Conclusions

The three papers in this thesis address the question of interest rate risk faced by non-financial firms when they choose to issue debt either at fixed rates or at floating rates. I first survey the corporate risk management literature and identify the limitations of existing theories and empirical tests in explaining interest rate risk management. Further, in the second paper, we collect and analyze a unique dataset that sheds further light on the highly heterogeneous choices of firms and on the absence of a relevant benchmark. Finally, in the third paper, I propose a theoretical approach to explaining the choice between fixed and floating rate debt.

It is clear that interest rate exposure is a significant question for firms. A rough indicator of this is the fact that the gross market value (*not* notional value) of interest rate derivative contracts which involved non-financial counterparties exceeded USD 800 bn in 2010. It is no wonder then that the use of derivatives has often led to serious mishaps and litigation involving both sophisticated and unsophisticated firms. Despite this, interest rate swaps are often referred to as cost-saving devices. What further confounds our understanding of interest rate exposure management is that it is not carried out exclusively through derivatives usage. It should then be no surprise that reliance on derivative usage as a proxy for hedging has contributed to contradictory findings in the empirical finance literature. Should we be able to observe the appropriate exposure measures for firms, a further problem is that no clear benchmark is available for hedging the dual nature of interest rate risk. These points are emphasized in the survey paper, which also covers the development of risk management theory in general and attempts to highlight the need for a dynamic rather than static approach to the theory.

The second paper starts out with the objective of distinguishing hedging activity from speculation using a hand-collected dataset. We do this by identifying firms that are more active in varying interest rate exposure and checking that this activity is not convincingly related to the traditional variables that reflect hedging motives in risk management theory or the empirical literature. We find that while firms with higher growth opportunities are more active, those with higher leverage are in fact not. We also find no evidence favouring variables related to liquidity. Instead, and contrary to expectations, we find that firms with lower sensitivity to interest rates in their underlying business cash flows are more likely to be active in varying their exposures. We also evaluate whether changes in exposure prior to monetary policy surprises are ex-post profitable, and whether they are in any way linked to real performance of the firm. Firstly, we can confirm that firms are on average not skilled at predicting interest rate surprises, if that is indeed their motive in varying exposures. In addition,

those who do vary exposures more have no apparent advantage on average in firm performance parameters such as profitability. At the same time, in the year following a policy surprise, firms that had made an ex-post profitable decision perform better than others on their before-interest-expense profit margins. This turns out to be related to cost management rather than revenue advantage, supporting the idea that managers act consistent with their views when taking interest rate exposure decisions.

The other issue identified in the survey and the second paper is the lack of a benchmark by which to determine what the optimal exposure is for a firm. In other words, how should managers choose between issuing fixed or floating rate debt. The third paper proposes an approach to this problem by looking in a dynamic context at two dimensions of interest rate hedging, viz. while fixing rates may lead to borrowing constraints, floating rates may lead to cash flow constraints. In this paper, I suggest a reduced-form model so that one may find the optimal mix based on firm characteristics such as cash flow exposure to interest rates or the degree of convexity of external financing costs. The model is a finite horizon discrete time dynamic setup that is consistent with target-cash-on-hand models established in the corporate finance literature. Having assumed that the firm would face risk management incentives, I find a pattern for its optimal interest rate exposure given its cash flows, reserves of cash, asset value, and external information based constraints. The benefit from maintaining an optimal mix of debt within a tighter range increases as the smoothing constraint gets stronger, and it is clearly best for a firm to have an equal share of the two types of debt when there is no correlation between its cash flows and interest rates. I also find that both extremes (all fixed or all floating) lead to significantly lower value for such a firm.

From the perspective of modeling, several issues remain to be studied. First, I consider a single margin (between fixed and floating rate debt) for the firm's interest rate risk exposure. The model in the third essay may be enriched to include the firm's cash balances and level of financing as endogenous decision variables. Further, the use of embedded derivatives in debt contracts is widespread. An analysis of their efficiency in terms of risk management would be useful, as would be the incorporation of these activities in an equilibrium setting. This would help develop a more complete picture of the supply and demand for debt instruments and the manner in which risks are shared between agents in the economy. While the model in the paper is calibrated using realistic values of parameters estimated from data or found in other empirical studies, further work would also involve the use of empirical measures to calibrate the risk-management constraints of firms. This would help carry out more

detailed empirical tests of the model's predictions. It is my hope that we will be able to provide practical advice to firms on optimal exposures once the key risk-sensitivity parameters are linked quantitatively to firm characteristics based on further study.