Corporate Financial Risk Management

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Why do firms hedge: a theoretical framework

2.1 Introduction

What are the fundamental reasons firms engage in risk management? Why do firms hedge or speculate? These questions are at the heart of this dissertation. The purpose of this chapter is to provide a framework that comprehensively integrates the existing theoretical work on rationalizations of corporate risk management. This framework allows us to define a research agenda for the remainder of the dissertation. To his end we survey the literature that has provided a rationale for corporate risk management.

We start our analysis with a discussion of the benefits of risk management in a neoclassical setting. Characteristic for this type of analysis is that the firm is considered a “black box”; it is completely transparent and there are no conflicts of interest between the different stakeholders. In this setting, we identify two - purely exogenous - reasons for firms to engage in risk management.

We then pursue with a discussion of the benefits of corporate risk management in a framework with asymmetric information.1 This perspective has proven to be extremely useful in analyzing a large variety of financing decisions. The existence of asymmetric information creates both moral hazard (or ex post information) and adverse selection (ex ante information) problems between different stakeholders which, in turn, affect the value of the firm. These information problems give rise to all kinds of inefficiencies (suboptimal behavior) or costly actions taken to mitigate the consequences of these problems. In particular, we will concentrate on contracting problems (due to asymmetric information) between the firm and its financiers and between

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1There is asymmetric information "... when the transacting parties are not equally informed either at the outset or ex post..." (Thakor, 1991, p. 137).
the manager and the shareholders. Risk management may reduce some of these contracting problems while increasing others.

Throughout this chapter we use very simple models and stress the main intuition behind a model rather than explore all side issues that arise. Each rationale for risk management presented leads to testable empirical predictions about the characteristics of those firms that are expected to engage in risk management. The empirical tests of these predictions will be discussed in the next chapter. In addition to the empirical predictions, the theories also have implications for the way firms benefit most from risk management. Generally, they provide insights on whether firms should hedge or speculate, where firms should direct risk management to (for example reducing volatility in cash flows versus reducing volatility in accounting earnings), and what types of instruments firms should use to optimize the benefits of risk management.

There are not many reviews of the literature of corporate risk management. Some accessible surveys are Smith (1995) and Smithson (1998). However, these surveys are far from complete and focus only on a subset of the rationales (taxes, contracting costs and investment distortions). Especially in the last few years much progress has been made in other directions. The survey presented here is more comprehensive covering this most recent work.

The organization of this chapter is as follows. In Section 2.2, we analyze risk management in a neoclassical framework. With some additional assumptions, we first show that the famous Modigliani and Miller irrelevance propositions apply both to corporate risk management decisions as well as to other financial decisions. After having established a world where risk management is irrelevant, we identify taxes and bankruptcy costs as the first two (exogenous) driving sources of risk management. Sections 2.3 to 2.6 then analyze risk management decisions in a world with asymmetric information. Sections 2.3 and 2.4 respectively focus on ex post and ex ante information problems between the firm and its financiers as a rationalization for corporate risk management. Sections 2.5 and 2.6, respectively, focus on the ex post and ex ante information problems between the firm's manager and shareholders as a rationale for corporate risk management. Finally, section 2.7 concludes.

2Other noteworthy reviews are included in Duffhues (2000) and Van Bremen (1998). They however have a broader focus than we have. Duffhues (2000) discusses corporate risk management from an integrated approach perspective of financial decision making. Van Bremen focuses on currency risk management of both non-financial firms and financial institutions. We restrict ourselves to the rationalization of corporate risk management by non-financials. Stulz (1996) also discusses theoretical rationalizations of corporate hedging and the failure of these theories to explain corporate practices.
2.2 A neoclassical analysis

2.2.1 Introduction

This section analyzes the corporate risk management decision in a neoclassical framework. Characteristic in this approach is that all stakeholders of a firm agree on maximization of the value of the firm as objective (unanimity principle). In addition, the existence of an ideal type of market is assumed in which information is equally distributed among economic agents who are price takers.\(^3\)

In the neoclassical setting, the value of the firm \((V)\) equals the discounted value of its expected cash flows \(\left( E(CF_t) \right)\) over \(t\) periods,

\[
V = \sum_{t=0}^{\infty} \frac{E(CF_t)}{(1+r)^t}
\]

where the discount rate \((r)\) reflects the investors’ required rate of return on an equivalent risky asset traded in the financial market.

Below, we analyze corporate risk management first in a neoclassical framework with a frictionless markets, then in settings with taxes (Section 2.2.3) and bankruptcy costs (Section 2.2.4), respectively.

2.2.2 The irrelevance of corporate risk management

In 1958, Modigliani and Miller (MM) published an influential paper entitled: “The cost of capital, corporation finance and the theory of investment”. In this paper MM argue that in a highly stylized financial market, the market value of a firm is unaffected by a firm’s capital structure decisions thereby making these types of decisions irrelevant. The basic idea behind this proposition is that firms cannot create value with capital structure decisions that investors can reverse or copy on personal account. Others have extended these irrelevance propositions to all financing decisions and reduced the necessary conditions required to establish this result considerably.\(^4\)

To our knowledge, Stiglitz (1974, p. 853) was the first to explicitly address the irrelevance of the corporate hedging decision.\(^5\) Still muffled away in Footnote 4, Stiglitz argues: “... when

\(^3\)See Haley and Schall (1973) for a text-book on financial decision making in the neoclassical tradition.


\(^5\)An important part of the earlier literature on corporate risk management concentrated on the impact of (price) uncertainty on a firm’s real decisions. This literature goes back to the work of Baron (1970) and Sandmo (1971). In this literature, the firm is characterized with a (concave) utility function thereby
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Relative prices are uncertain. Firms must decide on whether to buy futures (or hold inventories) of inputs or sell futures (or hold inventories) of outputs. In short all such "hedging" decisions have (under the assumptions below) no effect on the market value of the firm.

Although it seems like financial archeology to go back to the analysis pursued in these early papers that explore the irrelevance propositions of financing decisions, we think this is important. First, it helps to develop a clear perspective on the way corporate finance theory has developed. Second, the conditions required to make risk management irrelevant clearly indicate where to look for rationalizations of corporate risk management. A final reason is that we return to the more macro-oriented framework that will be developed in Chapter 5.

Perhaps the simplest way to establish the irrelevance of corporate risk management is to assume that financial markets are perfect and complete. A perfect financial market refers to a frictionless market with (1) no barriers preventing access to financial markets and no market participants that are dominant enough to affect market prices, (2) costless access to the capital markets (there are no frictions preventing the free trading of securities), (3) relevant information about the price and quality of each security freely available, and (4) there are no distorting taxes (see e.g. Brealey and Myers, 1996, p. 22). A complete financial market is a market where there are as many independent securities as there are states of the world. In such a world, all these securities' payoffs span all the consumption possibilities in all future states. Arrow (1964) has shown that such a world can be described by a set of primitive state-contingent securities; securities with a payoff of one in one state and zero in all other states. An important consequence of complete financial markets is that investors can achieve Pareto optimal risk sharing. Financial securities available in the market enable them to equate the marginal utilities of income over all states for each investor. Hence, in such a world investors can achieve full risk sharing. The addition of new securities or new ways of transferring risk can and will therefore not improve risk sharing by definition in such a world, a very general result. In complete and perfect financial markets assuming risk aversion by the firm. These papers argue that a risk averse firm's production decisions are affected by uncertainty. This result however changes if one introduces a futures market where price uncertainty can be hedged. Feder, Just and Schmitz (1980), for example, considered a firm characterized by a utility function that faces price uncertainty in a competitive market which can be hedged on the futures market. In the presence of futures markets they show that price uncertainty does not affect the firm's production decisions. The firm's (or more correctly, the single proprietor's) optimal hedge depends on the expected value of the futures contract. When the forward contract is actuarially priced a risk averse proprietor will completely hedge the price uncertainty. When the value of the hedge contract is positive a risk averse proprietor will underhedge or will not hedge at all. While this may be true for a firm with a single non-diversified owner, this behavior is not obvious for widely held firms.
markets corporate risk management (and all other financing decisions) are irrelevant.\(^6\) Risks are already spanned by the existing securities in the market and firms therefore cannot enlarge the consumption allocation space by entering into risk management. This holds even if there is a non-zero probability of default as long as bankruptcy is not costly.\(^7\)

Since the notion of complete markets is particularly strong, we will continue and verify whether we can achieve the same conclusions in an incomplete financial market. In an incomplete financial market the number of independent securities is less than the number of states of nature. As a result, we can no longer identify Arrow state prices and investors cannot achieve full insurance against all uncertainty by trading in financial securities. Is it even possible to establish the irrelevance propositions in such an incomplete asset market?

There are some important problems when we consider incomplete asset markets. First, the objective of the firm is no longer clearly defined. With complete financial markets, the objective is to maximize the market value of the firm. Given state prices, firms can (and should) maximize the market value of the firm. However, with incomplete financial markets unanimity among shareholders with respect to the firm's optimal decisions is no longer guaranteed.\(^8\) In the theoretical literature the conditions to reach unanimity have been discussed extensively. The introduction of a marginal spanning condition restores unanimity. Marginal spanning implies that the securities issued by the firm are already spanned by other firms' securities.

Below, we will show that in incomplete financial markets - given a marginal spanning condition - the corporate risk management decision is irrelevant.\(^9\)

The Model

We consider an economy that lives initially for one period with a finite number of \(I\) investors and a number of \(J\) firms. There is uncertainty with respect to the state of the world. At \(t = 1\) there are \(s\) mutually exclusive states of the world, where \(s \in \Omega\). We assume that there is a single consumption good in the economy, whose price is uncertain and state dependent. Furthermore, we assume perfect but incomplete financial markets. We assume however that the marginal spanning condition is satisfied; in effect, the firms' securities span the investors' opportunity set.

Firms in our model are exposed to some risk factor in the following way,

\(^6\)See for example Hirshleifer (1964). Using a model where uncertainty is captured with a complete markets state preference model he showed that the firm's financing decisions are irrelevant.

\(^7\)The only effect of the possibility of bankruptcy (at least in one period models) is that it affects the prices of certain state claims.


\(^9\)The model discussed below is based upon DeMarzo (1988) and DeMarzo and Duffie (1991). See also Baron (1976).
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\[ \tilde{Y}_j = \bar{\epsilon} y_j - cy_j \]

where \( \tilde{Y}_j \) refers to the firm’s operating income, \( y_j \) refers to the firm’s output exposed to some random risk factor \( \bar{\epsilon} \) (a future state-dependent spot price), and \( c \) refers to some variable cost function. Assume that \( \bar{\epsilon} \) is uniformly distributed on the interval \([\bar{\epsilon}, \bar{\epsilon}]\) and that the expected future spot price equals the forward rate \( E(\bar{\epsilon}) = f \). The only decision we consider here for the firm is the choice of the number of forward contracts it trades \( (\phi_j) \). All other financing (and real) decisions are assumed to be constant.

**Firms**

We assume that at \( t = 0 \) each firm \( j \)'s production plan is fixed. The firm’s output, \( Y_j \), is state dependent and will be realized at \( t = 1 \). Each firm \( j \) has financed its production plan by issuing financial securities. We only consider debt and equity. Equity is denoted by \( \bar{\varphi}_j \in \Gamma \), where \( \Gamma \) is the set of shares issued by all firms, and \( \phi_j \) refers to the share issued by firm \( j \). Each share provides the holder of the security with a claim on the dividend of the firm at \( t = 1 \). In addition firms have issued an amount of debt equal to \( B_j \). Debt is defined as a promise by firm \( j \) to pay \((1 + r)B_j\) dollars at the end of the period. We assume for the time being that firm \( j \) never defaults on its debt.

To hedge their exposure to the risk factor \( \bar{\epsilon} \) firms may furthermore trade in forward contracts. That is, a firm may buy or sell security (contract) \( h \in H \), which results in a fixed claim or obligation of \( f \) at \( t = 1 \). The gain on a short position in this forward contract is equal to the difference between the future spot price \( (\epsilon) \) and the forward price \( (f) \). As usual with forwards and futures, payment is due at \( t = 1 \). At \( t = 0 \), the securities \( h \in H \) are in zero net supply. If we denote firm \( j \)'s amount of forward trading with \( \phi_j \), then firm \( j \)'s dividend is equal to the sum of its operating income and income from hedge contracts minus the repayment on its debt contracts,

\[ D_j = \tilde{Y}_j + \phi_j (f - \bar{\epsilon}) - (1 + r)B_j \]

**Investors**

At \( t = 0 \) the investor \( i \in I \) is initially endowed with \( \bar{\varphi}^i_j \in V \) in equity of firm \( j \), and \( \bar{b}^i_j \) in bonds of firm \( j \), such that \( \sum_{i \in I} b^i_j = B_j \). We denote the initial endowments of the investor \( i \) as \( W_0 \). Investors may trade equity of firm \( j \) at \( t = 0 \) against prices \( v_j \). Consequently, the investor’s trading must satisfy the budget constraint,

\[ \bar{\varphi}^i_j v_j + b^i_j \leq \bar{\varphi}^i_j v_j + \bar{b}^i_j \]

\[^{10}\]Note that we may ignore margin requirements here, because in a world where the firm cannot default margin requirements are irrelevant.
Investors furthermore trade at date 0 in forward contracts $h \in H$. The payoff of the investments in forwards at date 1 of investor $i$ is $\phi_i(f - \bar{\epsilon})$. Investors use the proceeds of their investments to consume. Therefore, consumption at $t = 1$ of investor $i$ can be written as:

$$c_i^t = \phi_j^t D_j + \phi_i(f - \bar{\epsilon}) + (1 + r)b_j^i$$  \hspace{1cm} (2.1)

Preferences are defined over consumption. We assume these preferences are reflected in a Von Neumann Morgenstern utility function that is strictly increasing, differentiable and concave. Investors then maximize the expected utility of consumption at $t=1$.

As a result we may write investor $i$’s optimization problem as:

$$\max_{\phi_i, \phi_j} E[U_i(c_i^t)]$$  \hspace{1cm} (2.2)

subject to:

$$\phi_j^t v_j + b_j^t \leq \bar{\phi}_j^t v_j + \bar{b}_j^t = W_0^t$$  \hspace{1cm} (2.3)

Substituting this into the consumption function (2.1) results in

$$c_i^t = \phi_j^t D_j + \phi_i(f - \bar{\epsilon}) + (1 + r)b_j^i$$

whereas, optimization requires the following first-order conditions:

$$E[U'(c_i^t)(f - \bar{\epsilon})] = 0$$
$$E[U'(c_i^t)(D_j - (1 + r)v)] = 0$$

Since the utility function is concave, this is sufficient for an interior optimum.

The decision variables for the investor are the investments in the securities $\phi$ and in the forward contracts $\phi_i$. Trading takes place in anticipation of future events; we assume that investors have rational expectations.

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11Although we use a specific utility function the results do not depend on the choice of functional form (see Stiglitz, 1974) as long as, in equilibrium, the investors always choose the same consumption level from a set of consumption possibilities.
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Equilibrium

In order to have equilibrium all markets must clear, therefore:

\[
\begin{align*}
\sum_{i \in I} \varphi^i_j &= \sum_{i \in I} \varphi^i_j \\
\sum_{i \in I} b^i_j &= \sum_{i \in I} b^i_j \\
\sum_{i \in I} \phi_i &= \sum_{j \in J} \phi_j
\end{align*}
\]

The first two conditions guarantee that respectively the stock market and the bond market are in equilibrium. We do not allow firms to issue new securities, therefore investors may only trade in existing securities. The last condition states that there is zero net supply of futures contracts.

Further, it is required that investors choose a portfolio that maximizes the expected utility of consumption subject to its constraints.

**Proposition 1** When there is a general equilibrium where, given a firm’s hedging policy \( \phi_j \) and investor \( i \)'s allocations in stocks, bonds and forwards of respectively: \( \varphi^i, b^i \) and \( \phi_i \), there is another general equilibrium where firms have changed their hedging strategy to \( \hat{\phi}_j \). That new equilibrium is characterized with the same prices for all securities and consequently the same market value for firms. Investors do not change their consumption plan and only reallocate the position in forwards such that in a new equilibrium:

\[
\hat{\phi}_i = \phi_i - \sum_{j \in J} \varphi^i_j (\hat{\phi}_j - \phi_j)
\]

Therefore, corporate risk management is irrelevant.

**Proof.** First we will show that at this equilibrium markets still clear. Since ownership structure nor the amount of bonds has changed these bond and stock markets still clear if they cleared in the old equilibrium. Now we have to show that the forward markets still clear at the new equilibrium. In the initial equilibrium \( \sum_{i \in I} \phi_i = \sum_{j \in J} \phi_j \), so that

\[
\sum_{i \in I} \hat{\phi}_i = \sum_{i \in I} \phi_i - \sum_{j \in J} (\hat{\phi}_j - \phi_j) = -\sum_{j \in J} \hat{\phi}_j
\]

and therefore this market also clears in the new equilibrium.

The second step is to show that the new hedging position of the investors also satisfies the optimal consumption level.

The new consumption level is given by

\[
\bar{c}^i = \varphi^i_j \hat{D}_j + \hat{\phi}_i (f - \bar{c}) + (1 + r)[W^i_j - \varphi^i_j v]
\]
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Since $\hat{D}_j = D_j + (\hat{\phi}_j - \phi_j)(f - \bar{e})$ we can define the optimal consumption level as

$$\bar{c}^i = \varphi^i_j(D_j + (\hat{\phi}_j - \phi_j)(f - \bar{e}) + \hat{\phi}_i(f - \bar{e}) + (1 + r)[W^i_0 - \varphi^i_j v]^i$$

Now substitute the new hedge position, $\hat{\phi}_i = \phi_i - \sum_{j \in J} \varphi^j_i(\hat{\phi}_j - \phi_j)$, in the above equation and we will get

$$\bar{c}^i = \varphi^i_j D_j + \phi_i(f - \bar{e}) + (1 + r)[W^i_0 - \varphi^i_j v] = c^i$$

Therefore, consumption plans are unchanged. If the old consumption plan was optimal, then given the new hedge portfolio, the new consumption plan is also optimal. 

We have shown that even in an incomplete but perfect financial market, the risk management decisions of a firm do not affect the economy and therefore these decisions are irrelevant.\(^\text{12}\)

In general, proofs of these irrelevance propositions depend strongly on the fact that individual investors can duplicate or reverse a firm’s hedging decisions at the same costs as the firm so that personal hedging can perfectly substitute corporate hedging. This is only the case if there are no market frictions, investors have complete information with respect to the firm’s hedging decisions,\(^\text{13}\) there is no costly bankruptcy, and a change in the firm’s financial policy does not change the investors’ expectations.

Now that we have established the conditions under which risk management is irrelevant, we will analyze how certain market imperfections may rationalize risk management. In the neoclassical paradigm, two types of (exogenous) market imperfections have been identified that can make corporate risk management value enhancing, taxes and bankruptcy costs.

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\(^{12}\)Modigliani and Miller (1958) established the irrelevance of financing decisions of a particular firm in a partial equilibrium model with perfect financial markets. The irrelevance proposition that we derived here is more general. For more discussion see Fama (1978) and Stiglitz (1974). Stiglitz (1974) also establishes the irrelevance of financing decisions in a multiperiod model. The irrelevance of financing decisions has also been established in continuous time models. See for example Ingersoll (1987) and Merton (1990). Two additional assumptions need to be satisfied in these models: capital markets are open at all times (such that economic agents have the opportunity to trade continuously) and the stochastic process generating the state variables can be described by diffusion processes with continuous sample paths.

\(^{13}\)DeMarzo and Duffie (1991) rationalize the corporate risk management decision in a framework similar to the one presented here, however under the assumption that investors in a firm do not have information about the exposure to risk. In that case they show that the shareholders benefit if the firm enters into a full hedging policy. This reduces the noise, and enables investors to make better portfolio decisions.
2.2.3 Reducing expected taxes

This subsection shows how in a neoclassical framework corporate taxes may make corporate risk management value increasing. More specifically, we will show that risk management may reduce the expected taxes paid by a firm if taxes are a non-linear function of pre-tax income (see Smith and Stulz, 1985). If taxes are a convex (progressively increasing) function of the firm's pre-tax income, hedging increases the expected after tax value of the firm. The intuition is that corporate hedging reduces the variance of income and therefore removes income from high income states (which are heavily taxed) to low income states (which are less taxed). As a result, the firm reduces its expected tax bill. If, on the other hand, taxes are a concave function of pre-tax income, the risk management strategy that increases the value of the firm is speculation.

The reduction of expected taxes in the face of progressive taxation is illustrated in Figure 2.1. Consider two possible outcomes of a firm's pre-tax income, $Y_L$ and $Y_H$ with $Y_L < Y_H$. If the firm faces a convex tax function $T(Y)$, we can easily see that the expected taxes $E(T)$ paid by the firm are higher if the dispersion in pre-tax income is higher. As a result, a firm can reduce the expected taxes to $E(T')$ by reducing (hedging) the dispersion of income to $Y'_L$ and $Y'_H$. Corporate hedging reduces expected taxes and therefore increases firm value. This result follows from Jensen's inequality. Jensen's inequality states that if $T(Y)$ is a convex function of $Y$ then the expected value of this function is always equal to or higher than the function evaluated at its expected value ($E[T(Y)] \geq T(E[Y])$), provided that expectations exist and are finite (Ross, 1988, p. 356). As we will see in subsequent sections, most of the theories that rationalize corporate hedging (speculation) rely in one way or another on Jensen's inequality. Below, we develop a simple model to explore this more formally.
The model

Consider a model with the following features:

A.1 There are two dates, \( t = 0, 1 \);

A.2 Uncertainty in the economy is represented by a state preference framework. The state of the world at date 1 is denoted with a discrete set of states, \( s \in \{1, \ldots, S\} \). States are ordered with respect to income (i.e. from low to high income);

A.3 Financial markets are complete. We denote with \( P_s \) the price of a state-contingent security that pays out one unit in state \( s \) and zero in all other states (Arrow-Debreu security);

A.4 There are no frictions except taxes in financial markets. The firm’s tax rate is a function of its pre-tax income \( T(Y_s) \);

A.5 The firm’s income \( \widetilde{Y}_s \) is exposed to a random risk factor \( \varepsilon_s \) in the following way: \( \widetilde{Y}_s^U = X + \theta \varepsilon_s \), where \( X \) the firm’s operating income independent of shocks in the risk factor, \( \theta \) is a measure for exposure to the risk factor, and \( \varepsilon_s \) is the future spot price. We use the superscript \( U \) to denote that the income is unhedged;

A.6 \( \varepsilon_s \) is uniformly distributed on \([\underline{\varepsilon}, \overline{\varepsilon}]\);

A.7 The firm can purchase/sell forward contracts on the risk factor. This changes the hedged firm’s income \( Y_s^H \) into \( Y_s^H = X + \theta \varepsilon_s + \phi Z \), where \( f \) is the forward price, \( \phi \) is the number of forward contracts the firm takes, and \( Z \) is the payoff from a forward contract \((Z = \varepsilon_s - f)\). The expected value at date 0 of \( Z \) is zero \((E(Z) = 0)\);

A.8 Hedging by the firm is costless.

We consider the optimal risk management strategies of a firm in a market where there are no frictions other than taxes. The value of a firm at \( t = 0 \) when it does not hedge is equal to

\[
V^U = \sum_{s=1}^{S} P_s(\widetilde{Y}_s^U - T(\widetilde{Y}_s^U)\widetilde{Y}_s^U)
\]

(2.4)

Note that if \( \phi = -\theta \), the firm has a completely hedged position and \( Y_s^H = X + \theta f \). The value of a hedged firm at date 0 is in this case equal to:

\[
V^H = \sum_{s=1}^{S} P_s\{(\widetilde{Y}_s^U + \phi Z) - T(\widetilde{Y}_s^U + \phi Z)(\widetilde{Y}_s^U + \phi Z)\}
\]

(2.5)

In this simple set-up we can proof the following proposition:
Proposition 2 In the presence of corporate taxes risk management may drive down the expected value of corporate taxes as long as taxes are a non-linear function of pre-tax income. With a concave tax function this is achieved by increasing the volatility of a firm’s earnings (not hedging or speculating) and with a convex tax function by reducing the volatility in the firm’s earnings (hedging).

Proof. Risk management contributes to firm value if: \( V^H - V^U > 0 \). The optimal risk management strategy \( \phi \) satisfies the following:

\[
\max_{\phi} V^H - V^U
\]

Subtracting 2.4 from 2.5 gives \( V^H - V^U \) or

\[
V^H - V^U = \sum_s P_s [T(\tilde{Y}_s^U)(\tilde{Y}_s^U) - T(\tilde{Y}_s^U + \phi Z)(\tilde{Y}_s^U + \phi Z)]
\]

The difference in firm value arises only with respect to the expected value of taxes. The first term in the equation refers to the expected value of taxes paid by a firm without risk management while the last term reflects the expected value of taxes paid if it engaged in risk management.

If taxes are a linear function of pre-tax income then \( V^H - V^U = 0 \) for all \( \phi \). The expected value of taxes for a firm that entered into risk management equals that of one that did not. As a result the decision to manage risk or not is irrelevant.

If taxes are a convex function of income then the difference between the value of a hedged and unhedged firm can be increased by reducing the variability of income. This follows directly from Jensen’s inequality. The optimal hedge is that where variability in income is minimized. This requires a full hedging strategy where \( \phi = -\theta \).

Finally, if taxes are a concave function of income, Jensen’s inequality shows that the expected value of taxes is largest when fluctuations in income are largest. Hence, this requires not hedging (\( \phi = 0 \)) if risk management is restricted to hedging (\( -\theta \leq \phi \leq 0 \)) or if it is unbounded taking a speculative position is the optimal risk management strategy.

With respect to the firm’s optimal risk management strategy this proposition leads to the question: are corporate taxes a convex or a concave function of pre-tax income? Convexities in a firm’s tax schedule arise either from progressive tax rates or from specific features of the tax scheme. For example, investment tax credits and tax loss carry forwards below 100% make a tax function progressive, especially in the lower ranges of a firm’s earnings. Graham and Smith (1999) have modelled several provisions of the US tax code in order to estimate the average tax savings from corporate risk management. They found that for most firms the corporate tax function is convex and that corporate risk management (especially hedging) may result in economically significant tax savings and therefore contribute to firm value.\(^{14}\)

\(^{14}\)We will discuss these results more extensively in Chapter 3.
Two important assumptions may bias the results however. First, we have assumed that there were no transaction costs of risk management. Although these costs will reduce the benefits, risk management will remain beneficial as long as these transaction costs are lower than the increase in firm value due to reduced taxes. If transaction costs exhibit economies of scale, the firm either hedges everything completely or nothing at all if the tax scheme is convex. A second (implicit) assumption made is that investors in the forward contract are not being taxed. If they are and taxes paid by these investors are a linear function of the payoff of the hedging instrument, the results of the analysis hold. Personal taxes increase the price for firms against which they will be able to hedge. However, in most countries such a flat tax does not exist; personal income taxes are generally progressive. If the investors' marginal tax functions are non-linear in the payoffs of the hedging instrument, the analysis may become more complex. Especially, if the decreased expected tax liability of the firm is (more than) compensated for by an increased tax liability for the investors. This will increase the investors' required rate of return on the hedging instruments and may offset the benefit for the firm. Smith and Stulz (1985), however, show that as long as there are enough investors that face a linear tax function, they will perform the role of marginal investors and the results of the analysis - as we just discussed - will still hold.

2.2.4 Reducing expected bankruptcy costs

In Section 2.2.2 we did not allow for bankruptcy costs, a condition for risk management irrelevance. Bankruptcy however, is costly. For example, in order for a firm's creditors to assume ownership in the event a firm cannot fulfill its financial obligations, litigation costs have to be made. Moreover, liquidating the firm's assets is costly as well. In this subsection we will show that the existence of bankruptcy costs may serve as a rationale for corporate risk management.

Similar to Kim (1978) we distinguish 3 types of bankruptcy costs:

1. Direct bankruptcy costs - these are the litigation and liquidation costs;

2. Indirect bankruptcy costs - the (negative) effects of financial distress on the cash flows generated by the firm (e.g. lower selling prices, especially of those products that require future service and maintenance, less favorable credit conditions, etc.);

3. Loss of expected tax shields - if a firm ends up in bankruptcy it cannot make use of its future tax shields.\(^{15}\)

\(^{15}\)There has been quite some discussion whether the loss of tax shields is indeed a bankruptcy cost since the availability of these tax shields is an item that can be turned into money relatively easy by selling the bankrupt firm (with only the compensating losses). Although this indeed reduces the value of such loss, we think it almost never fully recovers the complete tax shield and therefore should also be considered as a bankruptcy cost. See also Kim (1978) for a discussion.
The expected bankruptcy costs are equal to the product of the probability of bankruptcy times the associated bankruptcy costs. If corporate risk management (hedging) reduces the probability of financial distress it will also reduce the expected bankruptcy costs and therefore increase firm value. Thus, under the assumptions of the neoclassical framework, bankruptcy costs provide a rationale for corporate risk management (see for example Dumas, 1978 and Smith and Stulz, 1985). We explore the effect of hedging on expected bankruptcy costs more formally in a simple model.

The Model

Consider the set up of the model in the former subsection:

A.1 There are two dates, \( t = 0, 1 \);

A.2 Uncertainty in the economy is represented by a state preference framework. The state of the world at date 1 is denoted with a discrete set of states, \( s \in \{1, \ldots, S\} \). States are ordered with respect to income (i.e. from low to high income);

A.3 Financial markets are complete. We denote with \( P_s \) the price of a state-contingent security that pays out one unit in state \( s \) and zero in all other states (Arrow-Debreu security);

A.4 There are no frictions except taxes in financial markets. The firm's tax rate is a function of its pre-tax income \( (T(Y_s)) \);

A.5 The firm's income \( \tilde{Y}_s \) is exposed to a random risk factor \( \varepsilon_s \) in the following way: \( \tilde{Y}_s^U = X + \theta \varepsilon_s \), where \( X \) the firm's operating income independent of shocks in the risk factor, \( \theta \) is a measure for exposure to the risk factor, and \( \tilde{\varepsilon}_s \) is the future spot price. We use the superscript \( U \) to denote that the income is unhedged;

A.6 \( \tilde{\varepsilon}_s \) is uniformly distributed on \([\underline{\varepsilon}, \bar{\varepsilon}]\);

A.7 The firm can purchase/sell forward contracts on the risk factor. This changes the hedged firm's income \( (Y_s^H) \) into \( Y_s^H = X + \theta \tilde{\varepsilon}_s + \phi Z \), where \( f \) is the forward price, \( \phi \) is the number of forward contracts the firm takes, and \( Z \) is the payoff from a forward contract \( (Z = \tilde{\varepsilon}_s - f) \). The expected value at date 0 of \( Z \) is zero \( (E(Z) = 0) \);

A.8 Hedging by the firm is costless.

In addition, assume:

A.9 The firm has an amount of risky debt outstanding (there are states in which the firm defaults). The face value of debt is denoted by \( F \);
A.10 If the firm defaults on its debt, bondholders receive the value of the firm minus the transaction costs of bankruptcy $C(Y_s)$. The transaction costs of bankruptcy are a decreasing function of $Y_s$.

Hence, we consider an ideal type of market but we now allow for both corporate taxes and bankruptcy costs.

$T(Y_s)$ is again the tax rate when the before-tax income is $Y_s$. In order to distinguish the rationale introduced here from the one developed in the subsection 2.2.3 we assume that taxes are a linear function of firm income.\(^{16}\) The value of an unlevered firm at $t = 0$ is equal to

$$V^U = \sum_{s=1}^{S} P_s \{(\tilde{Y}_s^U) - T(\tilde{Y}_s^U)\tilde{Y}_s^U\} \quad (2.6)$$

Debt financing has two consequences: (i) due to the tax treatment of interest payments it creates a tax shield and (ii) there is a possibility of default in some states (the firm cannot meet its debt obligation). Now assume for simplicity that the firm’s corporate tax shield is linear in the amount of debt, $T(Y_s^U)F$. Obviously, the firm only benefits from this tax shield if it does not default on its debt. Now define state $j$ as the state in which the firm’s income is equal to its debt obligations ($Y_j^U = F$). If the firm’s income is below the face value of debt ($F$) at maturity, that is in states $j$ and below, bondholders receive the firm-value minus the transaction costs of bankruptcy $C(Y_s)$, which we assumed to be a decreasing function of the income realized by the firm. These transaction costs of bankruptcy consist of the direct and indirect bankruptcy costs as specified before. If the firm’s income is larger or equal to the face value of debt, then the bondholders receive $F$. The value of a levered firm then can be described as

$$V^U(F) = \sum_{s=1}^{j} P_s \{(\tilde{Y}_s^U - C(\tilde{Y}_s^U)) + \sum_{s=j}^{S} P_s \{\tilde{Y}_s^U - T(\tilde{Y}_s^U)\tilde{Y}_s^U + T(\tilde{Y}_s^U)F\} \quad (2.7)$$

The difference in value of a levered firm ($V(F)$) and an unlevered firm ($V$) can be presented as follows:

$$V^U(F) - V^U = \sum_{s=1}^{j} P_s \{(T(\tilde{Y}_s^U)\tilde{Y}_s^U - C(\tilde{Y}_s^U)) + \sum_{s=j}^{S} P_s \{T(\tilde{Y}_s^U)F\} \quad (2.8)$$

The first term refers to the bankruptcy states. If $Y_s < F$, then the firm cannot repay its debt. A positive effect of being bankrupt is that one does not need to pay taxes in those states (the first part of that term). However, if $Y_s^U < F$, bankruptcy costs have to be made. These are given by $C(Y_s^U) \leq Y_s^U$, the second part of the first term in equation 2.8.

\(^{16}\)Hence, corporate taxes alone are not a rationale for risk management in this framework.
If the firm survives (states $s = j$ to $S$), then the difference in value between a levered and unlevered firm is equal to the current expected value of the tax shields.\footnote{Note that in our model, we have not explicitly modeled the value of the tax shield, but assume that it is proportional to the amount of debt.} Note that what we have is the trade-off theory of the capital structure; the optimal amount of debt is a trade-off between expected bankruptcy costs on the one hand and the tax shield on the other. However, we take the level of debt as fixed and concentrate on risk management instead.

Since risk management affects the firm's income, it will also affect the state where the firm defaults on its debt. More precisely define the state $k$ such that $Y^a_k + \phi Z = F$. With hedging the value of the firm then becomes

$$V^H(F) = \sum_{s=1}^{k} P_s \{ \tilde{Y}^H_s - C(\tilde{Y}^H_s) \} + \sum_{s=k}^{S} P_s \{ \tilde{Y}^H_s - T(\tilde{Y}^H_s)\tilde{Y}^H_s + T(\tilde{Y}^H_s)F \} \quad (2.9)$$

If the firm hedges ($-\theta \leq \phi \leq 0$) then it reduces its income volatility. The firm's operating income can be lower before the firm defaults with hedging (and hence, with hedging, $k < j$). We can now derive the following proposition defining the optimal risk management strategy:

**Proposition 3** A firm that is financed with risky debt may increase its value by hedging through a reduction of expected bankruptcy costs. The optimal hedge makes debt completely riskless (if possible) or otherwise as riskless as possible.

**Proof.** Risk management contributes to firm value if $V^H(F) - V^U(F) > 0$. The optimal risk management strategy maximizes the difference in value between the market value of the firm entering into risk management and that of one that did not ($V^H(F) - V^U(F)$). Hence,

$$\max_{\phi} V^H(F) - V^U(F) \quad (2.10)$$

Subtracting 2.7 from 2.9, gives after some rewriting

$$\sum_{s=1}^{S} P_s \{ \phi Z \} + \sum_{s=1}^{k} P_s \{ -C(\tilde{Y}^U_s + \phi Z) + C(\tilde{Y}^U_s) \} + \sum_{s=k}^{S} P_s \{(C(\tilde{Y}^U_s) - T(\tilde{Y}^U_s + \phi Z)(\tilde{Y}^U_s + \phi Z) + T(\tilde{Y}^U_s + \phi Z)F \} \quad (2.11)$$

The first term is the expected value of the hedge contract over all states. This term is zero by definition. The second term reflects those states where both a hedged and an unhedged firm
would default on their debt. The hedged firm in these states has a slightly higher expected income (from the payoff of the forward contract, which is positive in these states) and thus, also faces lower bankruptcy costs \( C \). The value of this term is positive, since \( \tilde{Y}_s^U + \phi Z > \tilde{Y}_s^U \) and \( C(.) \) is a decreasing function. Hence, \( C(\tilde{Y}_s^U + \phi Z) < C(\tilde{Y}_s^U) \).

The third term refers to the states where the unhedged firm defaults, while the hedged firm does not. The hedged firm benefits again; it does not face bankruptcy costs and is able to generate a tax shield from debt financing in these states while the unhedged firm does not. The only negative aspect is that the hedged firm in these states has to pay taxes. Again, this term is positive reflecting the fact that expected income is higher for a firm that has hedged.

The last term reflects those states where neither of the firms default. The hedged firm in these states is expected to have a slightly lower income and therefore also pay less taxes. However, this also has a slightly negative effect on the value of its tax shield.

Closer inspection shows that the third term is generally the largest by far. Therefore, if we can increase the number of states where the hedged firm does not default, while the unhedged defaults, the benefit from hedging is maximized. Now imagine that there is a hedging strategy \( \phi^* \), such that debt for the hedged firms is risk free for all \( s \),

\[
Y^U + \phi^* Z > F \quad \forall s
\]

then this will be an optimal strategy strategy. The optimal hedging strategy is the one that makes debt risk free or as riskless as possible; that is it makes the number of states where the firm defaults as low as possible. ■

In a neoclassical framework risk management increases firm value through a reduction in expected bankruptcy costs (including the expected value of the tax shield due to debt finance). The focus in risk management then should be on reducing default (or credit) risk of debt. Without any other market imperfections this would imply that a firm should hedge firm value. The firm will only default when the present value of its future cash flows is less than the value of its debt in a neoclassical world. Otherwise, it should be able to attract external finance if the firm has sufficient cash to pay its debt obligations.\(^{18}\) Hence, an optimal risk management minimizes the probability that the firm value is lower than the value of its debt.

Although we have assumed a firm with some risky debt outstanding, a more complete analysis should include the financing decisions as well. Without the possibility of risk management, the financing decision is a trade-off between the benefits of debt financing (the tax shield) and the costs of debt financing (bankruptcy costs). The optimal level of debt is a trade-off between these benefits and costs. However, with risk management expected bankruptcy costs can be reduced,

\(^{18}\)As we will see in the next section, as soon as financing is hampered by other imperfections (e.g. information problems) then a focus on a minimum amount of cash flow becomes the more prevalent strategy
2. Why do firms hedge: a theoretical framework

which implies that the firm can (and at the optimum will) be financed with more debt. This is an important observation showing that risk management and financing decisions are closely related.

An important assumption made in our analysis is that there are no conflicts of interest between financiers. We will argue in Section 2.4 that especially in the face of financial distress there are considerable conflicts of interest between debtholders and shareholders. These conflicts of interest create additional indirect bankruptcy costs and therefore may increase the benefit of corporate risk management. But they may also lead to opportunistiic behavior in risk management. As we will see, the gains of corporate hedging due to a reduction in the expected bankruptcy costs, can only be achieved if a firm is able to credibly commit to such a hedging strategy.

2.2.5 Concluding remarks and empirical predictions: risk management in a neoclassical framework

The neoclassical analysis applied to corporate risk management leads to some interesting insights. First, we have established conditions required to make corporate risk management irrelevant. Subsequently, we identified two exogenous market imperfections that rationalize corporate risk management, taxes and bankruptcy costs. Table 2.1 summarizes the major insights developed in this section and presents the empirical predictions.

With respect to taxes, we have shown that as long as a firm has a non-linear tax function (the firm’s taxes are either convex or concave in its pre-tax income) then firms have a rationale to engage in risk management. For the case of a concave tax function, the firm is expected to increase volatility in taxable income (unhedge or even speculate). With a convex tax schedule the firm is expected to reduce volatility in taxable income.

Therefore, we expect firms with expected taxable income in the convex (progressive) part of a tax function to hedge, while firms whose income is in the concave part of the tax function do not hedge or may even speculate. To increase value, a firm should focus on the volatility of annual taxable income in risk management.

If reducing expected bankruptcy costs is an important rationale for the firm’s risk management strategy, we expect that firms will hedge rather than speculate and that firms with higher expected bankruptcy costs will hedge more (frequently) than those with lower expected bankruptcy costs. Firms will use their risk management to reduce the probability of default. Hence, the focus is on reducing volatility of firm value.

Furthermore, we expect a direct relation between the amount of debt financing in a firm and risk management; the higher the debt ratio (or the lower the interest coverage ratio) the higher the probability of bankruptcy and therefore the more beneficial risk management is in reducing the expected costs of bankruptcy.
2.3 Ex post contracting problems between the firm and its financiers

<table>
<thead>
<tr>
<th>Source</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxes</td>
<td>Firms with convex tax schemes will hedge</td>
</tr>
<tr>
<td></td>
<td>Firms with concave tax schemes will not hedge or speculate</td>
</tr>
<tr>
<td>Bankruptcy costs</td>
<td>Firms with high expected bankruptcy costs will hedge</td>
</tr>
<tr>
<td></td>
<td>Firms that hedge will have higher debt ratios</td>
</tr>
</tbody>
</table>

TABLE 2.1. Taxes and bankruptcy costs as rationales for corporate risk management

Note also that a reduction in expected bankruptcy costs may induce firms to take more debt. Value is then created by increasing the value of interest tax shields rather than through a reduction in the expected bankruptcy costs. Moreover, these firms will not necessarily have a lower likelihood of financial distress compared to firms that do not hedge.

2.3 Ex post contracting problems between the firm and its financiers

2.3.1 Introduction

The previous section analyzed corporate risk management in a neoclassical setting. This setting however is rather limited and only useful to study purely exogenous reasons for corporate risk management.

In order to study the risk management decision in more detail, it is important to consider a richer framework. The modern corporate finance literature recognizes the importance of informational frictions in financial contracting. The acknowledgment of these information frictions has enhanced our understanding of many financing decisions and specific contract features such as covenants, loan commitments, call back facilities, etc.

In this section we consider a framework where we allow for the existence of asymmetric information between the firm and its financiers. We will first concentrate on ex post contracting problems between debt- and shareholders in a firm; that is, we focus on problems that arise due to asymmetric information after the firm and financier have entered into a financial contract. Due to this information asymmetry, financiers cannot perfectly observe what the firm will do with the funds provided by the financiers. In contrast to the neoclassical analysis, a typical result of this type of analysis is that financing decisions do matter in that they alter incentives in the firm, which has real cash flow consequences. In this section we will primarily focus on two investment distortions caused by the presence of risky debt:

- underinvestment (Myers, 1977);
- asset substitution (Jensen and Meckling, 1976).

Asymmetric information and the associated inability to write complete contracts create potential conflicts of interest between debt- and shareholders which affect a firm’s investment
decisions and which are especially relevant if a firm gets close to financial distress. These financial agency problems associated with debt finance add to the indirect bankruptcy costs (see Section 2.2.4) and provide an important rationale for corporate risk management.

2.3.2 Reducing underinvestment

In this subsection we will show how corporate risk management reduces the Myers (1977) underinvestment problem caused by a debt overhang. Myers (1977) has shown that the shareholders of a firm with risky debt outstanding have incentives not to exercise certain positive net present value investment opportunities. Exercising these investment opportunities would result in a wealth transfer from shareholders to debtholders. Debtholders, anticipating such under-investment, will require adequate compensation to be protected against such behavior. Myers (1977) therefore suggests that there is an agency cost of debt financing that reduces the optimal amount of debt in a firm's capital structure.

Risk management may substantially reduce the underinvestment problem, the agency costs of debt, and therefore increases a firm's debt capacity (Mayers and Smith, 1982 and 1987; and Bessembinder, 1991). Corporate hedging reduces the number of states where the firm is in financial distress transferring income from states where the firm can meet its obligations to states where it otherwise could not. This aligns the interests of the stakeholders in the firm and as a result reduces contracting costs. By taking away the conflict of interest, stakeholders with rational expectations will accept a lower compensation. Risk management therefore increases firm value as long as the firm can credibly commit to the hedging strategy over the life of the debt contract. Below we will explore this in more detail.

The Model

To consider the effect of risk management on the underinvestment problem, we extend our model of the previous section. Changes in basic (numbered) assumptions are given by adding a letter to the number while extensions are added to the list that describes the basic features of our model. An important change in the assumptions is that we now assume that all agents in the economy are risk neutral. This reflects the idea that the risk that we consider is diversifiable and therefore does not affect the firm's shareholders required rate of return. Moreover, it simplifies our analysis. A second important change in the assumptions is that there is asymmetric information and, as a result, shareholders and debtholders cannot write complete contracts. More specifically we assume:

A.1 There are two dates, \( t = 0, 1 \);

\[19 \text{We assume here that managers act in the interests of the shareholders.}\]
A.2a Uncertainty in the economy is represented by a state preference framework. The state of the world at date 1 is denoted with a discrete set of states, \( s \in \{1, \ldots, S\} \). States are ordered from low income states to high income states. Each state is equally likely and \( \pi_s \) denotes the probability of state \( s \);

A.3a All agents in the economy are risk neutral. The risk free interest rate is 0%;

A.4a Shareholders and debtholders cannot write complete contracts due to asymmetric information;

A.5 The firm’s income \( \tilde{Y}_s \) is exposed to a random risk factor \( \varepsilon_s \) in the following way: \( \tilde{Y}_s^U = X + \theta \varepsilon_s \), where \( X \) the firm’s operating income independent of shocks in the risk factor, \( \theta \) is a measure for exposure to the risk factor, and \( \varepsilon_s \) is the future spot price. We use the superscript \( U \) to denote that the income is unhedged;

A.6 \( \varepsilon_s \) is uniformly distributed on \([\underline{\varepsilon}, \overline{\varepsilon}]\);

A.7 The firm can purchase/sell forward contracts on the risk factor. This changes the hedged firm’s income \( (Y_s^H) \) into \( Y_s^H = X + \theta \varepsilon_s + \phi Z \), where \( f \) is the forward price, \( \phi \) is the number of forward contracts the firm takes, and \( Z \) is the payoff from a forward contract \( (Z = \varepsilon_s - f) \). The expected value at date 0 of \( Z \) is zero \( (E(Z) = 0) \);

A.8 Hedging by the firm is costless;

A.9 The firm has an amount of risky debt outstanding (there are states in which the firm defaults). The face value of debt is denoted by \( F \);

A.11 Shareholders are in control.

At date 0 the firm has a riskless investment opportunity with a positive net present value (NPV). The investment requires an amount equal to \( I \) and will produce riskless additional income at date 1 equal to \( A \).\(^{20}\) Therefore, total firm income at date 1 is equal to \( \tilde{Y}_s^U + A \) if the investment project is undertaken at date 0 or \( \tilde{Y}_s^U \) if the investment is not undertaken. Assume that at date 0 there is no cash in the firm available and therefore that the investment needs to be financed externally at date 0.

We will first abstract from the risk management decision to provide the intuition behind Myers’ (1977) underinvestment problem. Next, we will show that risk management may reduce the underinvestment problem. The timing of the decisions is as follows. First, the firm has to attract new finance (debt or equity) and make the investment decision. At date 1 the state of

\(^{20}\)Since the investment opportunity has a positive NPV, \( A \) is greater than \( I \) \( (A > I) \) by assumption here.
the world is revealed, income is realized, debtholders are repaid, and the residual is paid to the firm’s shareholders.

If the firm would have no debt outstanding, shareholders would maximize the value of their claim \((V_E)\). Simply comparing the value of their claim with and without the investment shows that it is clearly optimal to invest. The value of their claim without the investment is equal to

\[
V_E = \sum_{s=1}^{S} \pi_s Y_s^U
\]

while the value of their claim with the investment \((V_E(I))\) is equal to

\[
V_E(I) = \sum_{s=1}^{S} \pi_s (\tilde{Y}_s^U + A) - I
\]

The investment has a positive NPV by assumption \((A > I)\), and thus the value of equity with the investment is larger than without \((V_E(I) > V_E)\).

But what if the firm has some existing debt outstanding? How will this affect the investment decisions by the firm’s shareholders? Will they be willing to finance the investment opportunity? With existing risky debt equal to \(F\), the shareholders will only pursue with the investment if this increases the value of their claim. Let \(\tilde{s}\) denote the state where \(Y_s^U = F\); that is, where the firm’s income equals the firm’s obligations from debt. The value of the equity without the project but with risky debt is then equal to

\[
V_E = \sum_{s=\tilde{s}} S \pi_s (\tilde{Y}_s^U - F) \tag{2.12}
\]

Shareholders receive the surplus if the firm does not default on its debt. What happens if the existing shareholders invest an additional amount equal to \(I\)? The investment has a positive NPV. However, the shareholders only receive the benefits of the investment if the firm does not default on its existing debt. More precisely, the shareholders have to share the potential benefits of the investment with the debtholders while running the risk of loosing the initial amount invested in the project. It is clear that the shareholders will only step in if the project has a sufficiently high NPV to compensate them for this additional risk.

More precisely, shareholders benefit only if the value of their original equity claim is larger with than without the investment project. The value of the firm for the shareholders with the investment project equals

\[
V_E(I) = -I + \sum_{s=\tilde{s}}^S \pi_s (\tilde{Y}_s^U + A - F) \tag{2.13}
\]
where $s^*$ is defined as the state where operating income plus the proceeds from the investment equals the obligations to the debtholders ($Y^*_s + A = F$). That is the state where the firm can just pay its debt obligations. Note that $s^* < S$; the investment increases the number of states where the firm does not default on its debt.

The investment therefore has two effects: it may increase shareholders' wealth, but it also increases the existing debtholders' wealth. As we will see, the latter effect is responsible for the underinvestment problem. Comparing the value of the firm's equity when the investment is undertaken (2.13) with the value of the firm's equity without the investment (2.12) gives

$$V_E(I) - V_E = \left\{ \sum_{s^*} \pi_s(Y^ U_s + A - F) \right\} - I - \left\{ \sum_{s} \pi_s(Y^ U_s - F) \right\}$$

The shareholder only proceeds with the investment if this difference is larger than zero. After some rewriting this gives the following condition

$$V_E(I) - V_E = \left\{ \sum_{s^*} \pi_s(Y^ U_s + A - F) \right\} + \left\{ \sum_{s} \pi_s(A) \right\} - I > 0$$

Hence, the shareholder only proceeds with the investment if the additional value of the investment (for the shareholder) is larger than the investment. Note that this condition differs from the case where the firm has no risky debt outstanding. Without risky debt, all benefits of the investment ($A$) accrue to the shareholders and the shareholders will continue with the project if these benefits are larger than the investment. All positive NPV projects are then undertaken. Risky debt causes an investment inefficiency; firms select only those projects with a sufficiently high NPV.

Figure 2.2 illustrates this trade-off. The equityholders will only contribute capital for the investment if the added value for the shareholder of the investment (denoted with abcd in the figure) is larger than the investment. The added value of the investment for the debtholder is equal to the remaining part (cdef). It should be obvious now that there is underinvestment when there is risky debt; equityholders only contribute equity capital for investments that generate sufficient high NPV.\(^{21}\)

\(^{21}\)We can also show that with debt financing underinvestment occurs. The new debtholders do not want to finance the project if the value of the existing debt with the investment project (anticipating the shareholders' incentives) is larger than the value of debt without the investment. Note that the higher the existing debt obligations $F$ relative to $Y$, the less likely it is that the new project will be financed with debt. Higher debt obligations imply a higher probability of default and subsequent higher default premiums asked by the new debtholders. The more the debtholders require from the additional investment, the less likely it is that shareholders will want to step into this investment (the larger the underinvestment problem).
This is a classical example of Myers' (1977) underinvestment problem. Underinvestment caused by a debt overhang is an important agency cost of debt, which might induce firms to issue less debt. Since debt financing also has certain advantages (e.g., a higher tax shield) the optimal capital structure is a trade-off between the benefits and the agency cost of debt.

We now consider the possibility of risk management. Assume that shareholders decide on their risk management strategy (φ) before they attract financing for the new project and commit to this risk management strategy (they cannot lift the risk management decision during the life of the financial contract).\textsuperscript{22} With φ hedge contracts, the income that a firm realizes at date 1 $\tilde{Y}_s^H$ becomes flatter than $\tilde{Y}_s^U$. We can now show that the following result holds:

**Proposition 4** Given the setup above, risk management (hedging) reduces the underinvestment problem and therefore increases the value of the firm. The optimal risk management strategy minimizes underinvestment costs.

**Proof.** We first prove that the underinvestment problem is reduced when the firm has entered a hedge contract.

Next, we prove what the optimal hedge contract should be. Hedging reduces the number of states in which a firm defaults on its debt. It also increases the part of the additional value of the investment that goes to the shareholders, and thus reduces the underinvestment problem. The underinvestment problem completely vanishes if the total additional value of the project accrues to the shareholders. Given our setup, this is the case if debt has become riskless.

\textsuperscript{22}We will discuss this possibility later.
Now define $\phi^*$ as the optimal hedging strategy that reduces the underinvestment problem, we can then show that hedging shifts the locus of states where the firm does not default on its debt to the left (see Figure 2.2).

We have defined $s^*$ as the state where the firm (in case of the investment) just avoids default on its debt: $(Y_s^U + A = F)$. If the firm enters into hedging, the state where the firm defaults shifts to the left ($s'' < s^*$). This can be easily seen from, $Y_s^U + \phi^*Z_{s''} + A = F$. The payoff from the forward contract is positive hence $Z_{s''} > 0$, and the firm can carry a lower unhedged income before it defaults, $s'' < s^*$.

Now what is the optimal hedging strategy? We claim that the optimal hedging strategy is such that $\bar{Y}_s^U + \phi^*Z_s \geq F$ for all $s$. In that case all of the proceeds of the investment go to the shareholders, and the underinvestment problem disappears. If this is not possible, the optimal hedging strategy $\phi^*$ should minimize $\bar{Y}_s^U + \phi^*Z_s + A - F$, that is minimize the default risk of the debt (or the underinvestment costs).

The idea can also be illustrated graphically. Figure 2.2 illustrated the case for the unhedged firm. Note that the underinvestment problem is caused by the fact that shareholders only receive income after the debtholders have been repaid ($F$). Hence, the part of value of an additional unit of investments that contributes to equityholders is the dashed area (abcd). The part of the additional value from the investment under $F$ goes to the debtholders (this is cdef). What happens after the firm entered a hedge contract with an additional payoff $Z$? This increases the firm’s income in the low states and decreases the firm’s income in the high states; $\bar{Y}_s^H$ has a flatter slope. What is the result? This becomes clear as we inspect Figure 2.3. Due to hedging, shareholders receive a larger part of the benefit of the additional investment compared to the unhedged case. Clearly, the graphs show that risk management improves investment efficiency. A firm financed with risky debt that credibly commits to a risk management strategy which reduces the number of states where the firm otherwise would default on its debt, also commits to accept more projects with low but positive NPV’s. These improved investment decisions increase firm value.

What would be the optimal hedge? Note that the underinvestment problem completely disappears when the shareholders capture the total value creation of the investment. Therefore, if hedging increases the firm’s income such that debt becomes riskless ($\bar{Y}_s^H > F$ for all states), then shareholders capture the complete NPV of the investment and, as a result, the underinvestment problem has disappeared completely. Again, as with the bankruptcy argument, the optimal hedging strategy given some exogenous amount of debt would be to reduce the credit risk of debt as much as possible.

Note that we have assumed that the firm was financed with risky debt at the outset. This assumption is by no means trivial. In order to avoid the underinvestment problem, the firm’s shareholders could also refinance the firm; they could simply payoff debt by issuing equity as a
Why do firms hedge: a theoretical framework

substitute for risk management. Hence, the first question should be why does a firm have debt in the first place? Theories on capital structure have provided numerous explanations for issuing debt. Risk management therefore seems an obvious addition to debt financing to reduce the underinvestment problem. For example, the original analysis of Bessembinder (1991) assumes that debt generates a tax shield. Due to this tax advantage of debt financing hedging increases value because it increases the firm’s tax shield and reduces the firm’s underinvestment problem. The key point in the paper is that hedging improves firm value because it allows firms to issue more senior claims (which is beneficial). Hedging reduces the underinvestment problem and therefore allows the firm to take on more debt (with the associated benefits). As a result, we will not find hedging that minimizes the default risk of debt to be optimal. The optimal hedging strategy is a trade-off between the (reduced) underinvestment costs and the advantages of additional debt financing.

Although the analysis focuses on debt contracts, it holds for any claim that has legal priority to equity (e.g. future real services like maintenance contracts, warranties and deferred compensation contracts). This is also stressed in Titman (1984) and Shapiro and Titman (1992). They have shown that in case of financial distress, managers can undermine the interests of customers. For example, in order to reduce costs and prevent or postpone liquidation, they can reduce product quality, lower safety standards, etc. Assuming rational expectations, customers will anticipate these detrimental actions and price this ex ante. Obviously, the firm’s shareholders bear these agency costs and will therefore also have incentives to bond themselves ex ante.

Although any other advantage of debt financing can be used here. For example, Jensen (1986) suggested that debt may reduce the overinvestment problem.
Adequate risk management, such that the firm has a solid financial position over time, may help to build a reputation of safety and reduce these agency costs of liquidation. It may also rationalize why firms include risk management issues in clauses between contracting parties.

Extensions

Below we discuss two extensions to this strand of the literature. First, we discuss a tax related underinvestment problem as rationale for corporate risk management. Green and Talmor (1985) have shown that if a firm has tax deductible items (e.g. non-cash depreciations or tax credits), the firm may have an incentive to underinvest in risky activities if it cannot capture its tax deductions with certainty. By underinvesting in risky activities, it increases its earnings in states where it does not pay taxes and decreases its earnings where it pays taxes. However, such underinvestment is costly. MacMinn (1987) follows this line and shows that corporate hedging may reduce this costly underinvestment. If through corporate hedging the firm is completely certain that it can capture its tax shields, then underinvestment does not occur. Hedging therefore substitutes for the firm’s real decisions but has no apparent disadvantages. Hence, in his framework corporate hedging has two effects on the value of the firm; it increases the value of the firm because it can make full use of its tax shields and the incentive to underinvest in risky (but value creating) activities disappears.\(^{24}\)

A second interesting extension of the literature that rationalizes hedging due to its beneficial effect on the underinvestment problem put forth by Myers (1977), is Mello, Parsons and Triantis (1995). They: “...analyze a multinational firm with flexibility in sourcing its production and with the ability to use financial markets to hedge exchange rate risk.” (Mello, Parsons and Triantis, 1995, p. 28) A multinational with such flexibility will shift production from one country to another if the exchange rate has reached a critical level.\(^{25}\) Issuing debt however, changes the critical exchange rates where the firm shifts between production locations because the owners’ valuation of risks is distorted away from the first best solution (see also Myers, 1977; and Stiglitz and Weiss, 1981).

The benefits of hedging in such a setting are twofold: \(i\). the agency costs of debt go down due to an improvement of the firm’s operating policy (an efficient hedging strategy aligns the interests of debtholders and shareholders, and therefore generates a first best solution) and \(ii\). hedging reduces the deadweight costs of bankruptcy. Mello, Parsons and Triantis’ model is rich in that it incorporates first strategic decisions (in this case where to locate production facilities)

\(^{24}\)MacMinn (1987) further stresses the importance of non-interest tax shields (depreciation charges and tax credits) in his analysis. See for example DeAngelo and Masulis (1980) for an analysis of the same issue in the context of capital structure.

\(^{25}\)See for example Dixit and Pindyck (1994) for models (based on contingent claims analysis) to obtain these switching points.
with the firms’ hedging decisions. Moreover, the firm’s exposure is endogenous in this model and depends on the production location. Most other studies that rationalize corporate hedging consider the firm’s production framework to be static. This view is too simple; optimal hedge ratios derived in these settings should therefore be treated with care. Mello et al. (1995) is the first paper that integrates both the rationale for corporate hedging and its strategic environment in which hedging takes place.\textsuperscript{26}

2.3.3 Asset substitution and risk management

In addition to the underinvestment problem, shareholders of a firm financed with risky debt face another agency problem; they have an incentive to increase asset risk (asset substitution or risk shifting), especially if the firm is close to financial distress (Jensen and Meckling, 1976). The relation between risk management and the asset substitution problem is ambiguous. To understand the potential (ambiguous) relation between risk management we first present the asset substitution problem. We will then show how risk management may reduce the associated agency costs but also that risk management (especially speculation) may increase these agency costs of debt financing. Risk management in the latter case is a relatively cheap way for a firm to engage in risk shifting.

Consider the setup of the model from the former subsection. However, we ignore the investment opportunity $A$, and instead we focus on asset substitution. In their classical analysis Jensen and Meckling (1976), showed that a conflict of interest between shareholders and debtholders exists with respect to the riskiness of the firm’s cash flows.\textsuperscript{27} More precisely, shareholders have an incentive to increase the riskiness of the cash flows after the terms of the firm’s debt financing have been determined. In our model, we can write the value of the payoff accruing to the shareholders (with limited liability) at date 1 as:

\[ V_E = \max\{0, \bar{Y} - F\} \]

and that of the debtholders as:

\textsuperscript{26}The paper also derives some interesting implications on the trade-off between hedging and production flexibility (operating hedge) as a way to reduce exposure. It is shown that hedging enables a firm to move along its production possibility frontier while investments in production flexibility enable a shift in the production possibility frontier itself. Hence, hedging and investments in production flexibility serve different objectives. Also noteworthy in this perspective is Chowdry and Howe (1995) who focus on the difference between operational hedges and financial hedges. They however, show that operational hedges (e.g. having costs and income in the same currency) are especially important if exposure is uncertain. Financial hedging then cannot achieve the same risk reduction compared to operational hedging.

\textsuperscript{27}We assume here that shareholders have limited liability.
2.3 Ex post contracting problems between the firm and its financiers

\[ B = \min \{ \tilde{Y}, F \} \]

These payoff functions resemble those of a call option and a written put option (together with a loan), respectively. Hence, the value of shares (with limited liability) can be considered as a call option on the firm’s date 1 income with the face value of debt as the exercise price. Inspecting the payoff function to the shareholders shows that this function is convex. The convexity is caused by the limited liability nature of equity. Increasing the riskiness of the cash flows (for example via riskier investments) increases the expected value of cash flows to the shareholders. This obviously is costly for the debtholders who see their claim decrease in value. Debtholders - anticipating on this behavior - will require a higher compensation to protect themselves from this risk of expropriation of wealth which is an agency cost of debt.\(^{28}\)

Note that the impact of increased volatility in the value of the shareholders’ option is largest if the option is at the money. This is the case if the firm’s expected income at date 1 is approximately equal to its debt obligations or, in other words, if the firm is close to default.

Is there a role for risk management to be played? Indeed there is, but it is a dual role. Risk management may either increase or reduce the asset substitution problem. First, we argue that risk management is a cheap way to enter into asset substitution in the first place. More precisely, we argue the following:

**Proposition 5** If a firm has existing financial obligations, the optimal risk management strategy ex post (thus, after the financial contract has been entered) from the perspective of the shareholders is to increase risk, that is to speculate. The firm’s incentive to speculate increases with the amount of debt outstanding and the likelihood of default.

**Proof.** The value of equity is equal to the value of a call option on the firm’s assets, with the amount of debt as the exercise price. The value of a call option is increasing in risk and negatively related to the exercise price. As a result, the optimal hedging strategy for the firm’s shareholders is to increase asset risk. Note that this is anticipated by the firms’ debtholders and therefore priced ex ante. ■

Risk management (speculation in this particular case) is a low cost way of entering into asset substitution for a corporation. It is generally much easier for corporations to enter into risk shifting via financial derivatives than via the firm’s real investments. Shareholders of a firm

\(^{28}\)There are several ways a firm’s shareholders can reduce this agency conflict. Boot, Greenbaum and Thakor (1993), for example show how loan commitments offered by banks may reduce this agency cost of debt. Alternatively, the asset substitution problem is reduced if firms finance with short term debt (e.g., Barnea, Haugen and Senbet, 1980), or if they use convertible bonds or bonds with warrants (Green, 1984).
being close to default will have the largest incentive to speculate (the value of such behavior is highest around the convex part of the shareholder's claim). This implies an increase in the agency cost of debt (debtholders will rationally anticipate such behavior and price this ex ante).

But as we suggested before, risk management may also reduce the asset substitution problem. More specifically, we argue that:

**Proposition 6** If a firm can ex ante (before entering into a risky debt contract) commit to a hedging strategy that reduces the likelihood of default over the life of the debt contract, this contract will reduce the firm's incentive to enter into asset substitution and thus improves contracting terms.

**Proof.** The intuition of the proof is more or less similar as that of Proposition 4. We should now only consider two mutually exclusive projects, one more risky than the other but with a lower NPV. With risky debt, the firm may have an incentive to take the high risk project (because the firm evaluates the project based on the income that accrues to its shareholders). Financial markets anticipate this and therefore charge a higher price (repayment of $F$) to compensate for the risk. Note, however, that the higher the repayment, the more likely it becomes that the firm chooses the high risk project. This holds because the firm only considers the part of the income that accrues to the shareholders, and the higher $F$, the lower the expected value that accrues to its shareholders.

If the firm commits to a hedging strategy (over the life of the debt contract), this will reduce the firm's likelihood of default. It will also improve the initial contracting terms. With sufficient hedging, the improvement of contracting terms (lower repayments $F$), is such that the firm's incentive to take the less efficient but riskier project disappears.

Hedging therefore improves investment efficiency. Because of the hedge, it is in the interests of the shareholders to choose the low risk (high NPV) project.

If firms commit to a risk management strategy prior to financing decisions, and with a maturity that is equal to or longer than the life of the financing contract, shareholders can reduce the compensation debtholders require to protect themselves against wealth extraction of shareholders.

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29 Cases of firms at the end of the rope (with respect to their operating profits) that turn to speculating with derivatives are numerous. Examples of this are Balsam, Allied Lyons (see Boot and Ligerink, 1998, for descriptions of some of these cases).

30 We should stress here that there may be a managerial reason related to bankruptcy why managers will not engage in asset substitution. Managers often have great aversion against bankruptcy; because they have considerable firm related investments (human capital, reputational capital and shareholdings). In bankruptcy they would lose the proceeds of these investments. This may make managers risk averse and offset the asset substitution problem. See also Grossman and Hart (1982).
ers through risk shifting. Such a hedging strategy reduces the number of states where shareholders would otherwise have the largest incentive to engage in risk shifting and therefore improves the contracting terms between firms and investors.\(^{31}\)

Since the shareholders' incentive to shift risk increases close to the value where a firm is potentially insolvent, hedging strategies that reduce the probability of insolvency, given a specific level of debt finance, also reduce the agency costs of asset substitution. Corporate hedging reduces the costs of asset substitution, quite similar to the way it reduces the agency costs of the underinvestment problem. As long as a firm commits itself to a hedging strategy that reduces the probability of financial distress over the life of a given amount of debt, these debtholders will reduce their compensation that otherwise should compensate them for the incentive to shift to riskier projects.\(^{32}\)

However, there is a time consistency problem. Although shareholders have an ex ante (before they enter into a loan contract) incentive to reduce expected bankruptcy and agency costs through hedging, this incentive changes right after the financing has been arranged. The firm's shareholders can then increase the value of their claim by increasing the volatility (via lifting the hedge or speculating) of the firm's value. Debtholders however, anticipating this behavior, will require a higher rate of return. And unless the firm can credibly commit to keeping the hedging strategy alive over the life of the debt contract, hedging will not reduce the increased required rate of return asked by debtholders to compensate for potential wealth extracting investments. Bond covenants may effectively bond the firm to a hedging strategy and successfully mitigate the time consistency problem. Alternatively, firms may try to build a reputation of hedging (Smith and Stulz, 1985). However, this seems rather difficult since the firm's incentive to undo the hedge is largest when reputation ceases to be important (in states in which the firm faces financial distress). We therefore conclude that reducing the agency costs of debt commitment (underinvestment as well as asset substitution) is of crucial importance.

Although the intuition of the interaction between risk management and the asset substitution problem seems relatively straightforward, there is only one theoretical paper (Campbell and Kracaw, 1990) that analyzes the impact of corporate hedging on the asset substitution problem. However, this paper is very specific as it is only able to derive clear results for firms where price risk (denoted as observable risk) and operating risk (unobservable risk) are similar or closely related. An example of such a firm is a credit subsidiary. Their paper provides a rationale

\(^{31}\)Mayers and Smith (1982) suggest a positive role for corporate insurance along these lines. Although, there is no paper that formally tackles this problem, Barnea, Haugen and Senbet (1980), provide much of the intuition. They show that mergers reducing the variability in pay-offs of the investment opportunity set decrease the agency costs of debt due to a reduction of the shareholders' incentive for asset substitution.

\(^{32}\)See also Smithson, Smith, and Wilford (1990, p. 374) for a numerical example.
for shareholders of a credit subsidiary to commit to hedge interest rate risk following from a floating rate loan in covenants. The authors argue that since financial risk is more observable, reducing this risk is beneficial since it will also reduce the (less observable) operational risk-taking incentives. Reducing financial risk therefore reduces the investment opportunity set and thus the possibilities for operational asset substitution. As a result the agency costs of debt decline.33

2.3.4 Risk management, investment distortions and debt capacity

We argued in Section 2.2.4 that the risk management decision and the firm’s capital structure decision are interrelated. Firms that hedge can reduce the expected costs of bankruptcy. In turn, this may induce firms to increase the amount of debt (and benefit, for example, from an increased tax shield) with the same expected bankruptcy costs as if it did not hedge. This interaction with capital structure may also have implications for the benefits of risk management that we have just discussed. Hedging may reduce the agency costs of debt. However, lower agency cost of debt may induce firms to increase the amount of debt in the firm’s capital structure. Hence, risk management is complementary to a higher debt level.

Alternatively, hedging and capital structure decisions can be considered as substitutes. For example, a firm can choose to reduce the asset substitution problem either by using a hedging strategy to which it adheres over the life of the financing contract or through a change in the capital structure (a lower debt level).34

To illustrate this line of reasoning, the following may be instructive. Consider a firm with existing debt outstanding and whose asset value is subject to volatility. Debt is priced such that it takes into account the underinvestment and asset substitution problem (and bankruptcy costs). Now a firm has the opportunity to bring down asset volatility (e.g. through a hedging strategy). How might the firm exploit this opportunity? Note that in order to benefit from reduced volatility, the firm should repay (and call back) its debt. It therefore needs some bridge financing to repay the existing debt. The firm then should enter into a hedging strategy and find a way to commit itself to the hedging strategy. For example, it could issue new debt financing that includes a covenant in which it specifies the firm’s duty to keep the hedge over the life of the

33 However, Campbell and Kracaw’s analysis is rather typical. If the imposed strong correlation between observable and unobservable risks is left, the conclusion can go anywhere; hedging the observable risk may both lead to reducing but also to increasing the riskiness of unobservable risks, thereby making the initial risk management decision with respect to the effect on asset substitution ambiguous.
34 A similar picture also emerged in the discussion about the underinvestment problem.
bonds. The price of these bonds should reflect the firm's reduced agency and bankruptcy costs. Ross (1998) provides a numerical example along this line.\textsuperscript{35}

From the discussion above it becomes apparent that the capital structure (debt ratio and maturity of debt) decision and the choice of risk (both ex ante and ex post) are related in a rather complex way. In order to capitalize on the benefits of debt financing (tax shields), the firm incurs default risk and therefore the expected bankruptcy and agency costs associated with asset substitution and underinvestment. The optimal mix of risk management decisions and financing decisions is not clear at the outset. A proper analysis of this problem requires a dynamic model that explores the various interactions among these decisions.

Leland (1998) and Ross (1998) have done some interesting work to gain insight into the complex relationship between capital structure and risk management. Building on the basic work by Merton (1974) on the pricing of risky debt using contingent claims analysis, and the more recent contributions by Leland (1994) and Leland and Toft (1996), where a valuation model is developed that values debt taking into account the asset substitution problem and credit risk, Leland (1998) is able to build a dynamic model addressing the costs and benefits of both risk management and capital structure.

Included in his model are the possibility of costly default, taxes, the asset substitution problem (the firm's shareholders can switch from high to low risk and vice versa), debt maturity, the dividend pay-out ratio, etc. In order to estimate agency costs associated with the asset substitution problem, Leland calculates first the value of the firm if it were able to precommit to a risk strategy and debt structure. He then calculates the firm value if risk choices are made ex post (after debt is in place). It is assumed that all agents have rational expectations and therefore could perfectly foresee the consequences of risk choices. The difference in maximum values then reflects the agency cost. With the model, Leland is able to study the value of the firm, the switching points (value of the underlying assets at which the firm switches from high to low risk or vice versa), the value at which debt is called, the expected debt maturity, the asset value at which default occurs, optimal leverage, yield spread and the (previously defined) agency costs.

Leland (1998) also studies the optimal risk management decision by analyzing what happens if firms can reduce asset volatility from 20 to 10% through costless trading in derivatives.\textsuperscript{36} Environments in which the firm can and cannot precommit to its risk management strategy are considered. It appears that hedging in either environments only brings modest benefits. If a firm cannot precommit to its risk management decision, hedging increases firm value by 3.60%. An ex ante commitment to always hedge, creates almost the same level of benefit (3.77%). If the

\textsuperscript{35}Ross (1998) also argues that the increased popularity of derivatives, may provide a rationale why firms issue more callble debt nowadays.

\textsuperscript{36}Leland also considers the case where the firm reduces asset volatility to 15%. Results however are in line (half of) the results reported further on.
firms can ex ante precommit to an optimal risk management strategy, the benefit is only slightly higher (4.66%).

Then the author considers apart from hedging (reducing volatility to 10%) also the possibility to speculate (increasing the riskiness to 30%). Again, if the firm can precommit to its (optimal) risk management strategy the benefits of risk management are largest and firm value will increase by 5.59%. This is mainly because, in addition to the case where hedging was its only tool, the firm can play its option to continue in business (to the detriment of taxes, etc.). However, if the firm cannot precommit to its risk management decision, the benefits are reduced to 1.02%. In comparison with the case, where hedging is not possible leverage increases but expected debt maturity decreases. This is also the case for the ex post optimal as opposed to the ex ante optimal strategy. Note that this is in accordance with Myers (1977) and Barnea, Haugen and Senbet (1980).

Hedging and hedging benefits increase with an increase in default costs. It enables the firm to increase its leverage substantially compared to the case where the firm does not have the ability to hedge. However, "It would be erroneous to presume that firms will hedge less when they have lower leverage and less risky debt. Indeed the opposite is true when default costs ... are the source of variation". (Leland, 1998, p. 1236).

Other results are that lower pay-out ratios lead to greater hedging benefits but shorter debt maturity and that short-term debt is more incentive compatible with hedging than long-term debt. Lower cash flows further implies greater benefits from taxes (due to convexity of the tax function).

"A somewhat surprising result is that agency costs and the benefits to hedging are inversely related in many cases. High bankruptcy costs, short average debt maturity, and low cash flows are all associated with larger hedging benefits but low agency costs. These results challenge the presumption that greater agency costs necessarily imply greater benefits to hedging." (Leland, 1998, p. 1237).

Work in this area is important and contributes to a better understanding of risk management decisions, primarily because these dynamic models (although under some simplifying assumptions) capture the impact of many different financing decisions at the same time. In Leland's (1998) model, for example, the joint effect of capital structure decisions (debt/equity and debt maturity choices), dividend pay-out policy and risk management decisions are studied. With sensitivity analysis, one can increase our understanding of the relative importance of each of these decisions to firm value.

One of the more interesting results of the analysis is that the most important benefit of hedging is not a reduction in the expected costs of financial distress, nor is it a reduction in the agency costs of debt, but that the major benefit of risk management lies in an increase in the firm's debt
2.3 Ex post contracting problems between the firm and its financiers

<table>
<thead>
<tr>
<th>Source</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underinvestment</td>
<td>Firms where growth opportunities are important will hedge</td>
</tr>
<tr>
<td></td>
<td>Firms with higher debt levels will hedge</td>
</tr>
<tr>
<td></td>
<td>Firms with valuable long-term obligations will hedge</td>
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<tr>
<td></td>
<td>Firms will commit to a hedging strategy in loan covenants</td>
</tr>
<tr>
<td>Asset substitution</td>
<td>Firms with higher debt levels will hedge</td>
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<tr>
<td></td>
<td>Firms will commit to a hedging strategy in loan commitments</td>
</tr>
<tr>
<td></td>
<td>Firms close to financial distress will speculate (or do not hedge)</td>
</tr>
</tbody>
</table>

TABLE 2.2. Underinvestment and asset substitution (due to an ex post financial contracting problem between shareholders and debtholders) as rationale for corporate risk management

capacity. Risk management enables the firm to take on more debt, which generates a higher tax shield.

2.3.5 Conclusion and empirical predictions

In this section, we have shown that risk management may reduce the agency costs of debt financing as long as a firm precommits to a hedging strategy. Table 2.2 summarizes the empirical predictions of the literature surveyed in this section.

Myers’ (1977) underinvestment problem is positively associated with the firm’s growth opportunities and its debt level. As a result we expect that firms with more debt and growth opportunities will be more likely to hedge (and do so more frequently). Since firms can only reduce the costs associated with the underinvestment problem if they commit to a hedging strategy over the life of senior claims, we also expect firms to include clauses about hedging strategies in loan covenants with senior claimants. Further, the theory predicts that risk management is especially beneficial for firms that enter into valuable deferred obligations such as service contracts and warranties or deferred compensation obligations, and those that enter long-term operating contracts involving firm-specific investment by contracting parties.

We then focused on a second agency problem related to debt financing, the asset substitution problem (see Table 2.2). Relatively healthy firms that intend to attract external (debt) finance have an incentive to engage in hedging and commit to hedging over the life of debt contracts (for example in loan covenants). These covenants (and thus hedging) become more likely the larger the firm’s long-term debt and the more volatile its operating cash flows. On the other hand, firms close to financial distress can be expected to unhedge or even speculate. Risk management then is a relatively cheap way to increase the risk of the firm and as such increase the value of claims of the firm’s existing shareholders. We should however be careful not to overemphasize

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37 Alternatively, the firm can develop a reputation of having a stable cash flow (by hedging). However, this is not easy to test empirically.
the importance of the asset substitution problem here; there is some empirical evidence that the asset substitution problem is not that significant.\textsuperscript{38}

Hedging may reduce the agency costs of debt. However, reduced agency costs may also imply that firms increase the amount of debt (which in turn increases these agency costs). From the literature it is not perfectly clear which of these two rationales are most prevalent; does risk management increase the firm's debt capacity, or does it reduce the agency costs of debt given some amount of debt? Empirical research should establish the main effect of risk management.

One way to test this would be to examine the riskiness of the firm's equity of both derivative and non-derivative users and non-users. If firms hedge to reduce for example the asset substitution problem, we would expect that the firm's equity returns are more volatile than for non-hedgers. If on the other hand, derivatives users also increase their debt, the riskiness of the firm's equity is not necessarily lower compared to firms that do not use derivatives. Also, the probability of financial distress is not necessarily lower for firms that use derivatives (even if they use them for hedging purposes). Again, this follows from the fact that these firms also tend to issue more debt.\textsuperscript{39} Another empirical prediction is that firms using derivatives to hedge tend to have larger interest rate tax shields and thus on average pay lower taxes than firms that do not hedge.

If the focus of risk management is on reducing the agency costs of debt (improving investment efficiency), we expect that firms hedge downside (cash flow) risk around the period when debts fall due. Full hedging generally is not required to achieve this objective. Note that this contrasts the optimal risk management strategy identified in Section 2.2.3. In a neoclassical analysis with bankruptcy costs we found that the firm should reduce the volatility of its asset value.

Finally an intriguing question remains given the several mechanisms in which a firm can reduce its agency costs. Apart from the capital structure and hedging decision, firms can enter into loan commitments, issue convertibles or use short term debt to reduce agency costs. Therefore, it is interesting to investigate the relationship between risk management and these alternative ways of reducing the agency cost of debt.

2.4 Ex ante information frictions between the firm and its financiers

2.4.1 Introduction

Whereas in the previous section the focus was on ex post information problems, this section analyzes the corporate risk management decision in a framework where there is an ex ante

\textsuperscript{38}See for example Grinblatt and Titman (1998, Chapter 15).

\textsuperscript{39}From Leland (1998), it also follows that if a firm enters into hedging it not only increases the value of the claim of the current debtholders, but also that of the shareholders; the tax advantage of greater leverage outweighs the value transfer to the bondholders.
(that is, prior to the signing of the financial contract) informational friction between the firm and its financiers.\textsuperscript{40} For example, there is an important financing problem if the firm has some private information about its credit quality that the financial market does not have. In such a case financiers are hesitant to finance the firm. And, if they are willing to finance at all, will generally charge a relatively high premium that compensates them against a potential loss if the firm tends to be of a lesser credit quality.\textsuperscript{41} As a result, external financing is costly. Because of these costs and the limited availability of external finance, firms will not undertake all positive NPV projects; as in the former section we have underinvestment.\textsuperscript{42} This underinvestment problem has important consequences for the firm’s financing preferences. Firms prefer financing internally over costly external financing. If they need external financing they prefer debt finance over equity finance since equity is more sensitive to asymmetric information (and therefore the premium that investors require is higher).\textsuperscript{43}

In this section, we will argue that risk management reduces potential investment distortions caused by costly external finance (Froot, Scharfstein and Stein, 1993). If risk management enables the firm to optimally coordinate its investment and financing policies it will increase firm value. An important difference with the results of the previous section is that where in the previous section the benefits of risk management were strongly related to the solvency of the firm, the results of the analysis in this section stress the value of liquidity as a rationale for corporate risk management.

\subsection*{2.4.2 Costly external finance and financial risk management}

We consider a two-period model with an interim financing stage. At the interim stage there is an investment opportunity. We assume there exists an ex ante information problem between firm and financiers and that, as a result, external financing is more expensive than internal financing. Firms may therefore have an incentive to protect the amount of liquid assets (or financial slack) available in order to finance (future) investments by means of an appropriate risk management strategy. Below we will illustrate this basic idea of Froot, Scharfstein and Stein (1993) in more

\textsuperscript{40}More specifically, we focused on information problems between the firm’s current shareholders and new shareholders or debtholders.

\textsuperscript{41}We are very general here. Financiers will undertake all kinds of costly screening activities to find out more about the credit quality of the firm. Firms of a good credit quality will undertake a variety of (costly) actions to signal that they are of a high credit quality.

\textsuperscript{42}See for example Myers and Majluf (1984) for a formal framework.

\textsuperscript{43}This financing behavior is well known as the “Pecking Order Theory” (Myers, 1984). International empirical evidence for this claim can be found in Rajan and Zingales (1995) and Titman and Wessels (1988).
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detail. For that purpose it is convenient to use a slightly different framework then was used in prior sections.

The Model

Consider a model with the following features:

A.1a There are three dates: $t = 0, 1, 2$;

A.3a All agents in the economy are risk neutral. The risk free interest rate is 0%;

A.5a A firm’s internal wealth at date 1 (financial assets) is exposed to price risk as follows:
$$\tilde{w} = u_0(1 + \bar{\epsilon})$$;

A.6a $\epsilon$, the primitive source of risk, is an element drawn from a normal distribution with mean zero and variance $\sigma^2$ ($\bar{\epsilon} \in N(0, \sigma^2)$);

A.7a The firm can purchase/sell forward contracts on the risk factor. We assume for simplicity that all fluctuations in internal wealth are completely hedgeable and that hedging has no effect on the expected value of $w$. After hedging with $\phi$ forward contracts, the firm’s wealth at date 1 is equal to:
$$\tilde{w} = u_0(\phi + (1 - \phi)\bar{\epsilon})$$;

A.8 Hedging by the firm is costless;

A.11 Shareholders are in control.

At date 1 the firm must decide on its investment expenditures ($I$) and its external financing needs ($e$), given an amount of internal wealth ($w$) it has available. The investment has a net present value $A(I)$ equal to $a(I) - I$, where $a(I)$ denotes the PV of the second period’s proceeds from the investment. Assume that productivity increases at a decreasing rate (i.e. $a'(I) > 0$ and $a''(I) < 0$). The total need for external financing ($e$) to finance the investment is equal to: $I - w$. Outside investors expect a repayment of $e$ in the second period. Assume that there is an additional deadweight cost of external financing denoted by $C(e)$, which is an increasing convex function of the amount of external financing needed. Since the costs of external financing are the trigger in the model, let us briefly consider this assumption. The costs of external financing arise from asymmetric information between managers in a firm and outside investors. Since the

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44The study by Mello and Parsons (1999) uses this idea as the basis for a more practical strategic approach to corporate risk management.

45In order to circumvent Myers (1977) underinvestment problem (see Section 2.3.2), we assume that the firm will commit to the investment decisions; it can not deviate to deprive the investors from wealth after the financing contract has been signed.

46Assume therefore that: $\frac{AC}{\delta e} > 0$ and $\frac{\partial^2 C}{\delta e^2} > 0$. 
firm cannot credibly communicate its private information to the market, the firm can issue only securities at a discount. The more external financing is needed (and the larger the amount of asymmetric information) the larger the discount and therefore the higher the costs of external financing. Hence the assumption of an increasing and convex function is well motivated.

Now, consider the firm’s optimal risk management strategy at date 0. We can show that the following basic result holds:

**Proposition 7** If external financing is more costly than financing internally, corporate hedging adds value. If investment and financing opportunities are fixed firms will completely hedge their exposure.

**Proof.** Shareholders maximize expected profit net of financing costs. To explore the impact of hedging on investment and financing decisions the model is developed backwards. Consider first the firm’s first period investment (and financing) decisions given a certain level of internal wealth \( w \). The amount of external finance needed is therefore \( e = I - w \). The maximization program can be written as

\[
\max_{I} \pi(w) = A(I) - C(e)
\]  

(2.14)

where \( \pi(w) \) denotes the amount of profit given a level of internal wealth \( w \). The solution to this maximization program follows from the first order condition,

\[
A_I = a_I - 1 = C_e
\]  

(2.15)

Note that, due to the costs of external financing, the firm’s optimal investment level \( I^* \) deviates from its first best solution. In the presence of external financing costs, the optimal level of investment satisfies \( a_I - 1 = C_e \), while in absence of these financing costs, the optimal investment should satisfy \( a_I = 1 \). Due to costly external financing we observe a lower investment level and hence underinvestment.\(^{48}\) In order to obtain a maximum the second order condition should be negative (\( \pi_{ww} < 0 \)),

\[
\pi_{ww} = a_{II} \left( \frac{dI^*}{dw} \right)^2 - C_{ee} \left( \frac{dI^*}{dw} \right)^2 < 0
\]  

(2.16)

If we assume the marginal return on investment is decreasing (\( a_{II} < 0 \)) and the marginal costs of external finance are increasing (\( C_{ee} > 0 \)) this second order condition is satisfied (\( \pi_{ww} < 0 \)).

In other words, the firm’s profit is a concave function of the amount of internal wealth.\(^{49}\) From Jensen’s inequality we can then show directly that corporate hedging is beneficial. However, we

\(^{47}\)Where we used the fact that \( \frac{ds}{dt} = 1 \) in the second period when \( w \) is given.

\(^{48}\)Note that this underinvestment is not the same as in Myers (1977).

\(^{49}\)The convexity of the cost of external finance (\( C_{ee} \geq 0 \)) is a crucial assumption.
can gain even more insight if we specify the optimal hedge ratio at date 0. We have assumed above that the hedge transaction does not affect the expected value but only the distribution of internal wealth. To determine the optimal hedge ratio, the firm should maximize its expected profits at date 0,

$$\max_{\phi} E(\pi(w))$$

(2.17)

anticipating the investment $I^*$, where the expectation is taken with respect to the risk factor $\epsilon$. The first order condition is,

$$E(\pi_w \frac{d\pi}{d\phi}) = 0$$

(2.18)

If we only consider linear hedging strategies, $\frac{d\pi}{d\phi} = 1 - \epsilon$, the first order condition can be rewritten as

$$\text{cov}(\pi_w, \epsilon) = 0$$

(2.19)

In the case of fixed investment and financing opportunities, the only hedge ratio in which this condition is satisfied is where $\phi = 1$. hence the case where firms completely hedge all marketable risks. This is the basic result in Froot, Scharfstein and Stein (1993).

Hedging is beneficial, because it enables the firm to invest (and to fund the investment or minimize the costs of external financing). This is an intuitive rationalization of corporate risk management; if external finance is costly, risk management allows the firm to execute its optimal investment strategy. Apart from this first basic result, the model furthermore has some interesting extensions with respect to cases where: investment or financing opportunities are

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50 We have motivated the costs of external finance with an ex ante information problem. However, Froot, Scharfstein and Stein (1993), (FSS), have shown that this also holds in a framework where there is a moral hazard problem after the financing contract has been signed. They explicitly refer to the costly state verification model of Townsend (1979). In that paper he refers to a conflict of interest; the managers in a firm have an incentive not to repay (and therefore cheat on) the investors. With rational expectations this incentive will be reflected in the price of external financing which also creates a discount. For the FSS rationale developed here it is sufficient that external financing is more costly than internal financing. We however would like to stress that ex ante information problems might also induce firms to hedge.

51 Although the idea behind FSS, that risk management may contribute to firm value if it enables the firm to make better use of its internal funds, is intuitively appealing there are also some counterarguments. For example, in a recent paper by Raposo (1997), the costs of external finance (exogenous in FSS) have been explicitly modeled. In that paper she shows that if the Myers and Majluf (1984) argument is used to make external financing costly the results by Froot, Scharstein and Stein (1993) do not necessarily hold. Raposo shows that firms will not necessarily hedge completely. To improve investment efficiency, firms may even remain completely unhedged. The idea is that by remaining unhedged the firm at least
correlated with the risk factor or to a multinational’s corporate hedging decisions and to the potential optimality of non-linear instruments. We will explore some of these additional issues below.

Additional insights

Consider first the case where investments are stochastic and correlated to market risk, for example a firm whose investments are positively correlated to an underlying risk factor (e.g. the price of oil).\textsuperscript{52} If firms hedge to reduce fluctuations in internal wealth, then the correlation between investment opportunities and the underlying risk factor becomes important. High oil prices mean high income but then also require large investments. Low oil prices imply low internally generated funds but since investments are also small, low cash flows in this state do not hamper the firm’s operations. In such cases a full hedging strategy would not be very successful; it would reduce the amount of cash available in states where it is needed most and vice versa.\textsuperscript{53} One implication therefore is that firms should not always hedge (at least not completely).

Another implication of the Froot, Scharfstein and Stein (1993) model is that it may not be optimal for firms to use linear instruments like futures and forwards but to use non-linear hedging instruments like options. In the example we just presented (where investments were positively related to the risk factor) a put option on the oil price (in particular if far out of the money) might be enough to guarantee the amounts of cash required in the low oil price states while leaving enough upward potential to have sufficient cash (to finance the investments) in the high oil price states. Non-linear hedging instruments enable the firm to customize the hedge on a state-by-state basis. With options it is easier to direct cash flows to the states where liquidity is needed most. Only if the total derivative of internal wealth with respect to the underlying risk \((\frac{dw^*(c)}{de})\) is a constant, will the use of futures ensure an optimal hedge. In all other cases (combinations of) options may be required to create a value maximizing hedge.

has the possibility to benefit from the investment opportunity because it has lower external financing needs (after a positive realization of the risk factor). If a firm had hedged completely, it may bypass the investment opportunity due to mispricing of the amount of external financing. Hence, not engaging in hedging in some cases may increase investment efficiency. These are intriguing results and suggest that it is important to endogenize the costs of external finance in future research. Empirical research has yet to prove whether the FSS explanation holds or not.

\textsuperscript{52}FSS also consider the case where external financing is stochastic and correlated with market risk. It is then no longer true that the investment can be completely insulated from shocks to \(e\) (even when investments are non-stochastic) using simple linear instruments like forwards. Non-stochastic investments would require that once the hedge is in place, \(C_e\) be independent of \(\xi\) (a variable measuring the correlation of the costs of external financing and the market risk). This can only be accomplished by non-linear instruments.

\textsuperscript{53}For a simple illustration of this idea see Ligterink (1995b).
2. Why do firms hedge: a theoretical framework

The framework in Froot, Scharfstein and Stein (1993) is also helpful in studying implications for the firm's choice between hedging instruments. For example, futures contracts require cash (margin calls) during the life of the contract, while forward contracts are settled at maturity. When hedging is primarily done for liquidity reasons (to maintain sufficient internal funds), additional fluctuations in cash flows caused by margin calls are not desirable.

An interesting real world illustration of this problem is the Metallgesellschaft case of 1993. The US subsidiary of this German conglomerate, called MGRM, sold long-term oil against a fixed price (five to ten year contracts) to clients and hedged the resulting oil price risk with (rolling) short-term (three to six month) futures contracts. The long term oil contracts were at a certain moment in the money, which caused problems for the firm since it had to face huge margin calls. These margin calls exhausted the firm's cash and finally brought the complete conglomerate close to bankruptcy. This clearly shows that a hedging strategy which does not account for the potential future volatility of cash flows is generally not optimal. It also adds a new intertemporal dimension to an optimal risk management strategy. Not only liquidity at one point in time but also liquidity over time is important to consider in the design of a hedging strategy. In order to gain insight into the intertemporal trade-off in the benefits of a risk management program one should consider a dynamic framework.

Mello and Parsons (2000) take such a dynamic approach. The intuition provided there is that a risk management program often reduces future volatility in cash balances while increasing the volatility in short term cash balances. An optimal hedging strategy is achieved as a trade-off between the marginal cost of increasing short term volatility versus the marginal benefit of reducing long term volatility in cash flows. The benefit of such a risk management program is an increase in flexibility and reduction of the costs of financial distress. The cost is that a hedge requires intertemporal funding. The optimal hedge minimizes the variability in the marginal value of the firm's cash balances.

Two predictions follow from the analysis by Mello and Parsons (2000). First, the optimal hedge ratio is contingent on a firm's (future) financial constraints. Thus a firm should hedge more if leverage increases or margins decrease. Second, hedging may not be possible for firms unable to finance the funding requirements of the hedge. This is especially relevant for firms

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54 There has been an interesting debate in the Journal of Applied Corporate Finance about this case, especially between Culp and Miller (1995) and Mello and Parsons (1995). Culp and Miller argue that Metallgesellschaft's hedging strategy was appropriate and that the parent was to be blamed for the enormous losses occurring when the hedge was unbundled. Mello and Parsons on the other hand argue that the firm was overheded (and therefore speculating on the basis) and that the hedging strategy was not in line with fundamental motivations for hedging. We sympathize with Mello and Parsons (1995) in this debate. See also Boot and Ligterink (1995b) for a discussion of this case.
that are severely financially constrained and may explain why small firms hedge relatively less than large firms.

The model by Mello and Parsons furthermore explains why firms hedge only part of their exposure and why this hedge ratio tends to vary over time. It may also explain the choice of certain combinations of financial instruments to hedge with. A firm whose current financial condition is poor will develop a risk management program which necessitates little cash. For example, in addition to using forwards, a firm may want to write options in order to reduce current financing needs. Alternatively, a firm with a lot of financial slack (and therefore relatively low current financing costs) will structure the risk management portfolio to meet future financing needs.55

### 2.4.3 Concluding remarks and empirical predictions

The theory developed by Froot, Scharfstein and Stein (1993) predicts that firms with difficulties in attracting external finance will benefit most from hedging; firms with more debt generally have less financial slack and therefore are expected to be more financially constrained. These firms therefore also are expected to hedge more (frequently). It is furthermore well-known that firms with a relatively large fraction of growth opportunities will suffer most from information problems and therefore have the most difficulties attracting external financing; these firms therefore benefit more from hedging. We expect firms with more growth opportunities to hedge more (in amount as well as frequency). Since firms with large cash balances are not financially constrained, we expect a negative relationship between the presence of cash balances (liquidity) and corporate hedging. The more cash a firm has available, the less hedging we will expect. Table 2.3 summarizes these empirical predictions.

Note that given the perspective taken here to guarantee the availability of sufficient cash flows in order to exercise the firm's investment opportunities, managing volatility in cash flows at certain moments in time (the dates of major investments) should be the primary objective in risk management. This may imply that, in some very specific cases, the firm overhedges and therefore increases the firm's cash flow volatility. Moreover, it may also rationalize why firms sometimes use options. They help to further fine-tune the amount of cash required in a specific state at a certain point in time.

55This insight has also been developed in Adam (1999).
2.5 Ex post information frictions between managers and shareholders

2.5.1 Introduction

We started our analysis of corporate risk management in a neoclassical framework. In the previous two sections we allowed for the existence of information frictions between the firm and its financiers and showed how (ex post and ex ante) contracting problems might rationalize corporate risk management. We will now address the existence of information frictions between the manager and the firm’s shareholders and study the implications for corporate risk management.

More specifically, we focus on potential (private) benefits for the manager as a rationale for corporate risk management. The existence of information and contracting problems give self-interested managers some leeway to act in their own interest rather than in the interest of the firm’s shareholders. This may lead to opportunism. Some examples of such opportunistic behavior are: insufficient effort, extravagant investments, entrenchment strategies (e.g. to make themselves indispensable) and self dealing (e.g. perk consumption). In practice, implicit (e.g. reputation in the labor market, promotions, capital market rationing, product markets) and explicit (e.g. management compensation) contracts align the incentives of managers with the firm’s shareholders, thus reducing these incentives for opportunistic behavior. Since the decision to hedge or speculate is effectively made by managers in a corporation, and generally unobservable or non-verifiable, managers may use risk management to achieve their own private objectives. Alternatively, risk management may also be used by managers to align incentives. This section will focus on rationalizations of corporate risk management along this line.

We identify and discuss in this section three possible managerial rationalizations of corporate risk management: (i) managers may use risk management to increase the expected utility of their compensation package, (ii) managers may use risk management for bonding in turn lowering the agency costs of managerial discretion, (iii) risk management enables managers to execute inefficient investment projects (from which they receive private benefits). These managerial rationales for corporate risk management all follow from the ex post information frictions. Finally, in Section 2.6 we will show that also ex ante information frictions may induce a manager to engage in corporate risk management; risk management allows managers to strategically manipulate the informativeness of earnings.

2.5.2 Risk management: increasing the manager’s expected utility of compensation packages

In this subsection we will show how a risk averse manager in a firm may use risk management to increase the expected utility derived from his compensation package.

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56See Tirole (1999) for an overview.
Below we will start with an analysis of a manager’s incentives to engage in risk management under the assumption that the management compensation package has already been set and is therefore exogenous. We then study the optimal risk management strategy when shareholders anticipate a manager’s risk management prior to setting the management compensation package.

Exogenous compensation packages

Early contributions in this strand of the literature focus on the hedging behavior of a risk-averse manager given a fixed (or exogenous) management compensation contract. If a manager receives a fraction of firm value and hedging through the firm is less expensive than hedging on the manager’s own account, a risk-averse manager may have an incentive to engage in hedging. The optimal hedge ratio then depends on the structure of the management compensation contract, the manager’s utility function (Stulz, 1984; Smith and Stulz, 1985), and the managers’ private exposure to price shocks (Stulz, 1984).

In order to illustrate the impact of risk management on a manager’s expected utility of his compensation package we consider the following simple model:

The Model

Consider a model with the following features:

A.1 There are two dates: $t = 0, 1$;

A.2 Uncertainty in the economy is represented by a state preference framework. The state of the world at date 1 is denoted with a discrete set of states, $s \in \{1, ..., S\}$. States are ordered from low income states to high income states;

A.3b Shareholders are risk neutral\textsuperscript{57}, managers are risk averse (preferences are given by a Von Neumann-Morgenstern utility function);

A.5 The firm’s income $\tilde{Y}_s$ is exposed to a random risk factor $\epsilon_s$ in the following way: $\tilde{Y}^U_s = X + \theta \epsilon_s$, where $X$ is the firm’s operating income independent of shocks in the risk factor, $\theta$ is a measure for exposure to the risk factor, and $\epsilon_s$ is the future spot price. We use the superscript $U$ to denote that the income is unhedged;

A.6 $\epsilon_s$ is uniformly distributed on $[\underline{\epsilon}, \bar{\epsilon}]$;

A.7 The firm can purchase/sell forward contracts on the risk factor. This changes the hedged firm’s income ($Y^H_s$) into: $Y^H_s = X + \theta \epsilon_s + \phi Z$, where $f$ is the forward price, $\phi$ is the

\textsuperscript{57}This captures the fact that shareholders do not care about firm specific risks, since they can diversify them away.
number of forward contracts the firm takes and $Z$ is the payoff of a forward contract
($Z = \zeta_s - f$). The expected value at date 0 of $Z$ is zero ($E(Z) = 0$);

A.8 Hedging by the firm is costless;

A12a Managers are in control of the corporate risk management decisions, which are not verifiable.

Managers have the ability to engage in risk management. The manager can also hedge on
his personal account but, due to scale economies in transaction costs, this is less attractive and therefore we ignore this possibility. Furthermore, assume that the manager receives a compensation contract related to the firm’s income, which will be denoted by $s(\tilde{Y})$. We assume initially that the manager’s wealth only consists of the manager’s compensation, ($W = s(\tilde{Y})$) and that managers have a von Neumann-Morgenstern utility function defined over wealth ($U(W)$).

In this case managers choose the optimal hedge position $\phi$ to maximize the expected utility of wealth,

$$\max_{\phi} E(U(s(\tilde{Y}))) \quad (2.20)$$

As in Smith and Stulz (1985), we can derive the following proposition:

**Proposition 8** If managers are risk averse (so that $U'' > 0$, and $U''' < 0$), they will:

(i) fully hedge ($\phi = 0$) if the compensation $s(\tilde{Y})$ is a linear, concave or insufficiently convex function of the firm’s income $Y$;

(ii) not hedge ($\phi = 0$), or even speculate if $s(\tilde{Y})$ is sufficiently convex.

**Proof.** The manager’s utility function is concave in wealth by definition. If compensation is a linear or concave function of $Y$ Jensen’s inequality implies that the manager’s optimal strategy is to reduce risk as much as possible. This implies that a full hedging strategy maximizes the manager’s expected utility of wealth.

If the manager’s wealth is a convex function of the firm’s income then the optimal hedging strategy is not clear at the outset. Jensen’s inequality implies that increasing volatility increases the expected value of management compensation, which affects the expected utility of a manager positively. Increasing volatility, however, also has a negative impact on the expected utility of the manager, since the manager is risk averse. The manager will now hedge if the reward (higher expected value of the management compensation contract) outweighs the manager’s risk aversion. Therefore, only if the expected marginal benefit is larger than the marginal cost of increasing risk on the expected utility of wealth, will increasing risk (by not hedging or even speculating) be the optimal risk management strategy. That is the case if the management compensation structure $s(\tilde{Y})$ is sufficiently convex.
2.5 Ex post information frictions between managers and shareholders

If the expected utility of wealth due to the benefits of increasing risk is exactly equal to the negative impact of increasing risk on the expected utility of wealth, then the manager is indifferent with respect to the risk management strategy.

Finally, if the expected utility of the benefit of increasing risk is smaller than the negative impact of increasing risk on the expected utility of wealth, management prefers to hedge. ■

The implications of this result are relatively straightforward; a risk averse manager who receives shares has a proportionate claim on the firm's income, and therefore prefers hedging. Managers receiving far out of the money options or options deep in the money will prefer to hedge. These options have almost no convexity and as a result, risk aversion outweighs the potential increase in the expected value of the compensation package obtained by speculating. However, managers receiving at the money options prefer to increase risk and therefore will not hedge, but rather prefer to speculate.

In our simple model, the manager's wealth only consists of the management compensation contract. This obviously is not very realistic. If a manager receives a fixed fraction of firm value \( s(\bar{Y}) \) is linear but has some initial endowment that may be correlated to the firm's risk factor, the manager will not prefer a full hedge but will instead choose a different hedge ratio \( \phi 
eq -\theta \) in order to minimize the volatility in his wealth (Stulz (1984)).

Endogenous management compensation contracts

In the previous subsection the management compensation package was exogenous. However, if the management compensation contract affects the firm's risk management decision, shareholders will anticipate this in the design of the management compensation contract. Hence, if the management compensation schedule is endogenous we should study the impact of managerial hedging on shareholder wealth in an agency framework (e.g. see Campbell and Kracaw, 1987).

To explore this, we consider a model with a standard agency problem between the firm and the manager where the latter has some private information about his (non-verifiable) effort. The principal (shareholder) only observes a noisy signal of the manager's effort, the level of profits \( Y \).

The Model

Assume the following:

A.1 There are two dates: \( t = 0, 1 \);

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\(^{58}\)As another extension, Stulz allows for speculative positions based on the manager's expectations that the interest rate parity does not hold. The less risk averse the manager is and the larger the expected deviation is, the larger will be the speculative position. We ignore this issue.

\(^{59}\)See Varian (1992, pp. 453 and 454) for a description of this model.
2. Why do firms hedge: a theoretical framework

A.3c Shareholders are risk neutral while managers are risk averse. Managers maximize utility based on the following: \( U(w) = -e^{-rw} \), where \( r \) is a measure for the absolute risk aversion and \( w \) is his wealth;

A.5b A firm’s income \( \tilde{Y} \) is exposed to a random risk factor \( \epsilon \) in the following way: \( \tilde{Y}^U = a + \theta \epsilon + \mu \), the level of profits is a function of the manager’s effort \( (a) \), the firm’s exposure \( (\theta) \) to some exogenous risk factor \( (\epsilon) \), and some uncorrelated noise \( (\mu) \). We use the superscript \( U \) to denote that income is unhedged;

A.6b Both the risk factor \( \epsilon \) and the noise factor \( \mu \) are normally and independently distributed:

\[
\begin{align*}
\epsilon & \sim N(0, \sigma^2_{\epsilon}) \\
\mu & \sim N(0, \sigma^2_{\mu}) \\
\text{Cov}(\epsilon, \mu) &= 0;
\end{align*}
\]

A.7b The firm can purchase/sell forward contracts on the risk factor. This reduces the volatility in the firm’s income;

A.8 Hedging by the firm is costless;

A.12a Managers are in control of the corporate risk management decisions which are not verifiable.

We focus on the case where the manager is compensated by a linear compensation contract. If the firm’s profits are defined as

\[
\tilde{Y} = a + \theta \epsilon + \mu
\]

this implies that the compensation contract looks like

\[
s(\tilde{Y}) = \delta + \gamma(\tilde{Y}) = \delta + \gamma a + \gamma \theta \epsilon + \gamma \mu
\]

where \( \delta \) is a fixed compensation amount and \( \gamma(\tilde{Y}) \) is the part of the manager’s wealth that is proportional to the level of reported profits. The risk neutral principal’s problem is to write a management compensation contract that maximizes his expected utility. Since he is risk neutral and residual claimant we may also write that he maximizes the expected value of his residual claim,

\[
E[\tilde{Y} - s(\tilde{Y})] = (1 - \gamma)a - \delta
\]

If the manager’s wealth only consists of the manager’s compensation,

\[
w = s(\tilde{Y}) = \delta + \gamma(\tilde{Y}) = \delta + \gamma a + \gamma \theta \epsilon + \gamma \mu
\]
then the manager's wealth is also normally distributed $(w \sim N(0, \sigma_w^2))$. The agent's expected utility now can be written as a linear function of the mean and variance of wealth as follows

$$EU(w) = \delta + \gamma a - \frac{\gamma^2 r}{2} \sigma_w^2$$

If we further assume that the manager has some private disutility of effort that we model as $c(a)$, we may define the manager's maximization problem as

$$\max_a [\delta + \gamma a - \frac{\gamma^2 r}{2} \sigma_w^2 - c(a)]$$

This completes the description of our model. We can now derive the following proposition:

**Proposition 9** Given the model presented, managers will hedge in equilibrium. In a competitive labor market managers will fully hedge and shareholders will capture all the rents from corporate risk management resulting in a management compensation package with a lower expected value.

**Proof.**

$$\max_a [\delta + \gamma a - \frac{\gamma^2 r}{2} \sigma_w^2 - c(a)]$$

The first order condition of this maximization program is

$$\gamma = c'(a).$$

The principal's maximization problem then can be written as

$$\max_{\gamma, \delta} (1 - \gamma) a - \delta$$

subject to

$$\delta + \gamma a - \frac{\gamma^2 r}{2} \sigma_w^2 - c(a) \geq \bar{U}$$

$$c'(a) = \gamma$$

The first constraint is the participation constraint; the manager will only provide effort if his expected utility is higher than his reservation level. The second constraint is the manager's incentive compatibility constraint. Solving this we find that

$$\gamma = \frac{1}{1 + rc''(a)\sigma_w^2}$$

Consider the impact of risk on the optimal compensation contract. In case there is virtually no risk ($\sigma_w^2 \approx 0$), the optimal management compensation contract is such that the manager will bear (almost) all the risk; $\gamma$ is close to 1 and hence the contract looks like

$$s(\bar{Y}) = \delta + \bar{Y}$$
If there is a significant level of risk, $\gamma$ will be smaller than one and each agent shares part of the risk. The greater the uncertainty or the more risk averse the manager, the smaller will be the proportional part $\gamma$ in the optimal management compensation package. Now we can easily show that the manager, given an initial management compensation ($\gamma, \delta$) contract, will prefer to reduce risk (complete hedging). Differentiating the manager's utility with respect to the variance of initial wealth we find

$$\frac{\partial U}{\partial \sigma^2_{\nu}} = -\frac{\gamma^2 r}{2} < 0$$

By reducing $\sigma^2_{\nu}$, through corporate hedging, the manager can increase his expected utility to a level $U^H > U$. However, in a competitive labor market where many managers compete the firm can capture all the rents; shareholders will write a management compensation contract that anticipates managers' full hedging behavior. Hence, in equilibrium the management compensation contract in anticipation of a manager's hedging will have a higher $\gamma$. Since the principal captures all rents this also implies a lower fixed part $\delta$. The expected value of this wage contract is lower than in case where hedging was not possible. Hence, shareholder wealth increases by this amount.

Proposition 9 captures the basic idea developed in Campbell and Kracaw (1987). Their framework however is more general in that all economic agents are risk averse (we assumed that the principal was risk neutral). As a result they find two rather than one source of wealth creation. The benefit from hedging is not only that fixed payments to a manager are reduced, but also that the renegotiated compensation contracts increase a manager's share of risky returns thus inducing a manager to exert more effort. This second effect does not follow straight from our framework because of the differences in assumptions with respect to risk aversion. An important general implication of our simple model and the more complex model of Campbell and Kracaw (1987) is that in the end shareholders gain this result from hedging because the value of the total management compensation is reduced. However, the results crucially depend upon the assumption that the managers' hedging decisions are perfectly observable for shareholders.60

The design of management compensation contracts is complex. Management compensation contracts are designed in such a way that managers bear unsystematic risk in order to align incentives. One key insight developed in Holmstrom (1979) is that managerial compensation schemes should not be based upon factors over which managers do not exercise control. Obviously, market price risks (like exchange rate risk or oil price risk) are good examples of such

60 This issue is covered in more detail in a paper by Raposo (1996). She models a similar agency problem as in Campbell and Kracaw (1987). However, her analysis focuses on the relevance of information disclosure of hedging positions. She shows that only when the information disclosure is high enough renegotiation between managers and firm’s owners about the managerial compensation contract is wealth increasing.
factors that are generally not under the control of the manager. An important question therefore is why we seldomly see management compensation contracts that are contingent on exchange rates, interest rates or commodity prices. For example, shareholders may create a compensation package that is contingent on the unhedged value and the risk factor. Such a contract would rule out perverse hedge incentives. Although a plausible argument is that it is much easier for compensation committees not to correct performance for all factors not under the manager’s control, especially when the manager can (and will) subsequently hedge them, this may not always give managers the right incentives; they sometimes do not hedge or even speculate.

Chang (1997) takes such opportunistic hedging decisions into account. He also focuses on the determination of an optimal management compensation contract when managers have discretion about the corporate hedging decision and face hedging costs. Shareholders always have the possibility to liquidate or restructure the firm. This liquidation/restructuring option clearly has value. More importantly, the option is worth more when the volatility in firm value is higher. The value of the option to abandon also increases with the liquidation value.

Chang (1997) shows that when agency problems are not too severe (i.e. the costs of inducing action by the manager is low) it is optimal to choose a relatively far out of the money compensation package. This induces managers not to hedge and therefore positively affects the shareholders’ value of the liquidation option. When agency problems are more severe it is also more difficult to induce managers to work without inducing them to hedge. In this case it is optimal to give them an in the money management compensation package. This will induce the manager to hedge (and therefore reduce the shareholders’ option to liquidate) and will also provide the manager with the right incentives with respect to choosing his level of effort. When the agency problems are very severe (the manager’s costs of spending effort are very high) a flat salary is the optimal compensation package. This will induce him not to work and not to hedge. As a result at least the value of the liquidation option is kept intact.

An important conclusion stressed in this section is that the design of a management compensation contract also gives managers an incentive to engage in corporate risk management.

Empirical predictions

A first empirical prediction arising from the analysis in the previous subsections is that risk management is directly linked to the manager’s compensation structure. If a manager’s compensation is linked to a firm’s accounting income, this will give the manager incentives to hedge the firm’s accounting income instead of the economic effects of price changes on the firm. On the other hand, managers compensated with stocks or with out of the money options on shares of the firm will have an incentive to hedge, whereas managers with at the money options included in the management compensation scheme will not hedge or may even prefer to speculate (see Table 2.4).
2. Why do firms hedge: a theoretical framework

<table>
<thead>
<tr>
<th>Source</th>
<th>Prediction</th>
</tr>
</thead>
</table>
| Management compensation | Managers compensated with stocks hedge  
|                         | Managers with (at the money) options do not hedge  
|                         | Firm value of derivatives users is not lower (vs non-users)  
|                         | Firms with high liquidation value will hedge less  
|                         | Profitable firms will hedge more  
|                         | The higher the impact of marketable risk the less hedging  |

TABLE 2.4. Management compensation as driving force behind risk management

The amount of managerial hedging furthermore depends on the correlation between the manager's initial endowments and the risk factor. However, in general this is empirically very hard to track.

A further prediction of this literature is that because managers have the ability to hedge (via the firm) this provides shareholders with the opportunity to write more optimal contracts. An important empirical prediction of this line of theoretical research is that managerial risk management therefore does not necessarily decrease firm value. One could expect that with hedging management compensation contracts are more effective in the sense that they induce managers to exert more effort, thus leading to a better performance for those firms that hedge. Moreover, the value of management compensation contracts is expected to be lower for derivative users than for those who do not.

An interesting implication of Chang (1997) is that the higher the liquidation value (e.g. the more tangible assets a firm has), the less hedging and the more out of the money compensation packages we may expect. Moreover, it is shown that the more profitable a firm, the more likely it hedges. Higher profits reflect the fact that managerial effort is high. The higher the managerial effort's impact on the firm, the more it pays to reduce agency problems and therefore we may expect more in the money compensation packages. As we have seen, this makes hedging more likely. Hence, high profit firms are more likely to hedge.

A final empirical implication is that the higher the effect of market risk on the firm, the less likely it is that the manager hedges. More volatile cash flows are beneficial for the value of the liquidation option, and therefore we may expect a relatively out of the money compensation package, where managers do not hedge. Chang (1997) relates this to the fact that firms in general tend not to hedge more distant cash flows. More distant cash flows are generally riskier. Hedging this exposure makes the firm less responsive to future changing conditions and therefore reduces the firm's option to liquidate or restructure.
2.5 Ex post information frictions between managers and shareholders

2.5.3 Reducing expected costs of managerial discretion (the overinvestment problem)

The previous subsection established the interaction between a management compensation contract (to align incentives with shareholders) and corporate risk management. Hence, we focused on how the design of an explicit contract to reduce managerial opportunism may induce a manager to engage in risk management. We will now focus on a second managerial rationalization that focuses on an implicit contract (mechanism) to reduce opportunistic behavior of managers. More specifically we will focus on incentives for risk management that arise from a manager's desire to bond through the choice of the firm's capital structure.

Extravagant investments, entrenchment strategies and self dealing by managers very much depend on the amount of free cash flows (the amount of cash flows after all positive NPV projects have been undertaken) available to the manager. For example, a manager may want to use free cash flows in a firm to take over another company. This would increase the manager's prestige and the value of his compensation package. The take-over therefore is clearly in the interest of the manager, even when it reduces shareholder wealth. With rational expectations, shareholders will anticipate such behavior and will take this into account in the pricing of the firm's securities and the design of the management compensation contract. As a result, a manager may have an incentive to reduce this agency conflict.61 One way to reduce this free cash flow problem is to issue debt (Jensen, 1986).

An important question that emerges concerns the amount of funds shareholders should trust to the firm's managers if they are aware of potential managerial opportunism. Too much cash gives rise to a free cash flow problem that we have just described and may induce the manager to overinvest. Too little cash at the discretion of a manager, however, may result in severe underinvestment. Stulz (1990) provides insight into this trade-off between the benefits and costs of funds under the discretion of a manager and shows that this may give rise to an optimal capital structure. More importantly, in the context of our survey, Stulz's study provides an additional rationale for corporate risk management. With risk management a manager can more precisely choose a capital structure where he bonds not to spend excessive cash, but which at the same time does not create costly underinvestment. Below we will explore this argument in more detail.

The model

Consider a model with the following features:

A.1a There are three dates: $t = 0, 1, 2$;

---

61 Alternative ways to control such behavior are the take-over market, the product market and the structure of managerial compensation packages. Jensen (1993) however, concludes that these mechanisms do not appear to be very successful.
A.3b All agents in the economy are risk neutral. Managers maximize their expected utilities which is increasing in the amount they invest. The risk free interest rate is 0%.

A.5b A firm’s assets in place at date 0 yield a random (nonnegative) cash flow of $Y$ at date 1. This cash flow is exposed to a random risk factor $\epsilon$. As a result, $Y$ has a uniform cumulative distribution function $G(Y)$ on the interval $[Y, \bar{Y}]$, and density $g(Y) = \frac{1}{\bar{Y} - Y}$.

A.7b The firm can purchase/sell forward contracts on the risk factor. This reduces the variability in $Y$.

A.8b Hedging by the firm is costless.

A.11b Shareholders are in control.

The firm has an investment opportunity at date 1, for which external financing is needed. The investment opportunity at date 1 generates some payoff at date 2. More precisely, the date 2 value of investment is $Z$ per unit for the first $I^*$ units of investment and $K$ per unit in excess of $I^*$, where $Z > 1$ and $K < 1$. With $K < 1$, the NPV of the investment is negative. An investment generating income equal to $Z > 1$ has a positive NPV.

To model the agency problem between the firm’s manager and shareholders, assume that shareholders are atomistic and cannot observe the firm’s investments nor the firm’s cash flows. A manager in that case may maximize his own expected utility and choose to consume more perks. Now assume that perk consumption is increasing with the level of the firm’s investments. As a result, the manager’s expected utility is increasing with the level of investments. In addition, we assume that the perks are also an increasing function of the investment’s NPV in order to guarantee that managers take positive NPV projects first. Therefore, the manager maximizes the amount of investments while shareholders maximize firm value. Shareholders determine the amount of funds available for the firm. The amount of funds at the discretion of the manager affects the level of over- and underinvestment. Too much funding at the discretion of the manager implies severe overinvestment. Too little cash implies underinvestment. Below, we first explore the optimal amount of external finance at the discretion of the manager.

First, consider the value of the firm at date 0 without any external financing. This can be expressed as follows:

$$V = I^*(Z - 1) + E(Y) - \int_{I^*}^{\bar{Y}} (Y - I^*)(1 - K)g(Y)dY - \int_{Y}^{I^*} (I^* - Y)(Z - 1)g(Y)dY$$

The first two terms in this equation denote the value of the firm at date 0 when shareholder wealth is maximized. However, because a manager in a firm does not maximize shareholder wealth, there are some additional costs; the cost of overinvestment (third term) and the cost of
underinvestment (fourth term). If assets in place at date 1 yield more than $I^*$, there is overinvestment. If they yield less than $I^*$ there is underinvestment.

Now, consider the investment decision. Managers will have an incentive to invest every dollar by definition. Financing policy may affect the costs of both underinvestment and overinvestment, however, not in the same direction. Assume that debt is riskless ($F \leq Y$). The maximization problem that the shareholders face is then equal to

$$\max_F V(F) = I^*(Z - 1) + E(Y) - \int_{F+1^*}^{\overline{Y}} (Y - I^*)(1 - K)g(Y)dY$$

$$- \int_{Y}^{F+1^*} (I^* - Y)(Z - 1)g(Y)dY$$

(2.21)

More debt reduces the overinvestment problem (third term) but increases the underinvestment problem (fourth term). Differentiation gives the first order condition

$$\int_{Y}^{\overline{Y}} (1 - K)g(Y)dY = \int_{Y}^{F+1^*} (Z - 1)g(Y)dY$$

The optimal amount of outside debt that the firm chooses is a trade-off between marginal costs of debt (more underinvestment, right hand side of the equation) and the marginal benefit of debt (less overinvestment, left hand side of the equation). Solving this with respect to the optimal level of debt gives

$$F = \frac{\overline{Y}(1 - K) + (Z - 1)Y}{Z - K} - I^*$$

(2.22)

The optimal level of debt is determined by the investment opportunities and the spread between the highest and the lowest income realizations.

Now we have to consider the optimal risk management from the point of view of the shareholders. Assume that at date zero, the firm has the ability to hedge risks and as such to reduce the volatility in $Y$ (at date 1). What in this framework is the optimal risk management strategy? We can establish that:

**Proposition 10** Risk management (i.e. reducing the volatility in operating income $Y$) increases the usefulness of financing policy to reduce the agency costs of managerial discretion. With hedging the firm will have more debt (because the underinvestment problem is less severe due to hedging), which reduces the overinvestment problem and therefore contributes to firm value. The optimal risk management strategy is to minimize the volatility in date 1 cash flows.

**Proof.** First we can show that the optimal level of debt increases with a reduction in the volatility of $Y$. This directly follows from Equation 2.22. With a lower spread in $Y$ the financing
Why do firms hedge: a theoretical framework

**Source** | **Prediction**
---|---
Overinvestment | Derivative users have more debt
| Derivative users produce more efficiently
| Firms commit to use derivatives in loan covenants

**TABLE 2.5. Overinvestment as rationale for corporate risk management**

Policy is more effective in reducing the overinvestment problem. In the absence of hedging more debt would have resulted in an increase in the underinvestment problem. However, with hedging risk management mitigates this impact of more debt on the underinvestment problem while leaving the positive impact on the overinvestment problem intact. As a result firm value is higher with (full) hedging than without.

We have shown that shareholders can increase their wealth by finding ways to force management to commit to a hedging policy which decreases the volatility of the date 1 cash flow. With a lower volatility in cash flows shareholders also increase the amount of debt in the firm which will better discipline the manager (lead to less overinvestment), but will not lead to more underinvestment.

**Empirical predictions**

Table 2.5 summarizes the empirical predictions that emerge from this strand of literature. We predict that firms who hedge also issue more debt. We also expect that firms using derivatives have a more efficient investment policy. We further predict that the larger the agency problems are (i.e. the potential for managers to engage in overinvestment or perk consumption), the more beneficial is corporate risk management (in conjunction with more debt). Again, we predict that managers commit to a hedging strategy with a focus on reducing cash flow volatility at date 1.

**2.5.4 Agency costs of risk management**

In the previous subsection, we illustrated that firms can hedge in order to reduce the costs of managerial discretion; hedging reduces the costs of the agency problem. In this section we will show however, that risk management can also aggravate a closely related agency problem. More specifically, we show (in line with Tufano, 1998) that risk management allows self-interested managers to undertake investment projects that benefit the manager rather than the firm's shareholders.

---

62Note that risk reduction is not only restricted to hedging; corporate diversification would also bring the volatility in operating income down. Both hedging and diversification across projects reduces the agency cost of managerial discretion because it makes cash flows more predictable and therefore the funds available to management closer to the target. Li and Li (1996) for example, consider conglomerate mergers as a way to more predictable cash flows.
The idea is simple and intuitive. Risk management enables firms to bypass financial markets. This potential benefits since external finance can be costly due to informational problems (see Froot, Scharfstein and Stein, 1993 and Section 2.4.2). On the other hand risk management may mitigate monitoring benefits if it causes firms to circumvent external financing. Financial markets have an important monitoring role that reduces managerial incentives to overinvest. Risk management initiated by the manager in order to ensure that the firm does not go to the financial market for external financing circumvents such monitoring. It may enable a manager to finance his own pet projects from which he receives private benefits but which are not necessarily in the interest of the firm's shareholders. Hence, there is also an agency cost associated with risk management.

The model

To demonstrate the intuition behind this, consider a simple version of the framework presented in Section 2.4.2.

A.1a There are three dates: \( t = 0, 1, 2 \);

A.3a All agents in the economy are risk neutral. The risk free interest rate is 0%;

A.5a A firm's internal wealth at date 1 (financial assets) is exposed to price risk as follows:
\[
\hat{w} = w_0(1 + \epsilon);
\]

A.6b \( \epsilon \), the primitive source of risk is either high or low;

A.7c The firm can purchase/sell forward contracts on the risk factor. We assume for simplicity that all fluctuations in internal wealth are completely hedgeable and that hedging has no effect on the expected value of \( w \). The firm may choose between full hedging and no hedging. With a full hedging strategy the value of liquid assets at date 1 is equal to \( E(w) \);

A.8 Hedging by the firm is costless;

A.12a Managers are in control of the corporate risk management decisions, which are not verifiable.

At date 1, the firm has a riskless investment opportunity that requires an amount of funds equal to \( I \) and warrants the firm a return equal to \( R \) at date 2. The firm can finance this investment opportunity either with internal wealth \( w \) or with external finance \( e \) from the financial market. The deadweight costs associated with the external finance are equal to \( C(e) \) and \( C'(e) > 0 \) and \( C''(e) > 0 \).

Funds not used for investment at date 1 do not earn a return in the second period. Assume that the amount of internal wealth available at date 1 if the firm hedged initially is such that \( w = I \).
If there is no agency problem between the manager and the shareholder, it is in the shareholder’s interest to hedge at date 0. The intuition is that hedging makes sure that the investment can be financed internally which reduces the deadweight costs of financing to zero. If the firm does not hedge and the realization of the risk factor is low the firm should attract costly external financing. These costs lead to underinvestment. Hedging prevents such underinvestment and therefore creates value (see Section 2.2.4).

However, assume now that there is an agency problem between the manager and the shareholders. Because the cash flows from the projects are unverifiable, a self-interested manager has an incentive to consume at date 2 before the financiers get paid a proportion $\psi$ of the investment proceeds. A manager for example, may want to use these cash flows for value-decreasing investments (or for perk consumption). We assume that they cannot take this from the money that is not invested at date 1 (this is perfectly contractible). Now we have to derive the (consequences for the) optimal risk management strategy.

**Proposition 1** Risk management increases agency costs by providing the manager with an instrument to circumvent the monitoring role of financial markets. This may give rise to an investment inefficiency; it enables self-interested managers to select their own privately preferred projects, which may reduce shareholder wealth.

**Proof.** Hedging enables the manager to finance the project and then pocket $\psi$ from the project’s proceeds. As a result, the NPV of the project for the shareholders is negative. Not hedging implies that managers can finance investments internally only after a favorable change in the risk factor, so that $w > 1$. After an unfavorable change, managers have to go to the financial market to finance the investment. Investors, however, will anticipate that the manager takes $\psi$ from the project’s proceeds. Hence, they will only finance the investment if it is sufficiently profitable (i.e. if $R - C(\epsilon) - \psi > J$). If the manager is anticipated to grab too much from the investment’s proceeds, financiers will not step in at all. Hence, the financial market has a monitoring role here.

Now focus on the optimal strategy from the perspective of the shareholder. This is a trade-off of the benefits of risk management (reducing the deadweight costs of external financing) and the costs of risk management (the portion of proceeds $\psi$ that the manager takes for perk consumption or pet projects). If the deadweight costs of external financing are large and agency conflicts unimportant, both managers and shareholders prefer hedging. If, however, the agency conflict becomes important (when managers consume more than the investment proceeds) and the capital market turns down the request for external financing at date 1 because of this agency conflict, then the shareholders prefer no hedging while the manager will hedge. Hedging in that case enables the manager to circumvent the monitoring role of external financing. If these agency conflicts are severe this can be an important cost of corporate risk management.
2.5 Ex post information frictions between managers and shareholders

<table>
<thead>
<tr>
<th>Source</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrenchment</td>
<td>Firms that hedge have lower value</td>
</tr>
<tr>
<td></td>
<td>Firms hedge more frequently when fin. constrained</td>
</tr>
<tr>
<td></td>
<td>Firms with more (managerial) private benefits hedge more</td>
</tr>
</tbody>
</table>

TABLE 2.6. Overinvestment (2) as rationale for corporate risk management

We have given an alternative rationalization of corporate risk management. Namely, it provides self interested managers in the firm with the possibility to undertake their own favorite projects from which they derive a private benefit, but which may not be in the interest of the shareholders (Tufano, 1998). If the interests of shareholders and managers diverge, this clearly reduces shareholder wealth. This reduction in shareholder wealth and value of the firm (below the first-best level) can be seen as an agency cost of risk management.

Empirical predictions

Table 2.6 summarizes the empirical predictions arising from the above analysis. The analysis in this subsection predicts that managers will have an incentive to hedge (reduce volatility in cash flows to prevent from going to the financial market. Such hedging is positively related to the opportunity of managers to rip off the firm. Hedging therefore becomes more attractive if the private benefits of investing are larger. Note, that the analysis predicts that hedging reduces firm value.

2.5.5 Concluding remarks

In this section we have focused on managerial reasons for corporate risk management. It was first shown that the structure of management compensation plans may provide managers with an incentive to manage risks. The optimal corporate risk management strategy depends on the degree to which the manager is risk averse, the endowment of the manager, and the manager's compensation package.

We then focused on the agency costs of managerial discretion as a rationale for corporate risk management. We have shown that managers may use corporate risk management in order to reduce the agency costs of managerial discretion. Hedging allows a firm to issue more debt and as such aids in disciplining management; management has less ability to disgorge cash for its own (private) benefit. However, we also established that risk management may aggravate an agency problem between managers and shareholders; that is, managers may use risk management to prevent monitoring by financial markets.
2. Why do firms hedge: a theoretical framework

2.6 Ex ante information problems between managers and the firm

2.6.1 Introduction

In the previous section, we considered managerial incentives to engage in corporate risk management that were the result of the ex post consequences of asymmetric information (moral hazard) in contracts between managers in a firm and its shareholders. In this subsection, we will focus on the literature that rationalizes corporate risk management from ex ante information problems between managers in a firm and outsiders. More specifically, we focus on the problems of (a)symmetric information with respect to the manager’s ability (or effort) and the manager’s incentives to engage in risk management. If for example the ability (or performance) of a manager is not directly observable, outsiders have to rely on imperfect (but correlated) signals like a firm’s relative profitability or cash flow. It is then important to distinguish between two cases. The first is where both contracting parties are uninformed (we generally refer to this as symmetric but incomplete information). Risk averse managers then have an incentive to generate noise (and therefore do not hedge) in order to make profits (cash flows) as uninformative as possible with respect to managerial ability (e.g. DeMarzo and Duffie, 1995). In the second case, the manager has some private information about his ability that the market does not have (asymmetric information). Here, the manager’s optimal risk management strategy depends on the quality of its managers, the distribution of good and bad managers in the market, and the amount of noise in profits (Breeden and Viswanathan, 1996; Ljungqvist, 1994; and, Degeorge, Moselle and Zeckhauser, 1996). Below we will discuss these two cases in more detail and explore the implications for risk management.

2.6.2 Symmetric information: risk management to manipulate the market’s learning

We first study a manager’s incentives to engage in risk management when there is symmetric information (both managers and the labor market share the same information) with respect to managerial ability. The basic idea developed in this literature is that if the market learns from profits about the manager’s ability, it may be in the interests of a manager to use risk management to affect the precision of the signal (DeMarzo and Duffie, 1995).

The model

A.1 There are two dates: \( t = 0, 1 \); 

A.3b Shareholders are risk neutral while managers are risk averse (preferences are represented by a Von Neumann Morgenstern utility function); 

A.5b The firm’s income \( Y_s \) is exposed to a random risk factor \( \epsilon_s \) in the following way: \( Y^U = X(a) + 1\epsilon + \mu \), The level of profits is a function of the manager’s effort \( a \), the firm’s
exposure ($\theta$) to the exogenous risk factor ($\epsilon$), is normalized to 1 ($\tilde{\epsilon}$ is the future spot price). We use the superscript $U$ to denote that the income is unhedged;

A.6c The manager’s ability is either high ($H$) or low ($L$): $\tilde{a} = \{H, L\}$ with probabilities $p_H$ and $p_L$, respectively (and $p_H + p_L = 1$). This (prior) probability distribution is common knowledge. The proxy for the risk factor is the exchange rate which can assume three values: $\bar{\epsilon} \in \{\tilde{\epsilon}, \epsilon, \xi\}$ where $\xi < \epsilon < \bar{\epsilon}$. The probability of $\epsilon$ is $\pi$ and the probability of the other two realizations is each $0.5(1 - \pi)$;

A.7b The firm can purchase/sell forward contracts on the risk factor. This changes the hedged firm’s income ($Y^H$) into $Y^H = X(a) + 1\tilde{\epsilon} + \phi Z$, where $f$ is the forward price, $\phi \in \{-1, 0\}$ is the number of forward contracts the firm takes, and $Z$ is the payoff of a forward contract ($Z = \tilde{\epsilon} - f$). The expected value of $Z$ at date 0 is zero ($E(Z) = 0$);

A.8 Hedging by the firm is costless;

A12a Managers are in control of the corporate risk management decisions, which are not verifiable.

A firm’s operating profit at date 1 depends on managerial ability and the outcome of the random risk factor. Career opportunities are modelled by a second period wage renegotiation, where there are several firms competing for the manager’s services. These firms learn something about managerial ability from the first period profit $Y$ and other public information arriving in the market at that time. Below we restrict the labor market’s information set to $Y$; outsiders cannot observe hedging, but only observe the firm’s realized profits. The manager’s renegotiated wage at date 1 is determined in a competitive market; such that his wage at date 1 is a function of expected ability conditioned on all relevant available info in the market, $W_1 = E_1(a \mid S)$, where $S$ represents the information set. Hence, we assume that managers capture all expected rents from their ability.

If date 1 profits are completely uninformative about the manager’s ability the manager’s equilibrium wage offered to him at date 1 would be equal to

$$W_1 = E_1(a \mid S) = p_H a_H + (1 - p_H) a_L$$

$^63$ It is convenient to assume that $\pi > \frac{1}{3}$. This condition makes the posterior probability of being a high-ability manager monotonic in $Y$.

$^64$ In DeMarzo and Duffie (1995) the firm’s operating profit also depends on project quality and a random production shock. DeMarzo and Duffie (1995) also consider the possibility that managers have private information about the firm’s exposure. Hence, in their model $\theta$ is not necessarily equal to 1 and is private information.
Incomes Income composition Posterioir Probability

<table>
<thead>
<tr>
<th>Income</th>
<th>Income composition</th>
<th>$m_H$ (high ability)</th>
<th>$m_L$ (low ability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_1$</td>
<td>$X_H + \bar{\varepsilon}$</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>$Y_2$</td>
<td>$X_H + \epsilon. X_L + \bar{\varepsilon}$</td>
<td>$p_H \pi$</td>
<td>$(1 - p_H) \cdot 0.5(1 - \pi)$</td>
</tr>
<tr>
<td>$Y_3$</td>
<td>$X_H + \epsilon. X_L + \epsilon$</td>
<td>$p_H 0.5(1 - \pi)$</td>
<td>$(1 - p_H) \pi$</td>
</tr>
<tr>
<td>$Y_4$</td>
<td>$X_L + \epsilon$</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

TABLE 2.7. Posterioir probabilities of observing high (low) ability managers in non-hedging firms given the income realization.

Income Income composition Posterioir Probability

<table>
<thead>
<tr>
<th>Income</th>
<th>Income composition</th>
<th>$m_H$ (high ability)</th>
<th>$m_L$ (low ability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_2$</td>
<td>$X_H + \epsilon$</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>$Y_3$</td>
<td>$X_L + \epsilon$</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

TABLE 2.8. Posterioir probabilities of observing high (low) ability managers in hedging firms given the income realization.

However, if $Y$ is informative about managerial ability, shareholders will use this information to update the ex ante probabilities of being a high ability manager ($p_H$) in a Bayesian manner. In particular, the equilibrium wage will then be equal to

$$W_1(Y) = E_1(a | Y) = m_H a_H + (1 - m_H) a_L$$

where $m_H$ is the updated probability of being a high ability manager given the signal $Y$.

Now assume that

$$X_H - X_L = \bar{\varepsilon} - \epsilon = \epsilon - \underline{\varepsilon}$$

With this assumption we will have four possible realizations of $Y$, the noisy information signal about the ability of the manager. Table 2.7 summarizes the possible outcomes of $Y$ and the associated probability distribution of being of a high (low) ability manager after observing $Y$.

Managers in the firm at the initial date have the opportunity to engage in risk management. Note that if managers hedge ($\phi = -1$) the realization of $Y$ is fully revealing. If $Y_2$ is realized at date 1 the manager can only be of high ability. On the other hand, if $Y_3$ is realized the manager can only be of low ability (see Table 2.8.).

Now we can derive the following proposition with respect to the manager's preferred risk management strategy:

**Proposition 12** Assume that there is incomplete but symmetric information about the ability of the manager. Then, with risk averse managers and the setup as described in the text, managers prefer no hedging over a full hedging policy.
2.6 Ex ante information problems between managers and the firm

**Proof.** The optimal risk management strategy for the manager should satisfy

\[
\sup_{\phi \in \{0, -1\}} E[U(W(Y) | S)]
\]

where \( W(Y) \) is the wage schedule given the optimal risk management strategy chosen by the manager \( \phi^* \) and the updated market beliefs based upon the realization of \( Y \).

With a full hedging strategy the wage offered is consequently: \( a_H \) if profits at date 1 equal \( Y_2 \) and \( a_L \) if profits equal \( Y_3 \). The expected value of this wage schedule for the manager equals

\[
E(W) = (1 - p_H)a_L + p_Ha_H
\]  

(2.23)

Managers will choose to enter into full hedging if the expected utility of such a wage schedule exceeds that had the firm not entered into hedging (\( \phi = 0 \)). To establish the wage schedule if the manager did not hedge we need the posterior probabilities of being a high (low) ability manager given the various realizations of \( Y \). Table 2.7 provides these posterior probabilities \( m_H \) and \( m_L \).

With profits equal to \( Y_1 \) (\( Y_4 \)) the income is fully revealing about the manager’s ability; only firms with a high (low) ability manager can realize this income, and thus the wage given the income reported is equal to \( a_H \) (\( a_L \)). If the income is \( Y_2 \) or \( Y_3 \) the manager’s ability is not completely revealed.

Using these probabilities we can write the expected value of the wage schedule as the following:

\[
E(W) = p_Ha_H + [p_Ha_H\pi + (1 - p_H)a_L * 0.5(1 - \pi)] + [p_H0.5(1 - \pi)a_H + (1 - p_H)\pi a_L] + (1 - p_H)a_L
\]  

(2.24)

Now compare these two wage equations (2.23 and 2.24). We see that the manager’s wage schedule under a full hedging schedule is more informative (and thus the manager’s wage more sensitive) to the realization of the firm’s income than in the case without hedging. A risk averse manager who is uncertain about his own ability therefore prefers not to hedge. His future income then is less sensitive to the firm’s future income realization.

This result has been established in a more general framework by DeMarzo and Duffie (1995). Managers have an incentive to garble the ability related signal in order to reduce the risk on their second period’s wages. The more garbled the signal, the lower is the sensitivity of the manager’s wage in equilibrium, with respect to this signal and, as a result, the higher a risk averse manager’s utility. Furthermore, if we allow for speculation we will find that managers

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65 Their model is structured in such a way that the firm’s income not only depends on ability (in addition to the risk factor and the firm’s exposure to this risk factor) but also on some random shock and project quality. Hence, in their model the risk factor is one among many different sources of noise.

66 See Holmstrom and Ricart i Costa (1986), and Hirshleifer and Chordia (1991) for other examples of such signal jamming behavior.
may even have an incentive to speculate in order to garble the informative value of the signal further. These implications are important; managers may prefer not to hedge and this will affect (reduce) information production in the market.

Additional insights

We have just described the main insight behind DeMarzo and Duffie (1995). However, the original model is much broader. Below we will describe the other relevant insights the work has to offer.

DeMarzo and Duffie (1995) model the risk management decision as an information precision trade-off. Shareholders prefer more precise information because they have the option to continue or abandon the project in a firm. This option clearly has value. The shareholders prefer to continue with the project if and only if the expected value of continuing with the project is equal to or higher than the expected value of the next best alternative. In order to exercise the option, shareholders prefer precise information about the expected value of the current project.

Managers on the other hand prefer to obscure information (along the lines we discussed above). Hedging may reduce noise in the profit process and therefore increases the informativeness of this process. This has two important real effects: “(1) the quality of the information received by shareholders affects the value of their “option” to continue or abandon the investment project and (2) the information revealed by profits typically has a nonlinear effect on the reputation, and hence the future wages of the current managers” (DeMarzo and Duffie, 1995, p. 745). The more informative the profit is with respect to project quality, the better shareholders can decide on their option to continue or abandon the investment project, and thus the more valuable is the option. On the other hand, the more informative the firm’s profit is with respect to the ability of the manager, the more sensitive his future wage becomes with respect to this profit. This obviously is not beneficial to a risk averse manager. Since the manager is the one that makes the hedging decision he may have incentives not to hedge (see Proposition 12).

The way risk management affects information production in the market is further determined by accounting disclosure. If there is full disclosure of a firm’s exposure and a firm’s hedging position, outsiders can fully disentangle the firm’s operating profits from hedging profits. The profit process in that case is very informative over the managers’ ability (and project quality). Consequently, the hedging decision is irrelevant; outsiders receive the same signal irrespective of the manager’s hedging decision.

However, if we slightly reduce the information set available to the market and assume that shareholders do know the number of hedging positions taken by the firm, but do not know what the effect is since they have no information about the payoff of the hedge instrument, then the manager may have an incentive to anti-hedge and thereby garble the information to the

\[\text{For a discussion of resolution preferences see Hirshleifer (1993) and Hirshleifer and Chordia (1991).}\]
market. Since shareholders cannot disentangle results from corporate risk management (hedging or speculating) from operational outcomes of the firm, they can infer less information about the manager’s ability and the value of the abandonment option from the firm’s income and therefore they will make a wage offer that is less sensitive to this income. Risk averse managers prefer such a contract. (Note that this is the case we established in Proposition 12).

The next step is to consider the case where the hedging position is common knowledge but the firm’s exposure is private information. The result in this case is not completely clear. Since shareholders observe the firm’s (manager’s) hedging position $(\phi Z)$, they can disentangle production profits from hedging profits. It is shown that hedging is ineffective if it is independent of (and hence uninformative about) the risk exposure $(\theta)$. However, if the hedging position depends on the firm’s exposure, it becomes informative and serves as a signal which enables outsiders to improve their assertion of managerial ability. This may result in a multitude of signalling equilibria. DeMarzo and Duffie (1995) show that the signalling value of the managers’ choice of $\phi$ about the firm’s exposure $\theta$ is the only relevant aspect; the managers’ only concern in choosing its hedging policy then is the inference that shareholders make regarding the exposure. A maximal hedging equilibrium can only exist if it is in the managers’ best interest to reveal their true level of risk exposure $\theta$ to the market, an unlikely condition. Using some specific distributional assumptions they evaluate the incentive to misreport. Under certain conditions, managers prefer to choose hedge ratios that overstate the magnitude of the firm’s exposure as a means of reducing the risk of their future wage.

Finally, consider the case where there is no common knowledge with respect to the firm’s risk exposure or the firm’s hedging position. In this case maximal hedging is viable as an equilibrium hedging strategy. Since shareholders cannot disentangle operating from hedging profits, managers can increase their utility by hedging. Hedging then reduces the volatility of the firm’s profits and hence his wage. The information set described here closely resembles that when firms report according to hedge accounting.

Given that the manager’s hedging decisions crucially depend on the disclosure of the firm’s risk exposure and hedging decisions, and that shareholders establish the way firms should disclose information, what then would be the optimal degree of accounting disclosure? DeMarzo and Duffie (1995) show that this boils down to a trade-off of two effects; shareholders have an incentive to obtain more precise information as this allows them to exercise their option to continue or abandon the current investment project, and the manager has an incentive to obscure the information, since this reduces the risk of his future wage. However, while determining the optimal disclosure requirement, shareholders should anticipate the manager’s actions given a certain disclosure requirement. Therefore, shareholders are actually better off by requiring an
accounting system in which separate accounts are not made available.\textsuperscript{68} Although with such an accounting system the shareholders receive less precise information about the firm's operating income, the managers' risk management decisions under such a scheme are such that in the end the information is less disturbed than when the shareholders choose for an accounting system that allows for complete separate accounts, but where managers are able to garble information by speculation.\textsuperscript{69}

2.6.3 Asymmetric information: risk management and managerial incentives

In this subsection we proceed with the setup of the model in the previous subsection but now assume that managers have private information about their own ability. What will be the impact of this assumption on the firm's hedging strategy?

First, the optimal managerial risk management strategy may become related to ability. For example, one may conjecture that good managers like the profit process to be as informative as possible, while bad managers may prefer more noise. If hedging increases the informativeness of the profit process about managerial ability good managers may prefer to hedge while bad managers will not (or may even speculate). We verify whether this equilibrium conjecture holds when all agents anticipate this behavior in our simple model.\textsuperscript{70}

Let $\phi_L \in \{0, -1\}$ be the hedging strategy of the low ability manager and $\phi_H \in \{0, -1\}$ that of the high ability manager. If $\phi_L = 0$, the low ability manager does not hedge whereas when $\phi_L = -1$, the low ability manager fully hedges the firm's exposure. To keep matters simple we do not consider mixed strategies (partial hedging strategies). An equilibrium is described by a set of hedging strategies $\{(\phi_H, \phi_L)\}$, a market belief function that specifies the market's posterior probability that given the observation $Y$, the manager is of high ability and a firm's action function (which specifies the hedging decisions of the managers). We want to establish the equilibrium hedging strategies for the low and high ability managers. Because hedging is unobservable the market can condition its posterior beliefs about the ability of the manager only on the realized income.

**Proposition 13** If managers have private information about their ability then the pure strategy Nash equilibrium risk management strategy is $(\phi_H, \phi_L) = (-1, 0)$.

\textsuperscript{68}The authors note the simplicity of their model and stress the need to reinvestigate this issue in more complex settings.

\textsuperscript{69}The authors also show that the managers' hedging decisions might affect investment decisions ex ante. If a manager can choose between two projects of which one is superior but riskier, and he cannot effectively hedge this exposure under certain conditions he will choose the suboptimal project.

\textsuperscript{70}More technically, we verify whether $(\phi_H, \phi_L) = (-1, 0)$ is a perfect Bayesian Nash equilibrium.
TABLE 2.9. Posterior probabilities for high (low) ability managers conditional on the hedging strategy that the high ability manager hedges and the low ability managers does not.

<table>
<thead>
<tr>
<th>Income</th>
<th>Posterior Probability</th>
<th>( m_H ) (high ability)</th>
<th>( m_L ) (Low ability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_1 )</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>( Y_2 )</td>
<td>( p_H )</td>
<td>((1 - p_H) * 0.5(1 - \pi))</td>
<td></td>
</tr>
<tr>
<td>( Y_3 )</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>( Y_4 )</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Proof. We have to establish that this hedging strategy maximizes expected utility for both types, given the market's learning from profits and that it is the only Nash equilibrium in pure strategies.

Table 2.9 specifies the posterior probability of being a high (low) ability manager, when the high ability manager fully hedges and the low ability manager does not hedge. As we can see, there is no full separation in this equilibrium. When the income realization is \( Y_2 \) or \( Y_3 \), the probabilities that it concerns a high ability (or low ability) manager conditional on the conjectured hedging strategies have been given in Table 2.9.

Now we can do the same for the other hedging strategies. Consider the case where both firms hedge. Then, the income is fully revealing and we will have a separating equilibrium (see Table 2.8). Although this is preferred by the high ability manager, the low ability manager has a higher utility if he does not hedge. Hence, for both types of managers hedging is not a Nash equilibrium. Finally we have to verify whether there is an equilibrium if both types do not hedge. If both firms do not hedge the market's learning is as in Table 2.7. Obviously, now the high ability manager can do better by entering into hedging. Hence, as a result we find that there is only one Nash equilibrium here, where the high ability manager fully hedges and the low ability manager does not hedge at all \((\phi_H, \phi_L) = (-1, 0)\).  

This is the intuition behind the work by Breeden and Viswanathan (1996). They, however, use a more complete model where mixed strategies (partial hedging) are also considered.\(^7\) Using this extensive model they find multiple equilibria.

The first type of equilibria they find is where the high ability manager always hedges, while the decision of the low ability manager depends on the differences in ability between good and bad managers. For the high ability manager, hedging leads to a more informative learning process than not hedging, whatever the low ability manager does. The equilibrium strategy of the low ability manager depends on the differences in ability. When there are small differences

\(^7\)Moreover, the mapping of ability in firm performance is stochastic. In our simple model this is fixed.
in ability low ability managers also hedge.\textsuperscript{72} The learning process from reported income in this case is not very informative (though more informative than when both types do not hedge). When the difference in abilities is high the low ability manager will not hedge and gamble on a lucky draw of the exchange rate so that in the end his firm is indistinguishable from a good firm. Between these two extremes, the low ability manager randomizes between hedging and not hedging (hedge ratio is between 0 and 1).

A second class of equilibria exists for specific parameters of change probabilities in exchange rates and the prior probability of being a manager of high ability. These equilibria occur where the risk factor creates much noise and where the difference in abilities is large. In these equilibria the low ability managers never hedge while the high ability managers randomize between hedging and not hedging.

Finally, a third (less intuitive) set of equilibria is derived. In that equilibrium high ability managers do not hedge while lower ability managers randomize. This is the case where the amount of noise is high but where the prior probability of being a high ability manager is low. In this setting the market makes strong inferences from extreme outcomes. Hence, the good manager gains more from being in the highest state. The lower ability manager randomizes to become indistinguishable from good firms with unfavorable outcomes.\textsuperscript{73}

Breeden and Viswanathan (1996) subsequently study the problem when risk management (hedging) is costly. In turn, they consider the case where managers not only care about their reputation but also hold equity. For levered firms the value of equity can be considered as the value of a call option on the firm’s assets with the firm’s face value of debt as the exercise price. The value of equity depends on the riskiness of the firm’s activities. Reducing risk leads to a wealth transfer from shareholders to debtholders and reduces the value of the manager’s equity (see also Proposition 6).\textsuperscript{74} The cost of hedging - lower value of equity - is higher for low ability than for high ability managers. If this effect is considered, it is shown that high ability managers will not hedge when there are low differences in ability. Only when the difference in ability increases, are there equilibria where high ability managers hedge. Low ability managers do not hedge for low differences in ability. However, as the difference in ability increases low ability managers do hedge and finally for high enough differences in ability they do not hedge. As the cost of hedging increases, the intermediate region where the low ability manager hedges, disap-

\textsuperscript{72}Although the profit process is not very informative here, low ability managers obscure a poor ability signal by hedging low realizations of profits that would screen them out as low ability managers.

\textsuperscript{73}The authors regard this latter class of equilibria as unreasonable. Standard refinements fail to reject these equilibria. When taking costs into consideration these strategies are inconsistent with an equilibrium.

\textsuperscript{74}Breeden and Viswanathan (1996) consider the case for savings and loans and for banks. These firms have access to deposit insurance. Hedging reduces its value and is thus an additional cost to shareholders.
pears. In general, the authors argue that the equilibria entail greater separation when managers hold equity.

Extensions

A first extension of this framework is to expand the strategy set with corporate speculation.\(^75\) DeGeorge, Moselle and Zeckhauser (1996) consider a continuum of hedging and speculating strategies. Although DeGeorge, Moselle and Zeckhauser (1996) assume risk management to be costly, they do not consider the relation between costs and managerial ability (as in Breeden and Viswanathan, 1996) but simply assume that the hedging or gambling costs are monotonically increasing with the amount of risk management.\(^76\) They first assume that both the choice of risk is observable (here it serves as a signal) and that the firm's current earnings also reveal additional information. Since managers manipulate the distribution of earnings, the resulting model contains both signalling by means of risk choice as well as signal jamming through profit reporting. With respect to the signalling part, it is assumed that there are no exogenous differences in costs which typically drive standard signalling models.\(^77\) An endogenous reputation difference emerges between the two types: "That is, the good type has less to gain by deviating from the mean maximizing variance choice than the bad type, as his ability will be at least partly revealed through his performance."

In the second part it is assumed that the choice of risk is unobservable (as in DeMarzo and Duffie, 1995; Breeden and Viswanathan, 1996; and Ljungqvist, 1994). The model then is a standard signal jamming model as in Breeden et al. (1996), although much more complicated because the strategy space is larger. Analysis of equilibria appear to be intractable and the

\(^{75}\)Ljungqvist (1994) first studied the issue of corporate speculating on these grounds. The paper argues that there is such an incentive when managers have private information about firm value and seek to increase the stock price on behalf of the shareholders. In the model profits serve as a signal of firm value. A manager knowing the true value (e.g. low productivity) may have incentives to gamble in order to mimic a high output firm by reporting a high profit. When the mapping of profits in share prices is nonconcave corporate speculation is an equilibrium strategy because it distorts profits and hence, manipulates stock prices. In equilibrium share prices adjust to reflect the ongoing speculation, but a remaining effect of such corporate speculation is that profits and therefore share prices become less informative about firms' true worth. The idea in the paper is that costless speculation creates noise in the profit process which creates an informational externality by making share prices less informative. Optimal speculation strategy depends on the shape of the mapping which is in turn affected by those decisions on speculation.

\(^{76}\)Note that Ljungqvist (1994) assumes that risk management (gambling) is costless.

\(^{77}\)Breeden and Viswanathan show that there is some endogeneous cost of hedging for the equity holders. Along this line of argument, equityholders even gain from speculating. It may be interesting to add these additional costs in the analysis. Especially, since these costs/gains are ability related.
Why do firms hedge: a theoretical framework

Authors use numerical methods to gain additional insights. Four effects are determined. For the good firm the effects of lowering the variance are:

- A reduction in earnings (because risk management is costly);
- A shift in the profit distribution of the good firm to the left (due to costly risk management) of the bad firm. (This hurts the good firm’s posterior expectation);
- A diminishing of the overlap of the left tail with the bad firm’s distribution;
- For very unlikely events, hedging will bolster the good firm’s posterior expectation.

Another interesting extension to this literature is an expansion of the information set. In Breeden and Viswanathan (1996) the information set of the market is restricted to the firms’ reported profits. Expanding this information set for example with the total disclosed value of total derivative position is likely to affect the equilibrium actions. DeMarzo and Duffie (1995) have shown the importance of disclosure in case both the manager and the market are uncertain with respect to the ability of the manager. For example, if we extend the market’s information partition with the firm’s hedging decisions, we find the trivial case where hedging no longer has a signal jamming effect and managers have no incentive for hedging, not even when they have private information over their ability. Intermediate cases, e.g. the case where the firm reports the market value of its hedging instruments, may be worthwhile studying. If the firm’s hedging choice is observable we have a standard signaling model (see e.g. Cho and Kreps, 1987) with an extra stage in which the profits are reported.

Empirical predictions

Although the empirical predictions of the analysis in the previous subsection are not completely clear - they depend on the proportion of good and bad firms (in equilibrium) and the difference in ability between (high and low ability) managers - Breeden and Viswanathan (1996) suggest that firms that hedge will have both a lower volatility in earnings and a higher level of earnings (see Table 2.10). DeGeorge, Moselle and Zeckhauser (1996) also suggest that there is a positive relationship between earnings variability and average firm performance. The amount of information asymmetry, however, is relevant. The larger the information asymmetry, the more important the corporate use of derivatives may be (although the direction of use, hedging or speculation, is unclear).

78 This extended signaling model has been used in DeGeorge, Moselle and Zeckhauser (1996)
79 DeGeorge et al. (1996) also test if there is a negative relationship between performance and variability, on a set of 425 firms in the Standard and Poor’s index. They find empirical support for their hypothesis in 25 out of 28 industries in the sample.
2.7 Concluding remarks

A second prediction is related to the difference in managerial ability. If this difference is high, and if hedging is costly, it is more likely that we will observe hedging. One potential way to test this hypothesis is using age as a proxy. You expect for younger managers higher differences than for older managers. Hence, younger managers are more likely to hedge.

Finally, a third prediction is that we expect that firms that hedge are of considerable higher value than those that do not when the costs of hedging are high (e.g. if managers have stock options that are at the money).

2.6.4 Concluding remarks and empirical predictions

In this section we focused on managerial rationalizations of risk management as a result of ex ante information problems between managers and the firm. If the market cannot observe the quality of the managers the managers may want to use risk management to strategically manipulate the informativeness of earnings for reasons of risk aversion or from the impact on their reputation in the labor market.

This holds both for cases with symmetric and asymmetric information about the ability of corporate managers. We have shown that the equilibrium risk management strategies depend on disclosure of risk management, differences in ability of managers in the market, and the costs of risk management. Although the analysis does not provide us with straightforward answers, it clearly shows the importance of taking into account managerial incentives to engage in risk management when analyzing risk management and decision making.

2.7 Concluding remarks

In this chapter we developed a framework that integrates the existing theories of corporate risk management. We identified four major driving forces behind corporate risk management: (i) taxes, (ii) bankruptcy costs, (iii) investment distortions due to contracting problems between firms and financiers, and (iv) managerialism due to imperfect contracting between the manager and shareholders. Figure 2.4 summarizes the main insights developed in this chapter. In the next chapter we will discuss the empirical literature that has tested the (predictions of these) theories. We conclude this chapter with some observations.
<table>
<thead>
<tr>
<th>Type of Analysis</th>
<th>Underlying Source</th>
<th>Driving force</th>
<th>Benefits (costs) of corporate risk management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neoclassical</td>
<td>Non-linear tax</td>
<td>Taxes</td>
<td>Reduces taxes</td>
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<tr>
<td></td>
<td>scheme Bankruptcy costs Bankruptcy costs</td>
<td>Reduces expected costs of financial distress</td>
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<td>Analysis</td>
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<tr>
<td>Information</td>
<td>Asymmetric</td>
<td>Investment</td>
<td>Reduces agency costs of debt financing/</td>
</tr>
<tr>
<td>Economics</td>
<td>information:</td>
<td>distortions</td>
<td>allows more debtfinancing</td>
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<td></td>
<td>- between share-</td>
<td>- Underinvestment</td>
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<tr>
<td></td>
<td>and debtholders</td>
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<td></td>
<td>post contracting</td>
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<tr>
<td></td>
<td>- Asset</td>
<td></td>
<td>(Low cost instrument for shareholders to increase risk in order to exploit option)</td>
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<tr>
<td></td>
<td>substitution</td>
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<tr>
<td></td>
<td>- Underinvestment</td>
<td></td>
<td>Allows firms to execute strategic plan and lower financing costs</td>
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<tr>
<td></td>
<td>Prior to</td>
<td></td>
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<tr>
<td></td>
<td>contracting</td>
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<tr>
<td></td>
<td>Asymmetric</td>
<td>Managerial</td>
<td>(Allows managers to increase the expected utility of the management compensation contract)</td>
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<tr>
<td></td>
<td>information</td>
<td>compensation</td>
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<td>between</td>
<td>contract</td>
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<tr>
<td></td>
<td>contracting</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- Managerial</td>
<td></td>
<td>Reduces agency costs of managerial discretion by allowing more precision in the amounts of financing in the hands of the manager</td>
</tr>
<tr>
<td></td>
<td>compensation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>contract</td>
<td></td>
<td>( Enables the manager to bypass (the monitoring function of) the financial markets and select projects with (large) private benefits)</td>
</tr>
<tr>
<td></td>
<td>- Overinvestment</td>
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<tr>
<td></td>
<td>- Overinvestment</td>
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<td></td>
<td>- Strategically</td>
<td></td>
<td>( Enables risk averse managers to reduce the informativeness of ability related signals and thus the sensitivity of the management compensation contract.) Allows (high ability) managers to increase the informativeness of corporate cash flows about ability</td>
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<td>Prior to</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>contracting</td>
<td></td>
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</tbody>
</table>

**FIGURE 2.4. A theoretical framework of rationalizations of corporate risk management**
First, the literature rationalizing corporate risk management lacks a comprehensive uniform framework. A wide variety of models is needed to describe the literature that rationalizes corporate risk management. The literature consists of many partial (possible) rationalizations which have not been integrated in an overall framework.  

Capital structure, managerial incentives, investment opportunities and risk management decisions clearly interact with each other. Moreover, the interactions are complex. Most papers focus on one of the driving forces or model optimal risk management as a trade-off of two opposing effects. The literature in this sense is still at a premature stage where we focus on one or two rationales at a time. In the end, we can only fully understand (and explain) these decisions if we take them all into account. This however requires a unifying framework. The lack of a uniform framework in corporate finance hampers the analysis of such interactions. This is not specific for corporate risk management but is typical for the corporate finance literature as a whole.

A second observation is that despite the fact that most of the literature presented in this chapter focuses on the use of derivatives in risk management, the rationales also apply to all other forms of corporate risk management such as the purchase of insurance, diversification of operating activities (for example via conglomerate mergers), geographical diversification, and other ways of reducing cash flow volatility or accounting earnings volatility. An interesting question is when and why firms prefer one alternative of corporate financial risk management over the other. Obviously, exposure is an important determinant. But to manage currency risk for example, firms can use both operational hedging (e.g. the choice of production location) as well as financial hedging. The theoretical literature to date on this matter is still very limited, but suggests that firms should use operational hedging for exposures that are longer term and more

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80 Some noteworthy exceptions are Leland (1998) and Ross (1998). These contributions integrate several rationales for both capital structure and risk management in a unifying framework. See Section 2.3.4 for a discussion.

81 Froot (1995) develops a perspective on the interaction between risk management, investment decisions and capital structure decisions in a world with both ex ante and ex post incentive problems. Froot argues that if a firm only faces marketable risk, it could completely solve the incentive problems with a well structured risk management program. However, if the firm (also) faces non-marketable risks, it will also need to adjust its investment strategy and capital structure to optimally deal with such problems. Froot ignores managerial incentives to a large extent.

82 Note that this can be important for a relatively new field of research; it provides researchers with many degrees of freedom.

83 With respect to rationales for firms to purchase insurance, Mayers and Smith (1982, 1987) developed some that are closely related to those discussed in this chapter. In addition, a more specific rationalization for the corporate purchase of insurance is that it may bring real services related to risks like loss prevention and claims handling.
uncertain and financial hedging for more certain short-term exposures. The current literature however, does not address questions about the relative optimality of derivatives in achieving such objectives. We expect future research to focus more on these issues.

The third observation is with respect to the focus of firms in financial risk management. The rationales developed in the theoretical literature have directly implications for the way firms should engage in risk management. Generally, to reduce the costs of financial distress (and the associated investment distortion, the firms should hedge downside risk (cash flow risk). To reduce taxes, the firm should hedge volatility in (annual) taxable income. Managerial reasons may induce firms to hedge volatility in cash flows, accounting income or firm value. The literature therefore already provides some important lessons with respect to the focus on corporate risk management. With respect to the optimal maturity of the risk management strategy, the theoretical literature however gives considerably less guidance. Most theories consider a single (or two) period model. We think that the intertemporal aspects of risk management deserve more attention.