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## Essays on corporate risk management and optimal hedging

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## ***Chapter 5***

### ***SUMMARY AND CONCLUDING REMARKS***

#### ***5.1 INTRODUCTION AND DEFINITIONS***

This dissertation studies the use of financial derivatives within corporate risk management programs. Risk management undertaken at the firm level has attained great attention in recent decades by both non-financial as well as financial corporations. This growing attention has been mainly stimulated by increased fluctuations in interest rates, exchange rates, and commodity prices, causing risk exposures to increase. Another important reason for the focus on risk management is the growing number of opportunities to manage different risk exposures (i.e., the evolution of financial markets on which risk exposures can be transferred quite easily among different market participants). A company can employ two approaches to manage risk exposures. First, firms can use financial derivatives to hedge risks and thereby stabilize the firm's cash flows, which is defined as financial hedging. Secondly, firms can change their operational policies in response to fluctuating risk factors, so-called operational hedging.

To give an example, an exporting manufacturer can reduce its currency risk exposure by buying or selling currency futures. As an alternative, it can also build plants overseas to hedge or offset receivables in a foreign currency with costs in the same currency. In this thesis, we focus on the first alternative of hedging, that is, risk

management through the use of financial derivatives. In this context, we define corporate risk management as the process of trying to control the effect of different risk exposures on firm value, using financial derivatives. In our analysis – especially in the main Chapters 3 and 4 – a key issue to explain a rational motive for risk management is the possible existence of market incompleteness. In this context, capital markets are said to be incomplete if the implicit private pricing systems, which are used by the manager and/or owner of the firm to value financial assets, differ from market's equilibrium pricing system. In this case, individual economic agents, such as the managers and owners of a firm, disagree with the market about the pricing of financial instruments.

In *Chapter 1*, we formulate the main goal of this thesis as:

*The main goal of this thesis is to extend the existing literature of corporate risk management to provide a better understanding of the interaction between optimal production and risk management decisions, through the use of financial derivatives.*

Based on this main goal, four research questions are formulated, which are answered in the Chapters 2, 3, and 4:

1. Are optimal production and risk management decisions dependent on the type of derivative contract that can be used for risk management purposes?
2. Is it rational for firms to engage in full hedging, or should they over- or underhedge total price risk of production?

3. Given the specific type of derivative contract and the optimal amount of production and risk management, is there separation between the optimal production and risk management decision?
4. Do optimal production and risk management decisions change for different kinds of managerial compensation?

In the remainder of this chapter, we summarize the preceding chapters, mention our main contributions to the existing literature and, finally, suggest some possible extensions to our analysis in future research.

## **5.2 SUMMARY OF THE MAIN RESULTS**

In the first part of *Chapter 2*, we provide the theoretical foundation for this study. In line with Modigliani and Miller (1958), who show the conditions for the irrelevance of a firm's capital structure, we start by analyzing the conditions under which corporate risk management is irrelevant. If capital markets are perfect this implies that – among other conditions – 1) there are no transactions costs, 2) firms and individuals have equal access to financial opportunities, and 3) individuals perceive that there are always perfect substitutes for any securities of a firm (see e.g., Fama and Miller, 1972). Given these assumptions, individual investors can always replicate or undo the firm's financial decisions (i.e., any financial decision can be replicated or undone through the use of perfect substitutes which are available in the capital market). If the “equal access assumption” does not hold, risk management at the firm level may be preferred to risk management at the level of the individual investor.

Smith and Stulz (1985) show that this situation occurs if capital markets are imperfect in the sense that certain costs are imposed on firms. It is shown that, from a theoretical point of view, a convex corporate tax schedule, costs of financial distress, and agency costs of debt provide motives for hedging to be undertaken at the firm level. These market imperfections impose discriminatory costs for certain states of the world, which can be reduced – or even eliminated completely – by hedging. The present value of the reduction in the expected costs increases firm value, assuming that the costs of hedging do not exceed the reduced “imperfections costs”. Since the discriminatory costs are borne by the firm solely, these risk management actions cannot be replicated by individual investors, providing a rationale for risk management to be undertaken at the firm level instead of by investors themselves. By reducing or eliminating these costs, firm value for the investor is increased.

A second explanation for corporate risk management is based on managerial utility maximization. It is shown that the manager who is responsible for the corporate risk management decisions will have an incentive to apply derivatives to maximize his own expected utility, if his personal wealth depends on firm value. Assuming risk-averse behavior, a manager who is (partially) compensated with shares of stock, will have a direct interest to reduce the firm’s risk exposure by hedging. If the same manager is compensated with call options on the value of the firm, the situation is more complicated. On the one hand, he is willing to reduce risk by hedging since the manager is assumed to be risk averse. On the other hand, however, since call options become more valuable if uncertainty is increased, the manager has an incentive to increase firm risk. He therefore faces a trade off between decreasing and increasing risk. As a consequence, the manager is assumed to hedge less than in

the case of compensation with shares of stock and – as an extreme – may be even inclined to speculate.<sup>104</sup>

In the second part of Chapter 2, we present an overview of some important empirical studies regarding corporate risk management. These include regression studies, survey analyses, as well as simulation studies. Empirical evidence provides rather mixed support for the theoretical motives for firms to engage in risk management activities. Overall, individual firms do not seem to hedge in order to reduce expected tax payments or the costs of financial distress. The empirical studies, however, do seem to support the hypothesis that firms hedge more if they face agency costs of debt. There is also some empirical evidence that managers may use derivative instruments to maximize their personal utility of wealth. A very convincing result – presented by all studies – is that large firms engage in risk management activities far more often than smaller companies do. It seems to be the case that transaction costs of hedging play an important role in explaining the corporate use of derivatives. Larger firms are in a better position of bearing the fixed costs to set up risk management programs, and can more easily contract specialized employees for executing these programs.

In *Chapter 3*, we extend the existing literature on optimal risk management and production decisions by applying the theory of optimal choice under uncertainty. In fact, we choose to analyze the second motive for risk management (i.e., managerial

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<sup>104</sup> Speculative motives may occur if the manager's future wealth is – as a consequence of the rewardance of call options – a convex function of firm value. Speculation increases the volatility of the firm, making the call options more valuable. This increases managerial wealth. The lower the level of managerial risk aversion, the higher the incentives to increase risk.

utility maximization).<sup>105</sup> A central element in this chapter is a risk-averse producer who maximizes a strictly convex Von Neumann-Morgenstern utility function (this producer is the single owner of the firm). We apply a state-of-the-world approach, as essentially introduced by Arrow (1964) and Debreu (1959). In our model, we examine a two-date framework in which in the future,  $N$  possible states of the world can occur. All states of the world have associated probabilities and prices, in which the assets are priced by the state price system. We examine a firm, which sells a single good to the market, of which the future price is assumed to be uncertain. The producer can choose total production to maximize his personal utility of wealth (output is assumed to be non-random). In order to manage commodity price risk of production, this producer can rely on the forward and/or the put market. The producer faces three choices: 1) the optimal amount of production, 2) the optimal number of forward contracts, and 3) the optimal number of put options. We analyze these choice alternatives individually, as well as simultaneously. The prices of the forward contracts and the put options are – in line with the standard literature on optimal risk management – assumed to be unbiased. In this context, unbiasedness of forward and put prices implies that the current price of the derivative contract equals its expected payoff.

Before we derive the optimal production and risk management decisions, we first analyze general conditions under which forward and put prices are unbiased predictors of their future payoff. In line with the standard line of literature, we

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<sup>105</sup> As argued in Chapter 1, applying both the framework provided by Modigliani and Miller (1958) and applying the theory of optimal choice under uncertainty results in a non-linear optimization problem. As a consequence, both frameworks lead to a rational incentive to decrease cash flow volatility (see Chapter 1, p. 7).

formally show that this can occur under the assumption of risk neutrality. We extend the existing literature by showing that – contrary to the traditional belief that unbiasedness occurs under risk neutrality only – restrictions on the probability distribution suffice for unbiasedness, even for the case of consumers being strictly risk averse. Unbiasedness of either forwards or puts only, implies restricting one probability of the probability distribution. This rather technical restriction depends on all the other probabilities and on the state prices, meaning that both the probability distribution and the state prices can have any form. Unbiasedness of both forward and put prices occurs if two restrictions are put on the probability distribution.

The remainder of Chapter 3 studies optimal production and risk management decisions by a strictly risk-averse, utility-maximizing producer. In our analysis, we define market completeness as the situation in which the producer's private implicit state pricing system equals the market-given state pricing system. We prove that in complete markets – as can be expected – there is no advantage for the producer in hedging, either by using forward or by using put contracts. This implies that risk management is not utility enhancing. However, if markets are incomplete, the producer does not agree with the market about the pricing of put options and forward contracts, implying that his private valuation of these contracts (derived from his private state prices, which are not equal to that of the market) differs from the market valuation. In this case, risk management by the use of forwards and put options can lead to welfare improvements. We show that, if the market prices are unbiased, the producer feels that the market forward price is too high, and the market put price is too low. As a consequence, the optimal derivatives' position for the producer is to sell forward contracts and to buy put options.



With respect to hedging with forward contracts – given incomplete markets – the producer will fully hedge commodity price risk. Furthermore, in this specific case, the optimal production and risk management decision can be separated, even though the producer perceives the forward contracts to be overpriced. With this result, we extend the existing line of literature, in which the producer agrees with the market valuation of the forward contract. The full hedging and separation theorems are therefore independent of the assumption of market (in)completeness.

For the case of hedging with put options, we show that the optimal put position depends on the producer's access to the bond market, resulting in the possibility of overhedging, full hedging, as well as underhedging commodity price risk. Furthermore, depending on his level of risk aversion, the producer will decrease total production (as compared to the case of hedging with forward contracts). As a result, the separation theorem does not apply.

Our final contribution to the existing literature on optimal production and risk management decisions is that we show that when both forward and put contracts are available for hedging purposes, there is a hedging role for puts. We show that the optimal decisions are to decrease production, buy put options, and completely eliminate commodity price risk with forward contracts.

In *Chapter 4*, we extend our model from Chapter 3 by examining the effect of different managerial compensation structures on the optimal production and risk management decisions. In addition to the producer (alternatively: the initial owner(s) of the firm), we introduce a manager who is responsible for the choice of production and hedging volume. In combining the literature of managerial compensation, with

the literature on optimal hedging and production, we are able to evaluate the relationship between managerial compensation and optimal choice under uncertainty. In this chapter, we analyze whether managers are given the right incentives by rewarding them with the most common compensation structures: cash in combination with shares of stock, and cash in combination with at-the-money call options. The incentive structure is optimal if the managerial production and risk management decisions are exactly the way the owners of the firm would want him to choose, which we define as “incentive compatibility”.

If the manager can manage price risk exposure with unbiased forward contracts, then, either in the case of compensation with shares of stocks or in the case of compensation with at-the-money call options, the full hedging and separation theorems apply. The result for compensation with call options is new in the literature on optimal hedging. Furthermore, since these decisions are also optimal for the owners of the firm, the manager exactly chooses production and hedging in the way the other owners of the firm should want him to. This implies there is incentive compatibility between the manager and the owners of the firm.

Incentive compatibility, however, does not occur if the manager can choose unbiased put options to hedge commodity price risk. We show that, both for the case of compensation with shares of stock as well as for the case of at-the-money calls, the optimal hedge is an overhedge using at-the-money put options. However, the optimal production decision is to decrease production (as compared to hedging with forward contracts) and this decision cannot be separated from the optimal hedging decision. We show that the overhedge decreases as the fraction of stock or call compensation increases, and if the manager is more risk averse.

Since the analytical model does not provide closed-form solutions on differences in optimal decision making when using put options as a hedging device, the second part of Chapter 4 provides numerical simulation results to analyze the conditions influencing optimal decision making. We analyze a simple model, in which four future states of the world can occur. The manager is assumed to maximize a power utility function, in which his private pricing system, like in Chapter 3, may differ from that of the market (i.e., we assume market incompleteness). We first analyze a benchmark case, which gives the optimal put position for the producer, after which we analyze the alternative choices undertaken by the manager. The benchmark case results – as can be expected – in an overhedge of total production. We show that this overhedge does not change drastically for alternative fractions of managerial compensation (i.e., more or less stocks and calls relative to firm value), for different levels of managerial risk aversion, for lower levels of production, as well as for changes in the implicit private pricing system. This implies that the robustness of the optimal ratios in the benchmark case is quite strong for changes in the most important input variables. This result also holds in extreme (worst-case) scenarios, in which the factors co-act together. Incentive compatibility occurs in very few accidental cases only. However, given the fact that the optimal overhedge is quite robust to – even unrealistic – changes in the parameter values, the shareholders of the firm will probably not be harmed too much. As a result, even though the manager will not hedge commodity price risk by the same amount the owner would want him to, this suboptimality (from the owner’s point of view) is quite small. From this we conclude that the incentives of the owner and the manager are reasonably compatible.

### **5.3 REFLECTION AND SUGGESTIONS FOR FUTURE RESEARCH**

Doing Ph.D. research is like the main focus of this study: making choices. In this thesis, we mainly apply the normative theory of choice under uncertainty, given a specific consumption-investment problem in an expected utility setting. Specifically, the decision maker – being either the manager or the producer – is faced with a set choices (i.e., total production and total hedging volume) that each involve possible outcomes, with payoffs, prices, and probabilities associated to these possible outcomes. From each possible outcome a subjective utility is derived and, by optimizing the choice variables, the decision maker maximizes his personal expected utility of wealth. Since his expected utility of wealth, by the combined choice of variables, is maximized, this results in an optimal solution for the decision maker.

In general, normative theories are primarily concerned with describing how economic agents should act when they are faced with possible choice alternatives. This rather deductive analysis is mainly based on a number of assumptions regarding rational choice (see e.g., Von Neumann and Morgenstern, 1947). The most attractive feature of normative modeling in our setting is that – give rational agents – optimal choice behavior can be derived. The ability to derive optimal choices, is the main motivation to choose for a normative approach in this thesis. Given the normative approach, we intend to present a fundamental framework, which shows how production and risk management decisions interact, from a rational and optimal point of view.

The rather deductive and mathematical approach to modeling economic choice behavior has – besides its main advantage to build a fundamental framework – also some drawbacks. A usual reaction of an opponent may be that this kind of modeling

is oversimplified since it does not capture all the complexities that exist in the “real world”. Although this is definitely true, it must be countered that the advantages are also apparent and may be worth a certain loss of realism, as long as the simplified normative model is as similar as possible to the desired model. This means that the model must capture the most important aspects of decision making and present logical results. If the range of possible choices and exogenous factors in the “real world” is rather complicated, the optimization problems may become too complex and it may be hard to derive results which have a simple meaning. The challenge is, therefore, to incorporate the most important variables into the model and derive tractable conclusions from these variables (i.e., it is important to exclude variables that may be (partially) relevant, but relatively unimportant to the conclusions of the analysis). A certain amount of simplification is necessary – or at least tolerable – to gain the advantages of formalization in order to derive optimal individual behavior.

A second drawback of normative models is that there is no real reason to suppose that actual individual behavior does conform to the principle of rationality.<sup>106</sup> As a consequence, normative theories may turn out to be descriptively false when the results are presented to describe *actual* instead of *optimal* behavior. Over the last decades, numerous research has indicated that individual behavior may structurally deviate from rational behavior, leading to experimental anomalies. This has resulted in a relatively new area of research within the field of financial economics, generally referred to as “Behavioral Finance”. Behavioral Finance focuses on describing and explaining actual behavior as well as experimental anomalies within the field of

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<sup>106</sup> Whether this is a real drawback may be questioned and depends on the goal of the model: is the model intended to describe optimal or actually-observed behavior?

financial economics.<sup>107</sup> A major contribution to this line of research is the so-called prospect theory, developed by Kahneman and Tversky (1979), which is the most important behavioral alternative to the expected utility theory. Whereas the expected utility model is a normative decision model intended to derive optimal choice behavior by individuals, prospect theory can be seen as a descriptive decision model for individuals, which explicitly incorporates behavioral elements. The major modifications to the expected utility theory are that 1) possible choices (so-called prospects) are evaluated according changes in wealth (gains or losses) as opposed to total final wealth, 2) the value (utility) of a possible outcome is multiplied by a decision-weight instead of a probability, and 3) contrary to overall risk aversion, individual agents tend to be loss averse and often show risk-seeking behavior in the domain of losses. In fact, in prospect theory, the process of decision making can be separated into two distinct phases: framing and valuation. The framing phase consists of a qualitative analysis of all available prospects, which are relevant for the process of decision making. The phase of valuation consists of a quantitative comparison of the possible alternatives.<sup>108</sup>

As is apparent from the drawbacks of normative research in general, the framework we apply in this thesis is still incomplete. In order to extend our model to make it (more) useful for both normative as well as descriptive purposes, we suggest some

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<sup>107</sup> For an overview of some important issues in the field of Behavioral Finance, see e.g., Thaler (1993 and 2005).

<sup>108</sup> Contrary to expected utility, the valuation function is S-shaped. People tend to be risk-averse in the domain of gains, and risk-seeking in the domain of losses. Furthermore, losses loom larger than gains. Finally, the decision weights measure the impact of events on the desirability of the prospects instead of the (perceived) likelihood of these events. See e.g., Tversky and Kahneman (1992).

possible improvement and extensions for future research. First of all, this study heavily leans on the assumption of unbiased forward and put prices. Although we show that risk-neutrality is not a necessary condition for unbiased derivatives' prices, in practice, these prices are not expected to be unbiased predictors of their future payoff. Future research could, therefore, focus on the effect of biased pricing on optimal production and risk management decisions. A second extension that can be applied is to interact the impact of multiple risk factors on optimal decision making, given the assumption of market incompleteness. For instance, in our model we assume production to be fixed. If production is assumed to be stochastic, a natural hedge may be expected between production and price risk exposure, implied by an expected negative correlation between the two. As a consequence, this interaction influences optimal decision making. Furthermore, in multi-period models, the effect of changing parameters of the probability distribution can be analyzed. A final suggestion we offer for future research is to focus on the effect of bounded rationality on (optimal) decision making. In our model, we assume that the manager of a firm, makes optimal decisions given the information set available to him. We provide rational recommendations on the optimal choice of derivative instruments within corporate risk management policies at the firm level. However, as mentioned before, empirical evidence shows that actual choice behavior often differs from optimal behavior, which has been the main focus in this study. Incorporating behavioral elements into the analysis may contribute to our understanding why actual risk management behavior often differs from what is optimal from a theoretical point of view.