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JANNE KETTUNEN

Dr. Custos, Dr. Opponent, Ladies and Gentlemen,

Most investment decisions of profit-seeking organizations are made under uncertainty about the obtained return. Consider for example an investment opportunity in a fossil fuel power plant. Its return is uncertain due to several reasons including variable fuel costs, changing demand levels, and power prices, to name a few. In the evaluation of investments with uncertain return, it is pertinent to assess not only the expected return but also risks. Risks can be defined, for instance, to stem from the outcomes when return is less than a certain pre-specified level, which represents the risk tolerance of the investor.

Also, as portfolio investments are possible, it is important to consider diversification benefits that may reduce the risk of the portfolio. As Harry Markowitz, who was also granted the Nobel Prize in economics, demonstrates the variance of the portfolio return can be reduced by selecting assets that hedge each others' risks. Considering again the investment in the fossil fuel power plant, the diversification benefits can arise from the existing portfolio of power plants. For example, fossil fuel power plants can be more profitable under low carbon prices and non-fossil fuel plants under high carbon prices. Consequently, a balanced combination of fossil and non-fossil fuel power plants can reduce the overall carbon price risk.

The investment decision is also complicate because it may involve managerial flexibilities, or real options. Real options can allow, for instance, postponing the fossil fuel power plant investment to obtain more information about the possible climate policy outcomes or upgrading the plant later on to reduce its carbon dioxide emissions. Real options can thus be beneficial in reducing the risks and in increasing the value of the investment.

In the thesis, I analyze investment decision-making and its financial implications under market uncertainties while acknowledging risks and real options. The developed decision models build on decision analysis, financial modeling, and stochastic modeling. The decision analysis approach is chosen to study the decision behavior of rational investors, which can differ based on their risk tolerance, for example. The financial modeling approach is applied because investments provide cash flows and are valued using principles, such as the expected net present value. The stochastic modeling approach is used to represent the market uncertainties via scenarios and optimize over them.

More specifically, the scenarios are generated such that they represent the possible evolutions of the uncertainties. This can be done via several ways. One possibility is to use subjective estimates of the experts for the possible outcomes and their likelihoods. This approach can represent non-traditional stochastic processes and risk factors, such as political, model, and liquidity risks, for example. If, however, there are reasons to believe that historical data may characterize future developments of uncertainties, then it is appealing to consider methods that are based on data, for instance, by deriving the parameters for scenario generation to match the moments or other statistical properties of data. Alternatively, scenarios can be generated by discretizing the underlying stochastic process as is commonly done in the discrete time scenario approaches of the finance literature. These approaches have several advantages, such as (i) they can match the market observed prices of the financial contracts, (ii) they can provide an arbitrage free pricing environment, and (iii) their parameters can be estimated based on historical time series data.

The appropriateness of the scenario generation method depends on the application context. If, for example, the problem deals with financial portfolio optimization or financial contracts, then a requirement for the generated scenarios is that they provide an arbitrage free pricing environment.

In my thesis, I develop scenario-based approaches and decision models for several problem contexts, such as (i) the optimal harvesting of forest stands, (ii) the management

of electricity contract portfolios, (iii) the investments in power plants, and (iv) the valuation of real options in new product development.

In the forest portfolio context, I consider a forest owner who needs to plan harvesting strategies under the price uncertainty. Risks of the forest owner are curtailed both at the intermediate and the terminal time periods concurrently. This is because managing risks only in the terminal time period is not enough if risks are needed to be managed consistently due to the forest owner's being close to financial distress or needing regularly a pre-specified cash flow to cover other financial liabilities, for example. The results show that extreme risks can be significantly reduced without appreciable losses in the expected terminal wealth. Also, the results indicate that risk-neutral forest owners harvest their forests later than risk-averse forest owners. This is because risk-averse forest owners do not want to be left with a large amount of timber at potentially low prices, which is why they harvest sooner than risk-neutral owners.

In the management of electricity contract portfolios, I consider the decision problem of an electricity retailer who needs to deliver an uncertain supply of electricity by purchasing it at uncertain price from the spot market and when it can also purchase future contracts to hedge the risks. The problem is further complicated as the stochastic processes of the electricity load and spot price are correlated and exhibit volatility clustering, in other words periods of low and high variance, and mean reversion, which describes the tendency for the time series to revert to a stationary average. This developed model captures (i) the correlation between spot price and load, which increases exponentially in load, (ii) premiums on future contracts, and (iii) temporal risk preferences at intermediate time periods over the contracting horizon. The results show that the modeling of price and load correlations is particularly important because otherwise risks may be underestimated, resulting in suboptimal decisions. An analogue can be found from the recent “credit crunch” which was partly due to failing to adequately account for the bankruptcy correlation between the banks.

In the long-term investment decision-making, I analyze a power utility that considers investing either in a new nuclear, coal, or gas power plant. The underlying uncertainty is the climate change policy that is manifested in the uncertain carbon price influencing hence the profitability of the power plant investment. Within this context is considered how the investment decision differs by companies that are heterogenous in terms of their risk aversion, existing asset portfolio, cost of capital, and opportunity rate of return. The results demonstrate that detailed financial analysis with real options and risk constraints can make substantial difference to the investment propensities compared to conventional economic analysis. Also, the effects of different carbon policies and market instruments on these decision propensities depend on the characteristics of the companies, and may induce path-dependent technology choice and market structure evolution. In particular, carbon policy uncertainty may result in a more concentrated and less competitive electricity markets, because the new investments are more likely to be made by larger financially stronger incumbent firms than small, project-financed independent power producers.

In new product development setting, I investigate the value of the development project and its embedded managerial flexibilities under uncertainties about competition. More specifically, the analyzed managerial flexibilities are the decision to enhance product development, the decision to abandonment development, and the decision to delay the launch of the developed product. The results indicate that stronger competition may increase or decrease the value of flexibility, depending on the market environment and whether the available options act as substitutes or complements. Also, the results show that the flexibility does not necessarily have greater value in a winner-takes-all market, in which the best-performing product captures the entire market, compared to a shared market, where many products can co-exist and capture market share depending on their relative performance. Furthermore, the option of delaying a product launch is showed to be typically the most valuable when competitors are weak, as the potential for increased profits due to a better-performing product make up for the lost revenues due to the delay.

Besides these application context specific managerial insights, these four applications demonstrate that the scenario based approaches can be successfully applied to support investment decision-making. In particular, I dare to say, that the scenario based approach suit well for situations when the management of risks is desired in multiple time periods, there exist several correlated uncertainties, investors are heterogeneous in their risk aversion, for example, and there are several actors, who interact in competitive markets. Furthermore, as the thesis demonstrates the scenario based approach is also suitable for analyzing policy level questions.

I ask you Professor Benjamin Hobbs, as the opponent appointed by the Faculty of Information and Natural Sciences to make any observations on the thesis which you consider appropriate.