Optimal Strategies for Information Updating and Investment under Knightian Uncertainty

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Abstract

Risk management is an essential aspect of business operations for project managers dealing with uncertain environments. The use of probabilistic models to forecast and assess future uncertainties has become a fundamental methodology in many disciplines. Simultaneously, it is paramount to prepare for extremely rare events - such as natural disasters or sudden market crashes - but have a profound economic impact when they do occur.

For example, the Great East Japan Earthquake in 2011 severely disrupted the global supply chain, resulting in parts shortages for many manufacturers. Similarly, during the Covid-19 pandemic, retailers reliant on face-to-face sales suffered significant revenue declines. In the financial sector, it is widely acknowledged that sudden market crashes can lead to financial crises that would not usually be considered.

One way to handle worst-case scenarios is to apply the maximin principle under Knightian uncertainty. Knightian uncertainty refers to situations where the probability distribution is unknown or immeasurable. Applying the maximin principle, which optimizes for the best outcome under the worst conceivable conditions, is a rational strategy in Knightian uncertainty. Firms gather information from various sources to reduce uncertainty in the face of ambiguous futures. For example, financial institutions can obtain information from market data, such as stock prices and interest rates, and update their underlying models. On the other hand, it is recognized that firms can proactively mitigate uncertainty through their own actions. For example, introducing new products utilizing innovative technologies or launching new gaming apps through online distribution poses significant challenges in predicting consumer acceptance. In such situations, the firms may choose to launch these products or services on a small scale to gather consumer feedback critical to updating information about future demand levels.

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In this paper, we investigate the value of learning options under the Knightian uncertainty. A theoretical framework is presented for determining optimal strategies for information updating, real investment strategies based on the updated information, and evaluating the information to resolve Knightian uncertainty. To this end, we formulate the problem of determining optimal real investment strategies under Knightian uncertainty using the real options framework. The formulation is notable for its inclusion of proactive information gathering. An analytical examination is conducted using a simplified model. Numerical demonstrations are used to complement this examination and determine optimal strategies, as well as to quantify the value of learning options across a range of scenarios.