Real Options Analysis

Summary

- Real Options Analysis (ROA) is a methodology that can be used to prioritise adaptation interventions while considering the possibility to adjust them in the future. ROA can be used to determine whether interventions should be immediate or delayed and test the value of interventions which present greater flexibility down the road.
- ROA is most useful in situations of deep uncertainty, thus a high risk of maladaptation. For example, ROA is suited for informing decisions on large-scale, long-lived and costly adaptation interventions, such as public infrastructure projects.
- ROA can change the “fate” of projects which may have passed or failed deterministic economic analysis by demonstrating that it may be better to wait until more information is available or, alternatively, to make an initial adaptation investment immediately but incorporating some degree of flexibility in the design of the intervention.
- ROA has a complex methodology, which typically requires high volumes of data and resources. A more qualitative approach combined with the use of decision trees can be taken, which is of benefit when significant amounts of data are unavailable.

What does Real Options Analysis do?

Traditionally used on the financial markets to mitigate investment risks, Real Options Analysis (ROA) can be used in adaptation to gain insight into the risks associated with investing in physical (real) assets. It is particularly useful when considering when to invest into an adaptation intervention or the value of adjusting adaptation interventions over time in response to changing events. ROA provides an economic analysis of the value of flexibility and future learning. Standard economic appraisal normally assesses the performance of a project over its whole lifecycle. ROA recognises that projects are usually more complex than a simple one-off investment, and ROA can add to the understanding of the value of expanding, contracting, or even stopping an intervention altogether if it appears unlikely to be successful.

ROA sets itself apart from more traditional, more deterministic economic analysis approaches through two types of results it provides. Firstly, when projects are deemed cost-efficient following a deterministic analysis, ROA sometimes demonstrates that it would be beneficial to delay investment while waiting for new information that may impact results. On the other hand, projects which fail under a deterministic analysis could benefit from upfront investment. In situations of uncertainty, as is often the case with adaptation, it frequently makes sense to keep such projects alive in their initial stages, in the event that these projects begin to look more beneficial down the road as more information becomes available.

When should I use Real Options Analysis?

ROA is particularly useful in considering large-scale, long-lived and costly adaptation interventions such as dyke flood protection or dam-based water storage. ROA can be used to support the scoping of such adaptation interventions projects and the value of securing investments for future development. It can also help explore how to incorporate flexibility into the design of these interventions and how the project value will evolve over stages of development.

ROA is most likely to be supportive of projects that have some combination of substantial near-term benefits, and the ability to scale-up or down in line with learning and new knowledge. This will be the case for example when there is an existing adaptation deficit that the immediate investment can reduce, such as current flood risks.

ROA is less useful when the adaptation intervention has most of its benefits in the long-term. In these cases, the framework will tend to suggest that there is value in delaying projects given the expectation of valuable information arising over coming years and decades regarding climate impacts. Capacity building, no-regret or soft options are generally only likely to be evaluated in ROA to the extent they are necessary initial steps in keeping open possible future investment options.

What are the key strengths and limitations of Real Options Analysis?

Key Strengths

- Can guide the timing of adaptation interventions.
- Allows for quantitative economic analysis of the value of flexibility and learning.
- Provides a structured way to conceptualise and visualise the concept of adaptive management.
- Can be applied more qualitatively when probabilistic data on impacts are limited.

Potential Weaknesses

- Requirement for quantitative and monetized information on costs and benefits.
- Can be data and resource intensive, especially regarding probabilistic climate information and quantitative impact data.
- Less applicable to situation of deep uncertainties.
- A complex method which may require expert input and significant resources.
- Identification of decision points complex for (dynamic) aspects of climate change, and need to match these decision points to equivalent climate data.

What does it involve?

ROA can be carried out in a variety of ways. The most relevant to adaptation is an approach called dynamic programming which is essentially an extension of decision-tree analysis, where nodes represent “risk events” that could occur in the future and each branch is associated with on possible outcome. Following this approach, the ROA value can be compared to a normal economic (cost-benefit) calculation that would simply be a probability-weighted average of the outcomes along each possible branch in the tree.

Under this approach, ROA generally involves the following steps:

1. Specify alternative designs of adaptation options. Typically, two design strategies are presented: adaptation option(s) that perform well against a pre-defined level of climate change impacts (e.g. worst case scenario) and adaptation option(s) that can be modified over time;
2. Present design strategies following a decision-tree defined by different climate scenarios: each branch of the decision-tree presents varying developments in the design of the adaptation options;
3. Assign probabilities to each branch of the decision tree;
4. Calculate and monetize the costs and benefits of each design development and multiply with the probabilities assigned to each branch
5. Calculate the net present value by subtracting the sum of the benefits to the sum of costs.

The application requires inputs related to probability or probabilistic assumptions for climate change and the identification of decision points. It is therefore less applicable under situations of (deep) uncertainty, where probabilistic information is low or missing. For such cases, alternative approaches, such as robust optimisation, may be considered. In Econadapt, an application of ROA has been carried out in the appraisal of coastal protection in Bilbao, Spain.

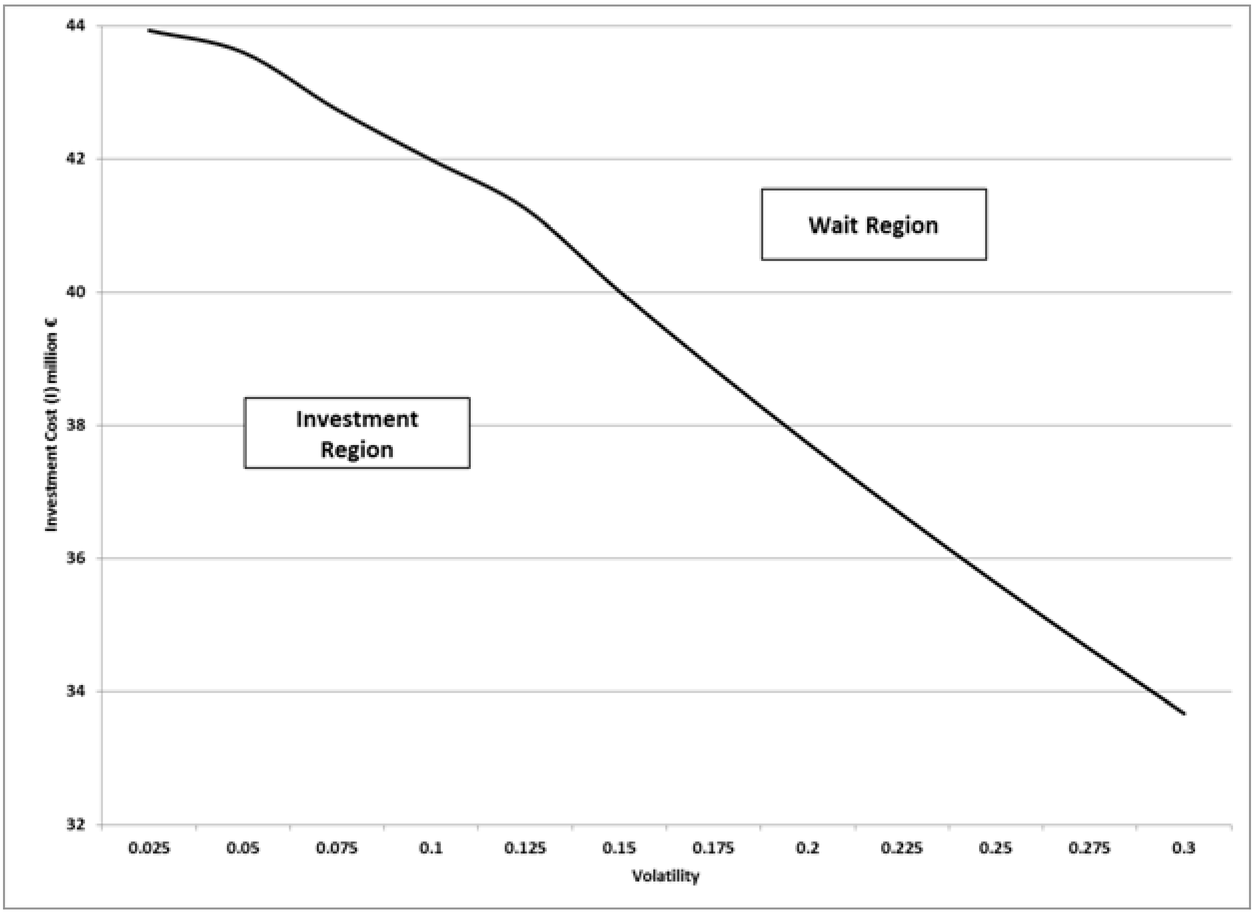
Case Study: Application of Real-Option Analysis for flood risk protection in Bilbao

This case study uses an application of real-options analysis (ROA) to inform decision-making on a public investment in infrastructure planned to reduce flood-risk in the city of Bilbao (Basque Country, Spain), which involves opening a pre-existing canal that will turn the current peninsula of Zorrotzaurre into an island in the Bilbao Estuary. The interest of this infrastructure lies in the fact that a new urban development had been approved for the district of Zorrotzaurre, which is a flood-prone area.

The first step of the study was to estimate expected damages at different points in time. To do this, a stochastic function was developed using damage data from a previous study (Osés Eraso et al., 2012) as an input. The stochastic function considered two variables: the frequency of extreme flood events and the stochastic growth rate of damage, taking into account climate change impacts and economic growth. Using the function, the expected flood damages of different return periods were calculated and expected benefits (in terms of avoided impacts) were estimated.

The second step was to estimate two risk measures that have proven to be very useful in contexts of uncertainty, namely the Value-at-Risk (VaR) and the Expected Shortfall (ES). The VaR expressed the losses that could occur for a time interval of 100 years (with a given confidence level α of 95%). The second risk measure is the Expected Shortfall (ES), which in this case represents the expected damage when VaR is exceeded, that is, the expected damages that would occur in the worst 5% of the cases. Both measures of risk have been estimated for the Bilbao case study, as the opening of the canal is expected to reduce not only the average expected damage but also the level of risk.

Subsequently, the risk assessment was performed using Monte-Carlo simulations for both the baseline scenario (keeping the peninsula) and the adaptation scenario (creating the island). This estimated the distribution of damages probabilities for different events in order to calculate the probability of exceeding different levels of damages. The damage distributions generated so far increase deterministically over time. However, the damage resulting from a given flood is not fixed but could vary for a number of reasons. One step further in the treatment of uncertainty would be to incorporate stochastic damage distributions. In the case of Bilbao, the stochastic model developed enabled us to consider that risks grow as volatility increases, though with an expected value identical to the case of deterministic growth. In other words, risk is not only a function of the discount rate and the economic growth, but also depends on volatility.



The final step was to evaluate the economic impact of different investment timing. In calculating the timing of investments through ROA, there are various parameters which influence the maximum cost that can be accepted for making investment immediately. For example, volatility can change the boundary of the wait-investment regions. As shown in the figure, the greater the volatility, the lower the investment boundary. In other words, higher volatility makes potential investors more demanding and they invest only when the cost is lower.

Further information: Skourtos, M., Damigos D, Kontogianni A., Tourkolias C., Markandya, A., Abadie, L. M, Sainz de Murieta, E., Galarraga, I., Wellman, J. and A. Hunt (2016). *Future values for adaptation assessment*. Deliverable 2.2, Econadapt FP7 research project.

Tool

Real Options Analysis allows for the possibility of an economic investment decision being delayed to account for learning over time. Alternatively, Real Options Analysis allows for the benefits of flexibility in the nature of the investment to be realized.

The following excel-document includes two simple examples of Real Options Analysis.

Econadapt insights
Appraisal of adaptation to river and coastal flood in Bilbao
Integrated uncertainties and risk management for robust decision making
Treatment of future learning: Real Options Analysis
Applying alternative discounting rules: The equivalency principle
Assessing flood risk management: United Kingdom

Dealing with changing preferences over time
Uncertainties and causes of uncertainties in climate change adaptation
Uncertainties and risk analysis in climate change adaption
Prioritisation of adaptation in the development context: Zanzibar
Sourcing and using climate information for economic assessments of adaptation