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# Analysis of Environmental Risks in the Assessment of the Economic Efficiency of Investment Projects

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**Abstract:**

Considering environmental risks in the assessment of the economic efficiency of investment projects is crucial for ensuring long-term success and sustainability. By identifying and addressing these risks early on, investors can mitigate potential negative impacts and enhance the overall value and resilience of their projects. Environmental considerations should be integrated into the project evaluation process to ensure responsible and sustainable investment decisions.

**Keywords:** Environmental risks, physical risks, transition risks, financial risks, transmission channels, financial impact of environmental risks, environmental risk analysis (ERA) and management, models for assessing environmental risks.

## Introduction

Environmental risks play a crucial role in the assessment of the economic efficiency of investment projects. When evaluating investment projects, it is important to consider the potential environmental risks associated with the project. These risks can have a significant impact on the overall economic viability of the project and should be carefully evaluated in order to make informed decisions.

Analyzing risks related to the environment is not only relevant for investors but has also started to be carried out by major financial institutions on a global scale. This is because the transmission of ecological risks into financial risks directly affects the evaluation processes that are being conducted. For example, companies operating in industries with high environmental risks may face

increased regulatory scrutiny, legal liabilities, and reputational damage. These risks can impact the financial performance of the company by leading to increased costs, lower profitability, and potential loss of market share.

Investors, lenders, and other stakeholders are becoming increasingly aware of these ecological risks and are taking them into consideration when evaluating companies. This can lead to changes in investment decisions, lending practices, and shareholder activism.

Therefore, it is important for companies to properly assess and communicate their ecological risks to stakeholders in order to mitigate potential financial impacts. Failure to do so could result in negative consequences for the company's financial performance and overall reputation in the market. In this case, understanding the classification of ecological risks today, comprehending their transition to financial risks, and researching models for their assessment have become crucial tasks.

**Analysis and results**

Today the levels of understanding of environmental risks are very uneven within the global financial community. But this does not mean that they are not studied. In particular, according to the G20 Green Finance Study Group (2017), NGFS (2019a), and other literatures such as Ma et al. (2018), the environmental and climatic sources of financial risks can be mapped to two key risk categories – physical and transition risks:

1) Physical risks that arise from the impact of extreme climatic events (such as exacerbated extreme weather events), rises in sea levels, losses of ecosystem services (e.g., desertification, water shortage, degradation of soil quality or marine ecology), as well as environmental incidents (e.g., major chemical leakages or oil spills to air, soil and water/ocean);
2) Transition risks that arise from human efforts to address environmental and climate challenges, including changes in public policies, technology breakthroughs, shifts in investors or public sentiments and disruptive business model innovations.

Physical and transition risks have many categories and subcategories (Table1).

**Table 1. Sources of environmental risks[1]**

| **Physical Risks** | **Sub-categories/examples** |
|---|---|
| Extreme weather events | Tropical cyclones/typhoons, floods, winter storms, heat waves, droughts, wildfires, hailstorms |
| Ecosystem pollution | Soil pollution and degradation, air pollution, water pollution, marine pollution, environmental accidents |
| Sea-level rise | Chronic sea-level rise or sea surges |
| Water scarcity | Drought or insufficient supply of water |
| Deforestation/desertification | Deforestation caused extinction of species, changes to climatic conditions, desertification, and displacement of populations |
| **Transition Risks** | **Sub-categories/examples** |
| Public policy change | Energy transition policies, pollution control regulations, resource conservation regulations |
| Technological changes | Clean energy technologies, energy saving technologies, clean transportation, and other green technologies |
| Shifting sentiment | Changes in consumer preference for certain products, changes in investor sentiment on certain asset classes |
| Disruptive business models | New ways to run businesses that can rapidly gain market shares from traditional businesses (e.g., virtual meetings that |

[1] Source: Caldecott et al. (2013); CICERO (2017); G20 Green Finance Study Group (2017); Ma et al. (2018); NGFS (2019a).

| | |
|---|---|
| | significantly reduce business travels; vertical farming that challenges traditional farming) |

It should be noted that risks arising from environmental factors have not been explicitly recognized and effectively addressed by many investors and project managers, especially those in developing countries. One reason for the lack of environmental risk analysis and management is the limited understanding of the transmission mechanisms between environmental risks and financial risks. Below we look at how environment- and climate- related risks are transmitted to financial risks (Figure1).

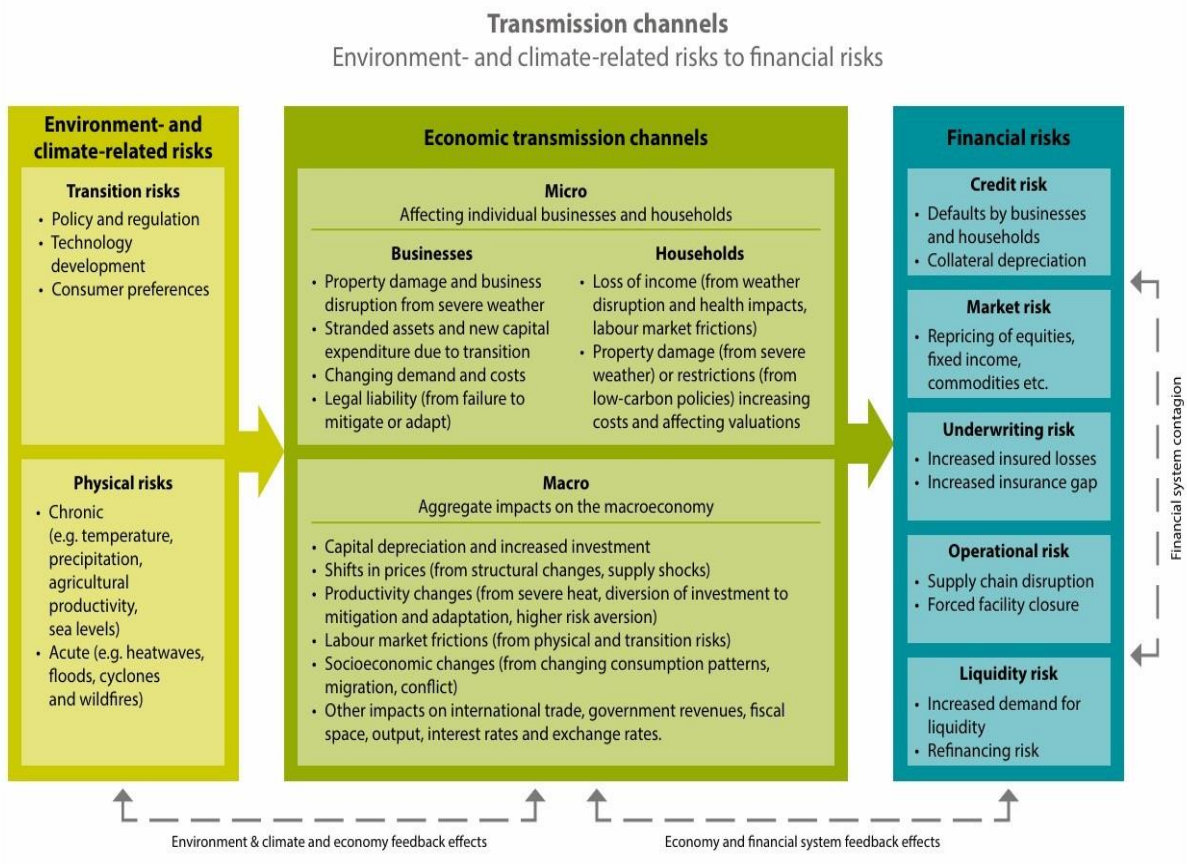


**Figure 1. Schematic illustration of transmission from environmental risks to financial risks[2].**

As illustrated in Figure 1, transition risks will affect the operations of businesses and the wealth of households, thereby creating financial risks for lenders and investors. They will also affect the broader macroeconomy through investment, productivity and relative prices channels, particularly if the transition leads to stranded assets. Physical risks affect the economy in two ways. Acute impacts from extreme weather events can lead to business disruption and damages to property. Historically these impacts were considered transient but this will change with increased global warming. These events can increase underwriting risks for insurers and impair asset values. Chronic impacts, particularly from increased temperatures, sea levels rise and precipitation, may affect labor, capital and agriculture productivity. These changes will require a significant level of investment and adaptation from companies, households and governments.

Table 2 describes 24 categories and sub-categories of environmental risks. Each type of environmental risks may result in financial risks such as credit (default) risk, market risk (valuation loss), and liquidity risk, as well as operational risk. There are therefore numerous scenarios for

[2] Source: Adapted from NGFS (2020c).

environmental risks to transmit to financial risks. Table 2 shows over 100 possible scenarios of environmental risk transmission to financial risks; we select 10 cases to illustrate how such transmissions could work. Note that these are just examples of how physical and transitional risks can lead to selected financial risks and operational risks, and that it does not mean that these events would not also lead to one of the other types of risks. For instance, typhoons and floods may have implications at the same time for credit, market, liquidity and operational risks of financial institutions.

**Table 2. Examples of environmental risks transmitted to financial risks[3]**

| Financial Risks for FIs / Environmental risks | | Market Risk | Credit Risk | Liquidity Risk | Other risks |
|---|---|---|---|---|---|
| **Physical Risks** | **Sub-categories** | | | | |
| Extreme weather events | Tropical cyclones/Typhoons | ❶ | ❶ | | ❶ |
| | Floods | | ❷ | ❷ | ❷ |
| | Winter storms | | | | |
| | Heat waves | | ❸ | | ❸ |
| | Droughts | | ❹ | | |
| | Wildfires | | ❺ | | |
| | Hailstorms | | | | |
| Ecosystems pollutions | Soil degradation and pollution | | ❻ | | |
| | Water pollution | | | | |
| | Marine pollution | | | | |
| | Environmental accidents | ❼ | ❼ | | ❼ |
| Sea-level rise | | | | | |
| Water scarcity | | | | | |
| Deforestation | | | | | |
| Desertification | | | | | |
| **Transition Risks** | **Sub-categories** | | | | |
| Public policy change | Energy transition policies | ❽ | ❽ | | |
| | Pollution control regulation | | | | |
| | Polices on resource conservation | | | | |
| Technological changes | Clean energy technologies | ❾ | ❾ | | |
| | Energy saving technologies | | | | |
| | Clean transportation | | | | |
| | Other green technologies | | | | |
| Shifting sentiment | | ❿ | ❿ | ❿ | |
| Disruptive business model | | | | | |

Let's now take a closer look at the 3 scenarios from the table 2 above.

Case 1: Transmission from floods risk to operational risk, credit risk and liquidity risk:

1) Climate change will result in more severe and frequent floods (physical risk);
2) Floods disrupt supply chains and plant operations of some non-financial firms (e.g., due to power and transportation disruption) that are investment projects or banks' clients, or threaten banks' business continuity by damaging their buildings (operational risk);
3) Business disruptions reduce revenue and increase repair/ maintenance cost, thus reduces profit of the affected non-financial firms;
4) Reduced revenue and profit of these firms weaken their ability to repay bank loans and increase loan default rates and LGD (credit risk) and also it leads to loss of efficiency of investment projects.

[3] Sources: adapted from G20 Green Finance Study Group (2017); NGFS (2019a); Ma et al (2018); CICERO (2017); Caldecott et al. (2013); EIOPA (2019).

5) Insurers that provide flood insurance may be under pressure to liquidate assets at a loss in order to cover claims due to major flooding (liquidity risk).

Case 2: Transmission from environmental accidents to legal risk and market risk

1) Environmental accidents by non-financial firms (e.g. BP's oil spill) may result in serious water and land pollution (physical risk);
2) Litigation may result in heavy penalties for these companies and associated reputation risk;
3) Lawsuits and penalties lead to extra costs and tarnish these companies' reputation and reduce their future sales;
4) From an investor/lender's perspective, the above-mentioned changes in revenue and cost as well as reputational losses of the non-financial firms could lead to a fall in their valuation (market risk) and an increase in their probability of loan default and loss given default (credit risk).
5) From an insurer's perspective, these could result in an increase in environment-related claims under liability policies (liability risk).

Case 3: Transmission from energy transition policies to market and credit risks

1) Energy transition policies may include measures (e.g., carbon tax/pricing scheme) to limit utilization of fossil fuels (transition risk);
2) These measures may result in higher costs for oil & gas companies, coal mining companies, and coal-fired power producers, meanwhile reducing market demand for their products;
3) Higher costs and reduced revenues cut profits and reduce the future cash flows of these companies.

We can see the practical proof of the above scenarios as a result of the research conducted around the world. For example, a Blackrock study estimates that the financial losses of 15 US cities could amount to USD$8 trillion due largely to sea level increase and more frequent extreme weather events, as a result of climate change. Or else, an EIU (Economist Intelligence Unit) study estimates that, from a private sector investor's perspective, global warming of around 4°C could result in a present value loss of US$4.2 trillion of financial assets globally, 5°C warming could result in a present value loss of US$7 trillion, while 6°C of warming could lead to a present value loss of US$13.8 trillion.

So, now let's review steps for environmental risk analysis and management. The framework for environmental risks analysis and management typically involves four steps:

- **Risk identification:** conducting strategic assessment of the types of environmental factors that may cause financial risks (e.g., value impairment from sea-level increases, extreme weather events, declining demand for or prices of fossil fuels, devaluation of associated infrastructure, interruption of supply chains, increased natural capital cost, and increased emission and pollution costs);
- **Risk exposure:** measuring the sizes of investment projects exposures to these risks;
- **Risk assessment:** estimating probabilities and magnitudes costs, can be the direct result of environmental or climate of financial losses arising from these risks (using ERA methods such as scenario analysis and stress test). The results of these ERA could feed into risk pricing;
- **Risk mitigation:** taking actions to reduce risks via introducing internal policies and processes that discourage exposures to environmentally risky assets.

There are various ERA models used by banks, asset managers and insurance companies for assessing the financial impact of their environment- and climate-related risks on a forward-looking basis.

Most ERA models assessing physical risks first capture the impact on company financials due to environmental risks. The financial impact, such as declining revenues or rising costs, can be the direct result of environmental or climate events that cause property and other damages, or an indirect or secondary effect of physical events. The most common secondary impact is business interruptions and reduced economic activities. Examples include electricity outages, disruptions to supply chains and declining demand for the company's products due to an economic slowdown. The resulting changes in financial statements are then integrated into financial models (e.g., PD and LGD models or securities' valuation models) to quantify the financial risks (e.g., credit risks for lenders and market risks for institutional investors) both on a portfolio basis and individual transaction/client basis. Results of these analyses are typically presented as a scenario analysis or a stress test.

Like physical risk models, typical ERA models assessing transition risks try to first capture the financial statement impact of policy and technological changes at the company level driven by environmental and climatic factors under various scenarios. In a climate-related transition risk analysis, the typical first step is the creation of temperature-based or event-based scenarios using underlying models, such as sector-specific models, macroeconomic models or Integrated Assessment Models (IAM). Given these scenarios, the financial models can then quantify the impact of energy transition policies (e.g., increasing carbon prices and contracting demand for fossil fuel products) and technology changes (e.g., causing downward pressure on the sales and prices of fossil fuel products) on companies' revenues and costs in carbon-intensive sectors such as oil & gas, coal mining, coal-fired power generation, steel, cement and transportation. These changes in corporate financial statements are then integrated into risk models by financial institutes and project managers to assess financial risks (e.g., credit and market risks) both on a portfolio basis and an individual transaction/client basis.

A major challenge in modelling climate-related transition risks is handling the interactions between economic variables, energy sector parameters and corporate reactions. ERA methods have also been developed to analyze the financial impact of other environment-related transition risks (such as pollution and water stress), albeit the number of such studies are significantly fewer than those on climate-related risks. For pollution-related transition risk analysis, a typical first step is to construct scenarios related to environmental-policy and regulatory changes, which would have an impact on the costs and/or revenues for companies in high-polluting sectors.

The methodology which is used mainly by institutional investors is called Environment, Social and Governance (ESG) scoring and integration.

ERA methodologies, often presenting results in the form of scenario analysis and stress tests, focus on forward-looking assessments of the financial implications of environment- and climate-related risks. Investment managers and banks also evaluate the ESG performance of their clients or assets held to facilitate investment/lending decision-making. Some empirical studies show that the ESG performance of listed companies and bond issuers has a positive correlation with their long-term financial performance. ESG scoring and integration methodology can be considered as another major category of tools for assessing environmental risks for investment holdings.

So based on our analysis, we have seen that assessing the environmental aspects of investment projects in foreign countries is becoming a regular practice for investors. But in the developing countries this approach is only just gaining popularity, and there is no uniform method yet.

In order to comprehensively evaluate investment projects in terms of both economic and environmental impact, including ecological risks, it is essential to establish a universal method with indicators that can be integrated into business planning as essential components.

The critical stage in investment decision-making is the analysis of investment efficiency, with a key focus on comparing project costs and benefits through the evaluation of the rate of return. Two main approaches, economic and financial, are used for this analysis. The economic approach assesses the feasibility and effectiveness of investment projects from a country's economic perspective, determining whether the societal benefits outweigh the costs incurred during project execution and operation. On the other hand, financial analysis aims to determine the profitability of investing in a particular project. Combining these approaches is essential for making informed and rational investment decisions.

In our prior research efforts, we have successfully developed techniques for assessing the efficiency of investment ventures. This has led to the creation of a structured approach for conducting environmental and economic evaluations, involving steps such as cost analysis, outcome evaluation, economic impact assessment, environmental harm assessment, and overall environmental-economic efficiency assessment. And also, we believe that ecological risks may be emphasized, measured and diminished by implementing certain programs for risk mitigation, based on adequate methods, Monte Carlo method being one of them.

The Monte Carlo method is a multi-iterative statistical method, which is based on various repetitive scenarios. It assesses the impact on the project from financial standpoint, but especially in terms of framing established for contractual objectives. As a result of the Monte Carlo method, it was possible to assess the impact of different types of risks, including the environmental risks for the investment project and, starting from this, defining adequate programs for risk mitigation, ensuring the prioritization of the measures to be taken.

As we know environmental risks typically do not cause delays in investment project timelines but can have a substantial financial impact due to the costs associated with mitigating their effects. Such risks may however affect the implementation program of the investment projects, considering the efforts to remediate the environment, which requires the use of the Monte Carlo simulation method to assess the risk effects.

## Conclusion

In conclusion, the multifaceted landscape of investment projects necessitates a meticulous examination of environmental risks to elucidate their potential ramifications on business operations. Environmental risk assessment, therefore, emerges as a linchpin in the strategic planning process, facilitating a comprehensive understanding of the intricacies involved. This proactive approach not only allows for the identification of potential pitfalls but also empowers decision-makers to develop effective strategies for their mitigation and management.

The utilization of advanced methodologies, such as the Monte Carlo simulation, further enriches the risk assessment process by providing insights into the uncertainties surrounding key performance indicators. By delving into the realm of environmental risks specifically, this method offers a nuanced perspective, enabling stakeholders to gauge the magnitude of potential impacts and devise appropriate contingency plans.

Moreover, the establishment of a robust risk management framework, underpinned by sophisticated impact analysis techniques, underscores the proactive stance adopted towards risk mitigation. Such a system serves as a cornerstone in the decision-making process, guiding stakeholders towards prudent investment decisions and ensuring the alignment of objectives with available resources and timelines.

By integrating environmental risk assessment and strategic risk management into the fabric of investment project planning, organizations can fortify their resilience against unforeseen challenges while capitalizing on emerging opportunities. This holistic approach not only safeguards against potential disruptions but also fosters a culture of adaptability and innovation, thereby enhancing the prospects of realizing desired outcomes within the dynamic landscape of investment endeavors.

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