Emission Reduction or Monetary Gain? Economic Decision Analysis for Energy Transition Projects

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Abstract

All decisions, including investing in energy transition projects, should satisfy the preferences of the owners. Yet owners of public firms have potentially contrasting preferences for emission reduction, value, and risk. For managers as agents of the owners, satisfying all tastes would be challenging. In this paper, instead of the commonly suggested multi-attribute-decision-making with such unclear trade-offs, we use simplifying measures from finance theory. Using insights from emission markets and an example from energy transition, in this paper we discuss that the single goal of "maximizing shareholder value" would eventually satisfy all the owners. This means that any preferences other than those of the market are irrelevant to business decisions. Corporations should make value maximizing decisions within the rules of the game (set by the regulatory system) that promote energy transition preferences.

1. Introduction

Most project analyses include a study of the decision makers' preference for their investment. They show for example preferences for profit, social responsibility, environment, or risk. The analysts then assess the values of decision alternatives using tradeoff mechanisms and recommend a course of action. In this paper, we discuss that unless such decisions are outside the well-functioning competitive markets, any such personal attitudes are irrelevant to project decision making. Investors could meet their monetary and environmental goals on their own once they have their money. The managers should focus only on shareholder value-creating decisions.

We discuss that Fisher Separation Theorem (Fisher, 1930) leads to useful insights for project appraisals and decision making. Not only managers should ignore their own preferences, but they should also ignore the priorities of the investors. These shareholders have varied and sometimes conflicting goals—one may prefer investing in environmental preservation while another prioritizes helping cancer patients. They may never be able to reconcile their conflicts. With Fisher Separation Theorem, once the firm makes monetary value, the investors would be able to use the money and achieve their personal goals on their own—use their money to support environmental preservation measures or cancer patients. The only goal of the firm should be making monetary value for its owners. The way the investors consume their money is separate from the way the firm uses it. This argument assumes the investors have access to financial markets to compare risky cash flows, and can trade in emission markets to compare emission reduction measures with monetary values.[1]

[1] What if owners do not agree with the firm's line of business? Then they can take their capital and invest elsewhere. All firms in the free markets compete in attracting investor's capital based on their potential to create more value.

Fisher Separation theorem (Fisher, 1930) is the seminal work of Irving Fisher in his book *The Theory of Interest* and has led to several fundamental insights in finance theory. For example, the Nobel prize-winning work of Modigliani and Miller (1958) leading to a fundamental understanding in finance—that investing and financing decisions in a firm are separate and independent—built on Fisher Separation Theorem. Modern Portfolio Theory pioneered by Markowitz (1952) and the Capital Asset Pricing Model (CAPM) also use the insights of Fisher Separation Theorem.

Fisher Separation theorem also led to insights in investment analysis and the real options theory. The value of a project reflects its potentials to generate future cash flows and add to the wealth of the owners. To make accept or reject decisions, the management should only consider the present value of the investment. This fundamental result leads to valuation principle, explained e.g., in Brealey et. al (2023). Arnold and Shockley (2002) resolve the common misconceptions about the applicability of the valuation principle and complete market arguments. With the new impetus for energy transition projects, we further hear that corporations should also consider the goal of "emission reduction" in their decisions.

The literature on operations research and decision analysis has focused on solutions to more general problems, not just corporate decisions. Making multi-attribute decisions need consistent trade off. Keeney and Raiffa (1993) discuss group preference aggregation rules to analyze decisions with varied preferences. Dyer and Sarin (1979) further discuss "strength of preferences" for groups for group preference aggregation. As Smith and Dyer (2021) clearly explain, this leads to measurable values functions.

Such general approaches are nonetheless useful for corporate decisions, especially for energy transition project. As Smith and Dyer (2021) explain, for every decision we consider whether the attributes are mutually preferential independence (the level of two attributes does not depend on a third attribute) and whether they are differentially independent (changes in one attribute is dependent on the level of another attribute). Any violations of these conditions lead to inconsistency in analysis. However, with diverse owners having conflicting priorities, the multi-attribute analysis becomes increasingly complex. For example, considering preferences for "making money" and "reducing emissions" in an energy project, it would be difficult to show an agreement on their tradeoff. It would be even hard to show that these attributes satisfy mutual preferential independence and differential independence[2] to assess a measurable value function.

Smith and Nau (1995) use arguments from Fisher separation theorem to show that within complete markets, consistent decision analytic and financial approaches to valuation both lead to the same business decisions. When markets are partially complete, they suggest an extension that leads to agreement between financial and decision analytic approaches. Their valuation scheme sheds light on the consideration of decision objectives. The decision analytic approaches converge to the financial formulations with added arguments about market completeness.

Using arguments in Makowski (1983), in this paper we further extend the decision analytic framework for project valuation and decision making. We discuss that we do not need to assess multiple attributes if decisions are within competitive (even incomplete) markets. Taking a normative approach (i.e., what

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Promising businesses attract more investors and failing businesses lose them. Does this mean businesses will engage in harmful activities to attract investors? Not if they stay within the rules of the game that regulators have set.

[2] Mutually independent preferences do not depend on a third common attribute. In this example, an economist may argue that making money and reducing emissions (leading to preserving the environment) are both dependent on a third factor: the long-term value for a sustainable society (e.g., as in Way et al, 2022). In other words, the two attributes are preferentially dependent. In addition, the two attributes would be differentially dependent. Project alternatives that lead to higher monetary values are also often more emission intensive.

managers *should* do, rather than what they normally do) we discuss that shareholder value (estimated by the net present value) should be the only attribute for the formulation of investment decisions. We further discuss the concept of "sustainable business" using applications in energy transition projects.

The next section uses simple arguments to show that when investors can trade within competitive emission markets, then they can compare emission reduction with monetary value and would agree on courses of actions that maximize the value. Then in section 3 we use the insight in modeling an energy investment decision. Section 4 discusses corporate applications and situations where our reasoning collapses. Section 5 concludes.

2. Decision Models with Market Insights

Common concerns in business analysis are "A dollar today is worth more than a dollar tomorrow" or "investors are risk-averse, they prefer less risky deals" or "investors prefer environmentally friendly energy project". If rational decision makers ought to have such attitudes, then we may naturally conclude that we should reflect all these attitudes in our decision models. We often estimate the value measures for each attribute and then estimate their "utility" to the decision maker. However, it would be hard to capture the collective preferences of many owners. Any inconsistencies would lead to inferior decisions and loss of value.

Assume, unbeknown to the manager, the owners of a firm have utility functions $u(x, y)$ where x and y are their desired measurable and preferentially independent attributes. While our formulation is general, we can think of x as "monetary value" and y as "emission reduction" in the context of energy projects. We have no specific assumptions other than that the attributes are measurable, and that the utility functions are positive and increasing.[3]

We show the owners' preference for monetary value and emission reduction by sets of indifference curves. In **Figure 1**, each curve shows combinations of x and y that an owner would be equally satisfied to have. We show two representative tastes: an "environmentalist" who favors emission reduction over monetary value (with $u_e(x, y)$ as utility function) and a "capitalist" who prefers monetary value over emission reduction (with $u_c(x, y)$ as utility function). The steepness of the curves shows the taste of the individual. An environmentalist has a comparably flat indifference curve. Because all individuals prefer more money and more emission reduction, the indifference curves on the upper right direction represent higher levels of satisfaction.

If individuals have access to emission markets, then they can buy and sell emission allowances and achieve their preferences. For example, with X amount of money, a pure capitalist will buy no emission allowances (with all X to spend) while a pure environmentalist may use all the capital to buy Y emission allowances (and nothing to spend).[4] Each point on the YX line represents a combination of capital and emission allowances.

[3] To draw indifference curves in figures we have used Cobb-Douglas utility functions of the form $u(x, y) = x^a y^b$. For the "environmentalist", we used $a = 1, b = 2$ and for the "capitalist" we used $a = 2, b = 1$.

[4] Buying emission allowances from the market will leave less allowances to industrial emitters, leading to lower total emissions.

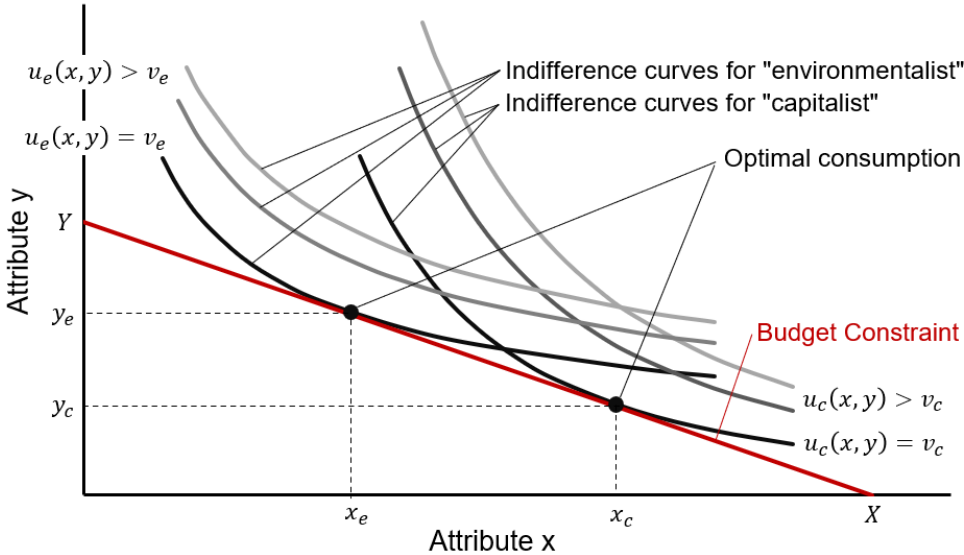

Figure 1—optimal consumption as the point that maximizes the utility of the owner within the budget constrain

The emission market will allow the individuals to transform money into emission reduction. They can use their capital to achieve their emission reduction ambitions. Any individual with X amount of money can move along the YX line by putting more money into emission allowances. We use the term "budget constraint" as the individual cannot move further to the upper right side of this line.

For any individual i, we should maximize their utility $u_i(x_i, y_i) = v_i$ subject to the following constraints. Note that B is the total budget.

$$x_i + y_i \leq B \quad (1)$$

$$x_i \geq 0 \quad (2)$$

$$y_i \geq 0 \quad (3)$$

The slope of the budget constraint line, $-\frac{Y}{X}$, is the market price for one emission allowance.

For our "environmentalist" and "capitalist" investors, the optimal combination of capital and emission allowance would be respectively the points (x_e, y_e) and (x_c, y_c). These points are where the indifference curve is tangent to the budget constraint line, yielding the highest utility $u_e(x_e, y_e) = v_e$ and $u_c(x_c, y_c) = v_c$ for the investors subject to the budget constraint.

Yet the market is not the only opportunity available to the investors. As in **Figure 2**, the investors can invest in a project that yields a combination of $\left(x_p, y_p\right)$. The investors would be better off if this combination sits on a line to the right of the market budget constraint. The new line Y^*X^* yields higher utility for any investor, including our environmentalist and capitalist. They can buy or sell along this line and achieve their ideal combination. For example, if the project offers x_p monetary value and y_p emission credits, then the capitalist investor can sell $y_p - y_c^*$ emission credits in the market and receive $x_c^* - x_p$ monetary value. This market trade will take the capitalist to the new optimal point (x_c^*, y_c^*) with utility $u_c(x_c^*, y_c^*) = v_c^* > v_c$. Likewise, the environmentalist would also achieve their ideal (x_e^*, y_e^*) with utility $u_e(x_e^*, y_e^*) = v_e^* > v_e$ by selling $y_p - y_e^*$ and receiving $x_e^* - x_p$.

So long as investors can trade in the markets, their tastes and preferences are irrelevant for project decisions. A manager should accept projects that lie on a line to the right of the market budget constraint. In other words, if the monetary value of a project exceeds the opportunities in the market, then it would be an economically acceptable project. It would create a new budget constraint line with more appeal to all investors. The decision to accept the project would be independent of the tastes and preferences of the individual investors.

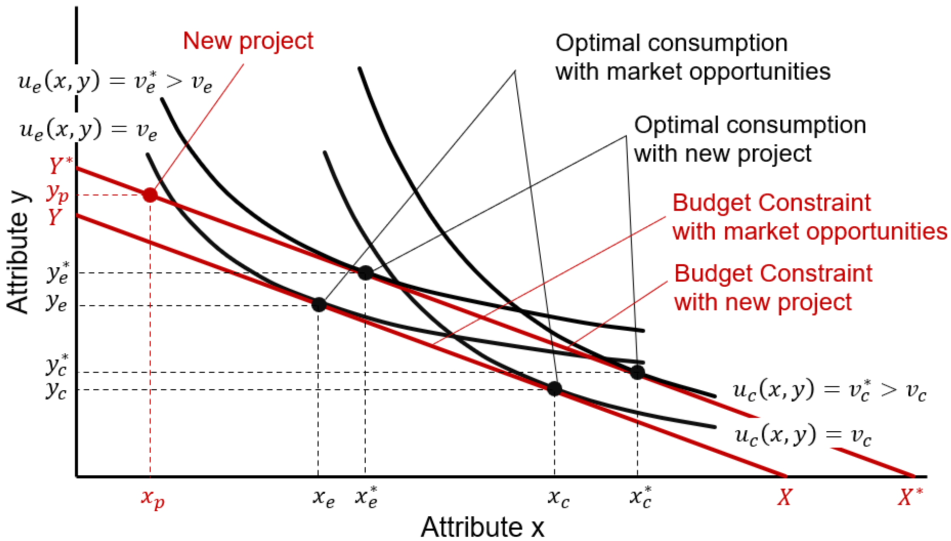

Figure 2—Introduction of a new project creates a new budget constraint line. All investors would be better off if the new budget constraint line is to the upper right hand side.

A manager that on behalf of the stockholders engages in social responsibility—e.g., by buying emission credits—is effectively imposing taxes on the investors. As Milton Friedman mentioned: "Taxing is a function of the government and therefore the manager is assuming the role of the government" (Friedman, 1970). The best a manager can do is to accept projects with the highest monetary value (net present value) within the taxes and emission allowances set by the government. The investors can then achieve their goals and ambitions using the added monetary value.

3. Investing in Energy Transition Projects

3.1. Corporate Objectives versus Externalities

Studies (e.g., Way et al, 2002) suggest that the long-term negative effects of misusing and misallocating fossil resources could overweigh their shorts-term utility. In other words, the environment is the tacit stakeholder in energy ventures. Examples of environmental neglect in energy business include the damages from oil spills, natural gas leakage, contaminations, and excessive carbon emissions. Such damages are often due to insufficient, or lack of, provisions. With more consistent assessments of their long-term effects, we make better decisions about including environmental provisions in energy projects.

In general, strict environmental provisions lead to higher immediate costs. For example, measures to stop natural gas leakage during production and distribution, taxes that limit emissions, or double-hulled tankers that reduce the risk of spills, all increase the immediate costs and eventually deteriorate projects' value. However, the regulatory system expects that such measures decrease the likelihood of future harm and are therefore, *investments* in with long-term effects.

Policy makers build in these provisions (and the added costs) into the economic system to avert the more costly long-term environmental calamities. In this context, the sacrifices are worthwhile. We pay a reasonable upfront premium to avoid excessive costs in the future. For energy projects, paying the added environmental premiums may lead to less worth (measured by net present value). The decline in value depends on the rate (and the design) of these premiums.

Ideally, the environmental provisions should penalize the most polluting projects while encouraging cleaner initiatives. For example, with the introduction of carbon tax (or alternatively, the emission allowance trading schemes), we expect the coal-fired power stations to gradually phase out. Similarly, the carbon intensive Steam-Assisted Gravity Drainage (SAGD) technology used in the heavy oil-sand production should also lose its appeal. On the contrary, cleaner projects that were expensive before the introduction of emission taxes should now become comparably more favorable—with deterrents and incentives, the regulatory system promotes a specific pattern of investment (Jafarizadeh, 2022).

3.2 Example

Motivated by a problem of developing petroleum exploration policy in the North Sea, in this section we discuss the role of emission pricing in energy investments. We consider exploring mutually exclusive hydrocarbon prospect α or β. They are almost identical from technical and managerial aspects, except that one has added potentials for more environmentally friendly development. The chance of success in either prospect is comparable, and we estimate the cost of drilling would be the same.[5] If drilling leads to a discovery, then their suggested development scheme (without environmental provisions) would be similar.

Under current economic forecasts of costs and hydrocarbon prices, the two prospects have comparable valuations. However, it is likely that the host government introduces carbon dioxide taxes or tradable allowances to reduce the emissions from exploration and development projects. Because the hydrocarbon prospects have similar expected hydrocarbon content and planned development scheme, at least under the current provisions such a carbon tax would equally affect their economics. In addition, the emission tax is a function of the prices of emission allowances in the market and would have the same effect on valuations.

With their standard development plans, both projects expect to emit on average thirty-five kilogram of carbon dioxide per barrel—an average figure that is high by industry standards. Having similar emission levels, both projects should pay a considerable amount in carbon taxes. The first row of **Figure 3** shows the expected cash flow profiles for standard development projects. The second row shows the cash flows if the government introduces the emission taxes. These payments will significantly erode the value of both projects.

Amid the growing environmental concerns and the possible loss of value due to the introduction of emission taxes, the energy company considers alternative development scenarios. They devise "green" development schemes as substitutes for the standard plans. These "green" schemes would be more costly because they have added environmental provisions. Specifically, they include a novel approach to platform electrification: instead of carbon-emitting gas turbines, the plan is to supply electricity from renewable resources through subsea cables. This will reduce the emissions to only five kilogram of carbon dioxide per barrel. However, the added upfront cost of subsea cables makes a more expensive development plan.

This leads to the dilemma of energy investment decisions. Should the company plan to invest in environmental provisions upfront and avoid excessive emission taxes, or should they go with cheaper standard development and pay excessive later emission taxes? The answer depends on the incremental present value of these courses of action. The prospects differ in their potentials for environmental

[5] Project specification, including chance of success (20% for α and 22% for β), drilling cost (USD 10 million) and features of their development, are available in the accompanying spreadsheet. To assess values, we have used valuation schemes as in Jafarizadeh and Bratvold (2021). We used hydrocarbon price forecasts using the framework in Jafarizadeh (2022b).

development. Prospect α is closer to existing infrastructure and the incremental cost of subsea cable (compared to development of β) would be lower. The green development project would have higher value for a discovery in prospect α than in prospect β. The third row of Figure 3 shows the cash flow profiles for these green development projects.

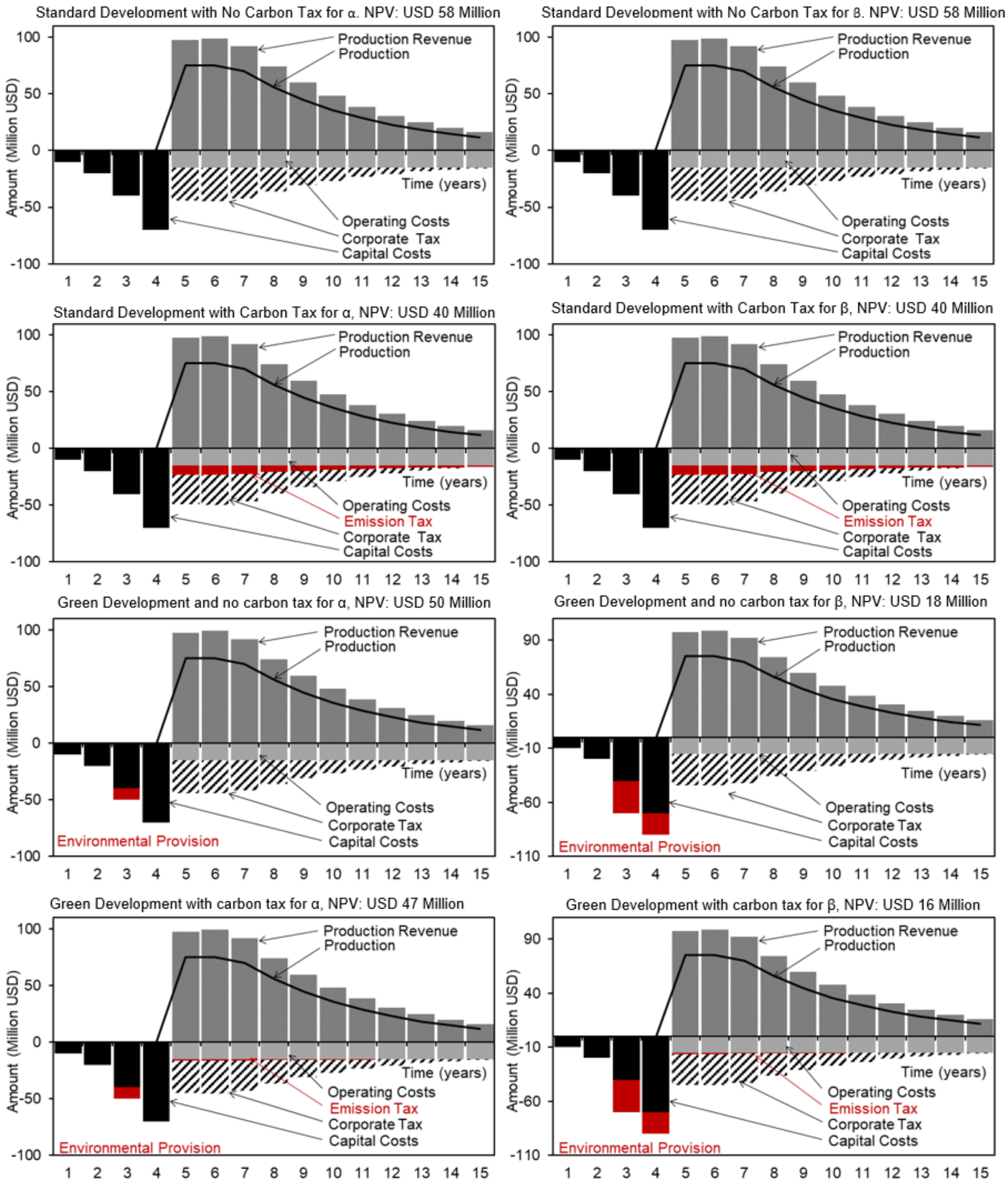

Figure 3—Cash flow diagrams for development projects of discovery in α or β.

Proponents of these green developments point out the benefits of reducing emissions against the cost of provisions. They favor the investment using the argument: “The subsea cable is expensive, but it brings electricity from a clean source and cuts the emissions from the otherwise carbon emitting gas turbines in the standard development scheme”. Yet, in the absence of carbon tax, as **Figure 4** shows, such arguments do not effectively change the decisions. The company answers to the shareholders and should select the course of action with higher expected monetary value. They would prefer to drill prospect β.

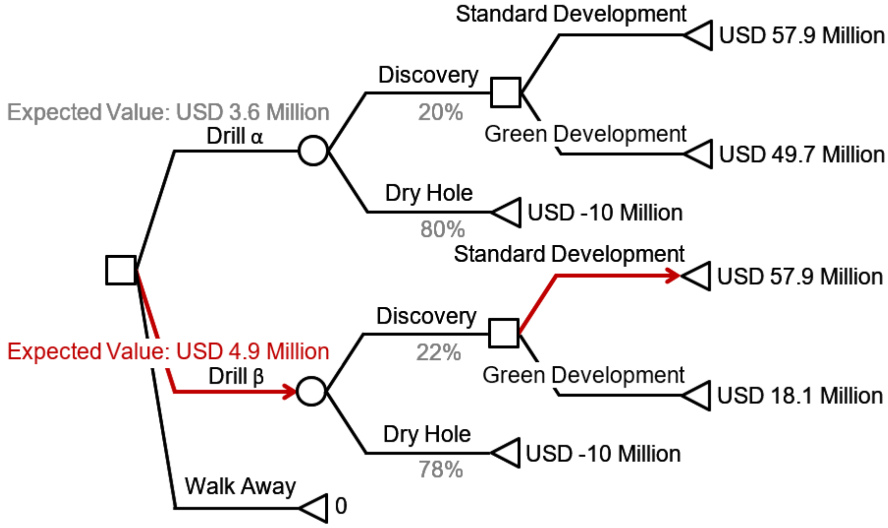

Figure 4—with no emission taxes, the decision tree model shows drilling β as the best course of action.

The host government’s regulatory system does not currently encourage drilling α, even though the electrification of its ensuing development project is more cost-effective. However, once the emission tax of USD 150 per ton of carbon dioxide takes effect, then the proximity to the existing installations could give an edge to prospect α. The cash flows in in the last row of Figure 3 show higher net present value for the development project of discovery in α. Here, the savings on emission taxes better justifies the added cost of environmental provisions.

With a revision in the regulatory system and the introduction of emission tax, the goal of value creation will naturally lead the company to selecting the course of action that is more environmentally appealing, as in **Figure 5**. By drilling prospect α, they will still have a positive expected net present value and in addition will honor the environmental concerns. In this example, the introduction of emission tax shapes the pattern of investment decisions towards more environmentally conscious choices.

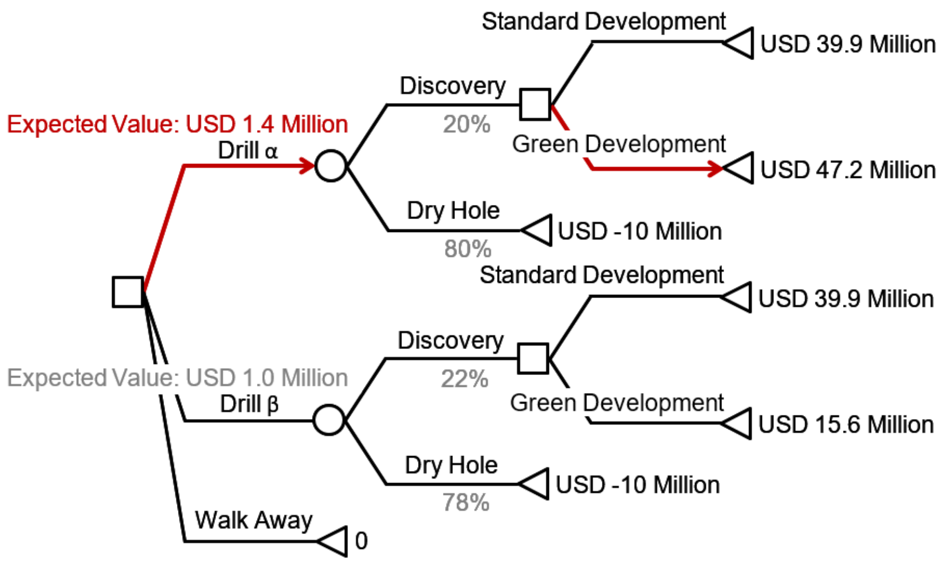

Figure 5—with the introduction of emission taxes, the decision tree model shows that the best course of action is to drill α prospect.

As we discussed earlier, the regulators implement measures to encourage a general pattern of investments, using either deterrents or incentives, but the details of implementations are up to the ingenuity of the investing companies. They detect or design value-adding opportunities within the constraints set by authorities. In our example, the emission tax affected the relative feasibility of the development solutions and led to the implementation of the environmentally friendly electrification solution. Without the emission tax (or alternatively, a trade-able emission allowance), the companies are unlikely to design a low emission solution on their own.

4. Corporate Applications

As in Fisher (1930), to use market insights in corporate decision making, the market should be *complete* so that we could replicate the value of a course of action using traded assets. Smith and Nau (1995) extend this framework to partially complete markets, where we could hedge part of the project uncertainties using market instruments (and use expert assessment for the non-market factors). Duffie and Huang (1985) show that if we assume aggregate consumption follows geometric Brownian motion, then the market would become complete only with two assets.

Makowski (1983) shows that completeness of the market and spanning are not necessary conditions for unanimity in corporate decisions. If markets are competitive—with no short selling—then all investors agree on project decisions that consider only the value. This is a more expansive condition, and we have used it in this paper in the context of emission markets and energy transition projects.

Our discussions relied on a key assumption: that the investors have access to competitive financial and emission markets. They can exchange money today with money in the future (capital markets) and can exchange money with emission allowances (emission markets). If such markets do not exist, or even that they do exist but are not competitive and well-functioning, then our reasoning collapses.

While financial markets at least in the UK and US are competitive, leading to theories for valuation of time and risk (as e.g., the Capital Asset Pricing Model in Sharpe, 1964), the emerging emission markets are narrow and limited (e.g., Bredin and Parsons, 2016). They are often cap-and-trade markets where regulators distribute emission allowances to corporations. These allowances are the “cap”, they show the maximum allowed emission for a firm. If their emissions exceed the cap, then they should buy any unused allowances from other sellers in the emission market. This encourages investments that save on emissions as the owners can make money by selling their unused allowances to those in need. As the authorities gradually reduce the total distributed emission allowances, they implicitly encourage investment in technologies that reduce total emissions.

For energy companies, such cap-and-trade emission markets lead to their emission allowance becoming a tradeable security. Like in any commodity market, it has a fair market price. In a comparable way that trends of hydrocarbon prices generate insight about the outlook of projects, emission price fluctuations and their market trends could also generate general insights about the economic outlook of emission-saving projects[6].

However, market insights are not globally available. The capital markets in emerging economies could be less competitive. Emission markets may also have inconsistencies (e.g., Palao and Pardo, 2021, discussing European Union's Emission Trading Scheme). With no competitive capital markets, the investors would not necessarily agree on a course of action with high net present value. In the absence of competitive emission markets, the investors would not agree on emission saving projects. With no market preferences, we will have divided investors having their subjective preferences.

To make project decisions in incomplete markets, we suggest sampling the owners and ask them to vote, according to the (more general) theory of syndicates in Wilson (1968). In competitive, yet incomplete markets, if the managers are also a shareholder, then, with their insight about the workings of projects and acting on self-interest, they would still make decisions that agree with the investor's preferences (Leland, 1974). However, corporate decisions without market insights would be intractable and difficult to solve.

5. Summary and Conclusions

In this paper, we use arguments from finance theory to discuss that multiattribute decision making is irrelevant to corporate decisions—value creation should be the only goal. Considering other goals in corporate decisions would overcomplicate the models and potentially lead to suboptimal decisions and loss of value. However, our arguments use a key assumption: that the investors have access to competitive markets. They can compare the value of certain amount of money today with an uncertain amount in the future using financial markets and can compare emission reduction with its equivalent monetary value using emission markets. Without such insights, our simplification does not apply.

With competitive markets, investment in energy transition projects depends on regulatory policies. By supplying emission allowances or imposing taxes, the regulators can encourage or discourage investment in specific types of projects.

We believe finance theory and the single goal of a firm—shareholder value creation—is still applicable in the energy transition context. We do not need to redefine the economics; we just need to design effective environmental constraints. Value creation is the goal, but to maximize shareholders' value, the firm needs to first satisfy other stakeholders—e.g., the creditors, the government, and environmental regulators. They all stand in a line ahead of the shareholders. The firm should meet their expectations first, before tending the shareholders. Shareholders' value creation still applies.

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[6] For example, an upward trending futures price curve for emission allowances favors investing in environmental solutions with long-term payoffs. The collective market participants hint on a future that rewards cleaner solution, even though the low spot prices do not say so. While emission taxes do not convey such a collective message, if they reflect market prices then we believe they would still inform investment decisions.

Supplementary Material

The analysis and valuation models used in this paper are available in the spreadsheet in the link below: https://www.dropbox.com/s/fy5zqbb6gxcngoe/Environmental%20Project%20Valuation.xlsx?dl=0

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