FIRM TRANSITION STRATEGIES: THE EFFECT OF EMISSION RESTRICTIONS AND UNCERTAINTY ON ASSET MIX CHOICES

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Overview

Over the past decades, the growing climate change concerns have triggered the shift in public perception of unsustainable companies, environmental regulations across the world, and decisions of investment institutions [1]. The changes in investors' preferences and the public's attitude, apart from regulatory incentives, have forced the increasing number of companies to adjust their asset portfolios investing in low-carbon technologies and supporting the *energy transition*. Yet, the financial tradeoffs make the choices on investments in alternative and displacement of traditional assets being far from clear. Strategies by the global energy champions, such as Chevron, Exxon, Shell, BP, Equinor, and Total Energy, have been quite diverse with some investing heavily in renewables while others, still growing their oil and gas assets [2] despite the common goals and commitments on carbon emissions [3].

The goal of our work is to 1) reveal the reasons for the observed variety of adjustment strategies, 2) build a model for the optimal asset mix for the companies facing emission constraints, and 3) provide insights which carbon restriction setups may accelerate the low-carbon transition.

Motivated by the data on investments and divestments by oil and gas producers, utility companies, and automotive manufactures, we investigate how the optimal transition path may vary for the shortsighted (profit-oriented or assigning a very high uncertainty to the future) versus long-sighted firms considering the future values of their assets. We capture the current carbon regulations and public preferences on emission reductions with constraints, which are imposed on either a project or asset level or entire company portfolio. Thus, the introduced framework is general enough and can be adopted for further theoretical or empirical analysis in different industries. We perform a set of simulations to demonstrate the insights and help the intuition.

Methods

We consider a rational firm investing in (and operating) projects or assets which allow it to generate profit by produce carbon emissions. The firm chooses a combination of assets to maximize its total value, including the growth asset or liquidation value, or only its current profit, assuming the uncertainty around future is very high or the firm has high discounting rate. We distinguish three types of assets, established, transitional and alternative, differentiating them based on their costs, associated uncertainty, and emissions (Table 1).

Table 1: Project groups description.

Group	Description	Cost	Discounting & Uncertainty	Emissions
Established	Unsustainable business as usual	Low	High	High
Transitional	Unsustainable business with limited harmful effects	Medium	Medium	Medium
Alternative	Sustainable business	High	Low	Low

Building on the classical approach to options by Pindyck [4] and the recent work highlighting the role of asset value under uncertainty by Miao [5], we develop a firm decision model and solve it assuming different emission constraint scenarios.

We derive the optimal asset mix and reveal how it depends, among other factors, on the relative emission differences and on whether the constraints are applied to individual projects or to the total production. The result allow us to explain why companies may take different approaches to their asset portfolio adjustment owing to the variations in perceived uncertainty, setup in emission targets, and relative costs. To develop further intuition about the interplay of carbon policies (or stakeholder requirements on emission reductions) and the firm's choices we turn to simulations.

Results

Motivated by the observed transitions in the power, raw resource production, automotive, and transportation industries, we design a model representing firm's decision on the use (and/or investments) in traditional fossil-fuel based production, transitional or hybrid, and alternative (clean) energy projects. We show how the emission-based limitations affects the asset mix and highlight the difference between profit and value-driven choices (Fig. 1).

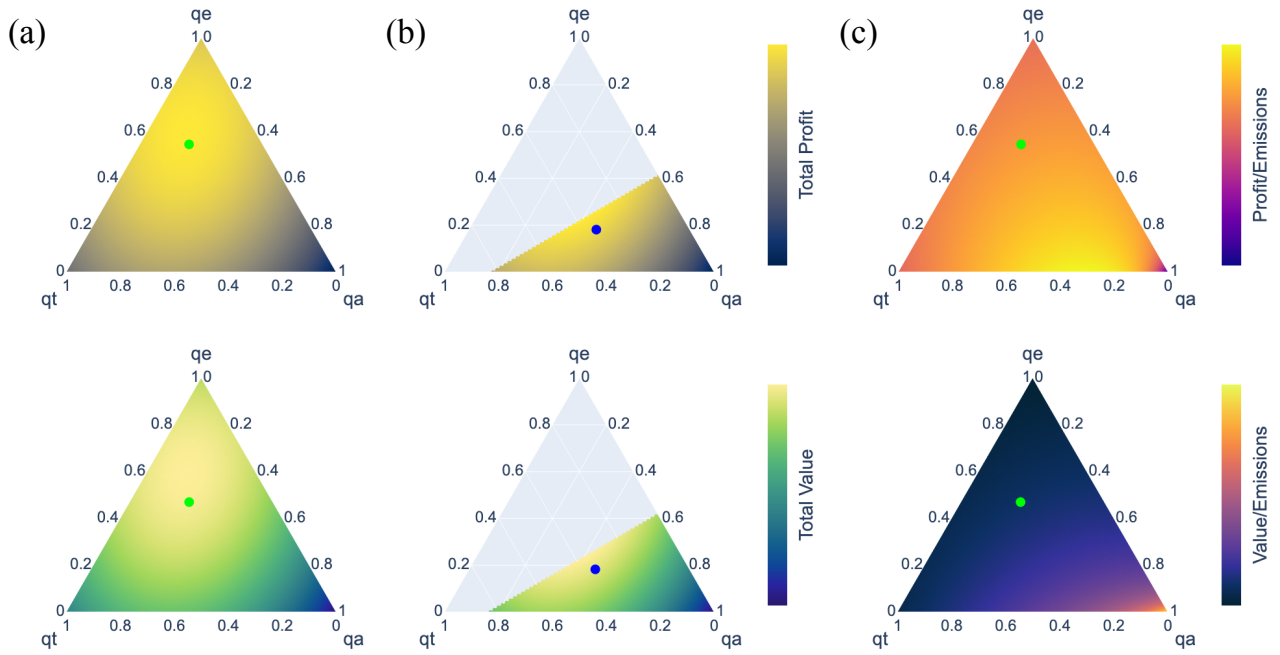

Figure 1: The optimal asset mix on ternary diagrams depicting profit and value distribution without (a,c) and with (b) emission constraints and showing the value per the unit of emission produced.

Simulations help us demonstrate several important insights:

- The shadow price of emissions for value-maximizing firms is lower than for profit-maximizing firms under each type of emission constraint.
- The asset mix choices may be the same under profit and value maximization if the expected profit outweighs the effect of uncertainty.
- Decisions on alternative project financing are independent of investments in established and transitional assets unless there is a common budget constraint.

With those results, we are able to shed light on the observed differences in firm's transition plans and show the effect of the specification of emission reduction goals.

Conclusions

The developed model is useful for a variety of energy transition related analyses, so that our study contributes to both the theoretical and applied literature on energy transition [6], financing of the energy transition, investment strategy [7], and industry dynamics [5, 8]. Our analysis helps choosing the appropriate incentives for companies to invest in technologies supporting energy transition, offering a much-needed formal and comprehensive approach Pickl [3]. The simulations enable us to highlight the trade-offs associated with capital allocation and foresee the changes in industrial supply under various market conditions and regulations.

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