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Evaluating the energy performance of buildings within a value at risk framework with demonstration on UK offices

Aidan Parkinson *, Peter Guthrie [1]

Centre for Sustainable Development, Cambridge University Engineering Department, Trumpington Street, Cambridge CB2 1PZ, United Kingdom

HIGHLIGHTS

- Evaluation of value at risk to specific assets through an exploratory analysis of supporting systems.
- Demonstration on UK offices of feasibility to develop a Capital Market Line for building energy performance.
- A scalable methodology for shadow pricing a market correction when internalising climate change impacts into accounting.

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ABSTRACT

Facility quality is dependent on the performance of utility infrastructure and local weather conditions in addition to social context. Theoretically, improvements in facility quality such as energy performance should reduce marginal costs of consumption for occupiers so as to increase asset values. This research explores the relationship between expectations of building energy performance and the financial value of real estate. The United Kingdom was selected as a leading case, being a large economy that has enacted legislation committing the government to delivering ambitious emission reductions to mitigate climate change. Appropriate instruments are identified and applied to a diverse set of case study offices. A scalable method is employed for calculating value at risk from energy performance for buildings. This involves a novel approach to testing supporting system capacity through an exploratory analysis of 2050 end-states and demonstration on real world contemporary cases as a feasibility study. In doing so, the significance of systematic risks to building energy performance can be quantified. By comparing systematic excess returns for energy performance with rental value for a large sample a Capital Market Line for building energy management emerges, providing a means to shadow price the social impacts of climate change.

1. Introduction

The quality of a facility is highly dependent on the performance of utility infrastructure and local weather conditions in addition to its social context. In theory, improvements in facility quality such as energy performance should effectively reduce the marginal costs of consumption for occupiers and increase asset values [1]. Therefore, the ability to identify opportunities for creating such value through appropriately evaluating expectations of future energy performance should be of keen interest to property investors and asset managers. This research asked the question:

> "How can specific market risks arising from expectations for the energy performance of real estate be appropriately evaluated?"

This research addresses this question through designing a value-at-risk framework for appropriate capital budgeting with regard to building energy performance and carrying out a feasibility study on a small sample of case studies to demonstrate implementation. Although this study focuses on the micro-scale of specific assets, it is ultimately scalable to include any number of buildings and uses.

2. Climate change as a global externality

Tyndall is widely credited as the first scientist to rigorously identify the absorption of radiant heat by gases and vapours [2]. Indeed, these observations have since become common knowledge and the effects that vapours have on radiant forcing in the

* Corresponding author. Tel.: +44 (0) 1223 333321.
E-mail addresses: atp32@cam.ac.uk (A. Parkinson), pmg31@cam.ac.uk (P. Guthrie).
[1] Tel.: +44 (0) 1223 333321.

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atmosphere has since been carefully scrutinised. Harvey explains the importance of considering not only the degree of radiant forcing, but also the duration that gases remain in the atmosphere. He describes how such estimation can cause difficulties as some vapours may remain in the Earth's atmosphere for a considerable length of time [3]. The current official perspective on this matter is presented in the Intergovernmental Panel for Climate Change (IPCC) Fifth Assessment Report [4].

Plausible climate projections included in the Intergovernmental Panel for Climate Change Fourth Assessment Report were based upon the application of the Special Report on Emissions Scenarios simulation ensembles of integrated climate and socio-economics models. The analyses of as many as 23 different climate models have been included in the report's cross-model comparisons. The reports states "*there is considerable confidence that climate models provide credible quantitative estimates of future climate change, particularly at continental scales and above*". The report provides a summary of projected global greenhouse gas emissions under these scenarios and corresponding resultant change in global surface temperature. The B1 scenario yielded a stabilisation in temperature change to a 2 °C increase from 1990 levels, with the least severe warming influence of any SRES scenario. The A2 scenario was found to have the most devastating warming effects on the climate, resulting in temperatures reaching over 3 °C by 2100 and probably continuing to rise [5].

Since the development of the SRES scenarios approximately 15 years ago there has been opportunity to evaluate the observed progress of development and make comparisons to them. It has become apparent that between 1999 and 2003 global society has developed most closely with an A1B SRES scenario, all others are now considered outliers [6]. In light of this it has become clear that, although the SRES scenarios benefit from detailed scrutiny, they are now largely obsolete and have lost decision-making utility.

New climate change scenarios have been developed for the IPCC Fifth Assessment Report which adopts an alternative and updated methodology superseding SRES. The SRES approach to scenario building explored the influence of pivotal uncertainties in socio-economic development on future climate change. In contrast to this the new scenarios make projections of Representative Concentration Pathways (RCP's) relating to various levels of combined mitigation and adaptation efforts resulting in alternative concentrations of greenhouse gases in the atmosphere. This means that the new scenarios are likely to retain consistency with a wide range of socio-economic futures. The Fifth Assessment Report provides four RCP's denoted by the level of radiative forcing in the year 2100: $2.6\,\mathrm{Wm}^{-2}$; $4.5\,\mathrm{Wm}^{-2}$; $6\,\mathrm{Wm}^{-2}$; and $8.5\,\mathrm{Wm}^{-2}$. Each scenario is considered plausible and illustrative, with no specific probability assigned to the likelihood of occurrence [4].

A comparison of radiative forcing between the SRES and RCP scenarios is made within the Fifth Assessment Report. It shows and $8.5\,\mathrm{Wm}^{-2}$ RCP scenario is similar to the trajectory of the SRES A1B scenario until 2050. However, these similarities are not sustained beyond the year 2050. The Fifth Assessment Report states how it is unlikely that mean global surface temperature will rise more than 1.5 °C between the present day and 2035 due to high levels of inertia in the atmospheric system. However, beyond 2035 there is the potential for large variation in the future climate depending on future concentrations of greenhouse gases. Therefore, immediate action to address climate change would have long lasting effects on the climate [4].

The reality of climate change poses great challenges to society. Greenhouse gas emissions have been an unknown and unmanaged externality of technological development for over a century. Stern asserts that climate change is "*the greatest and widest-ranging market failure ever seen*" requiring action that is "*global… long term…* (and) *ha*(s)… *the economics of risk and uncertainty at centre stage*" [7]. However, leading economists realise that Stern has arrived at the right conclusions from perhaps a significantly outlying economic position in regard to considerations of social equity [8,9].

3. Methodology

This research seeks to explore the relationship between expectations of building energy performance and the financial value of real estate assets. The context of the United Kingdom was selected as a leading case, being the largest economy to enact legislation that commits the government to delivering ambitious emission reductions to mitigate climate change impacts. Appropriate instruments are identified and applied to a diverse set of case studies. Through the analysis a scalable method for calculating value at risk from energy performance for specific case studies is determined.

3.1. Objectives

The valuation of risky assets requires the decision maker to evaluate expected returns over the duration of an investments life-cycle. Investments in property are a particularly challenging case where the underlying assets are in general highly illiquid, expensive, and commonly of unique quality [10]. Therefore, a credible and challenging expectation of plausible future development is a key consideration in evaluating long-term strategy. This research recognised that over the longer-term, the management of energy in the UK could be very different from anything that might be expected from current short-term trends and incremental change. Responses based upon such information could result in an over-investment in technologies that may become redundant or inappropriate over the course of time. Hence, there is a need to consider responses to energy challenges that are resilient to a broad outlook. Through evaluating a 40-year outlook a reasonable opportunity for significant system wide change is allowed for, including significant decarbonisation [11].

Objective 1: Develop plausible descriptions of expectations for the climate and energy systems towards 2050 for the UK.

To make the research outcomes most useful the study took a particular interest in commercial offices. This is because these assets are relatively expensive buildings providing services to high value industries that will grow regardless of energy prices [12]. Therefore, such buildings may be exposed to high levels of obsolescence within a competitive market. By focussing on such assets it is also more likely that the marginal costs of this research are very small compared with the capital value of the cases. It is the intention of this study that it is rooted in the real-world present day without requiring control of behavioural events. Real observations need to be analysed to demonstrate that such analysis can be carried out within a present state of circumstances.

Objective 2: Evaluate the expected energy performance of commercial property assets using an appropriate value at risk methodology towards 2050.

4. Describing expectations

This section provides a brief discussion of the field of 'futures studies' followed by an explanation of the approach taken for this research. Foresight provides a step-by-step guide to create descriptions of explorative scenarios and consider their implications, a procedure adopted by Parkinson et al. [13,14]. This study recognises the valuable insights of Parkinson et al.'s study, but also identified some clear deficiencies. To overcome this, the findings were translated for quantitative exploratory analysis.