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Green investment behavior in climate policy uncertainty: a suggested adjusted profit estimation model

Abstract

This paper ruminates on green investment behavior in the face of climate policy uncertainty and advocates an adjusted profit estimation model for potential green investors. Adopting a review method, the paper finds *inter alia*, that climate policy uncertainty constitutes investment risks. Furthermore these risks may trigger a risk averse or risk taker types of green investment behavior. To encourage green investment in the face of climate policy uncertainty, investors must seek for a risk cushioning through a risk premium; thus the paper reconstructs the Neuhoff's model of green investor profit and derives a suggested adjusted profit estimation model under climate policy uncertainty – referred to in this paper as the adjusted green investment profit under uncertainty (AGIPUU). The paper thus offers an agenda for further research to apply this model in a field case study research.

Keywords: green investment, investment behavior, green energy, investment risks, climate policy, probability, environmental economics, green economy.
JEL Classification: M14, M21.

Introduction

Climate change has been widely acknowledged as a systemic risk facing global society (Patwardhan et al., 2007; Kasperson, 2013), but notwithstanding this fear, human efforts towards halting climate change are still at an embryonic stage and this is made worse by uncertain and apathetic climate policy that has continued to offer green investors with little clear direction and timing (Gan et al., 2007). Similar to any other type of investment, lack of clear direction and commensurate long-term signal (Fuss, 2008) may jeopardize intended actualization of low carbon economic development, and thus prolong desired equitable growth and development. This is because investors' willingness to invest in green energy is affected by their perceived climate policy uncertainty and investors' risk behavior (Kittunen et al., 2011). Thus investors may need to have some measure of risk cushioning (a risk premium) to be encouraged toward investing in green energy technology in the face climate policy uncertainty must have (Blyth et al., 2007; Krey & Riahi, 2013). This is important because the consideration of risk aversion in green investment under climate policy uncertainty is important in understanding green investment behavior in climate policy uncertainty and in assisting policy makers when fixing the timing of climate policies (Kaufman, 2014); whilst economic theory indicates the importance of integrating risk aversion in climate policy decisions; current research indicates that most environmental regulations and/or policies are made without considering risk aversion (Kaufman, 2014); since therefore policy makers apparently fail to input risk aversion in the timing of climate policies, green investors need a risk cushioning premium to be able to invest under the uncertainties of climate and technological policy uncertainty.

Therefore in consideration of green investment risks in climate policy uncertainty (Weitzman, 2009; Keller et al., 2004); the paper is underpinned by the question of likely green investment behavior in the face of climate policy uncertainty; and a possible approach that may be used to arrive at a somewhat objective estimate of potential profit in green investment under uncertainty. Drawing from the above questions therefore, the objectives of this paper are: to review green investment behavior in climate policy uncertainty and to suggest a method of estimating potential profit of engaging in green investment under climate policy uncertainty.

Whilst previous literature in green investment and climate policy have been inclined toward a somewhat multifarious empirical methodology and complex economic modelling; this paper approaches the issues of uncertain climate policy and investor behavior from a review and/or conceptual and discursive slant to embrace the readership and understanding of investors with little or no economics literacy.

The paper is organized as follows: section 1 discusses the conceptual background of this article; section 2 gives a review of related literature. Following this, section 3 presents a suggestion of an approach to estimate potential profit of engaging in green energy investment in climate policy uncertainty. The final section provides the conclusion.

1. Conceptual framework

Before proceeding to the literature, this section presents some conceptual background that underpins the focus of this paper. It gives a brief discussion of the real option perspective of investor behavior as it relates to this paper; it then proceeds to give a brief highlight of green investment and climate policy uncertainty respectively.

1.1. A real option perspective of investor behavior. Without delving into the nitty-gritty of real option as expounded by Chvalkovská, & Hrubý (2010), it is apposite to mention that under climate policy uncertainty, investors in green energy may behave in a manner that bears a semblance of the real option theory, hence the real option perspective of investor behavior is referred to in this paper. In the context of this paper therefore, it is pertinent to recall Dixit and Pindyck (1994) description of real option in which they posit that when firms are opportune to invest, they therefore have an option to exercise; and this option is further expounded as an option to invest now or to invest in the future (Zhang et al., 2014). Accordingly Chvalkovská & Hrubý (2010) explain further that under the real option scenario, the asset is the investment; and, the decision or behavior facing the investor is either to invest or not to invest in the green energy project, given the outcome of conditions favorable or unfavorable for the project. They explain further that favorable conditions may include input and output prices including certain complex conditions like imminent or potential climate policies and/or regulations. These conditions may prompt the green investor to behave in a certain manner at a particular point in time. It is this behavioral disposition that is the concern of this paper and not the quantification aspect of real option and green investment. Theoretical evidence suggests that certain characteristic of real option behavior that also identifies the behavior of green investors under uncertainty includes *inter alia* reversing of a green investment; some green energy investments are imbued with flexible options and investors may exercise such options; given the uncertainty in the time frame of climate policy, green investors may exercise a deferrent option, only to invest when it seems profitable; green investors may exercise the option to abandon green energy projects if climate policies or prices disfavor such investments (Trigeorgis, 2002; Chvalkovská & Hrubý, 2010; Fuss et al., 2008; Zeng & Zhang, 2011; Hoque & Krishnamurti, 2012). A cause for concern is that although the related investments may be private or public, but exercising the aforesaid options by the green investors may be inimical to the goal of achieving sustainable environment through green energy investment. Hence the research concern that since every investor – including the green technology investor would wish to cushion uncertainties, a risk premium is thus desirable to motivate green energy investors to venture into green energy technology even in the face of climate policy uncertainty. Thus this paper would, in the later part of the following sections, suggest a green profit estimation model that incorporates risk premium.

1.2. Green investment. Green investments are regarded as investments that preserve the eco-system, natural resources, social and human health (Climent & Soriano, 2011). Thus the growing concern for environmental health has boosted the number and amount of mutual fund investments that are geared toward enhancing corporate environmental responsibility (Climent & Soriano, 2011; Jänicke, 2012). There is no single definition that may encapsulate green investment; however, according to (Inderst et al., 2012), green investment is a wide-ranging terminology including socially responsible investing, environmental, social, governance and sustainable investing. Hence green investment might refer to clean and climate change investing that enhances social, environmental and economic growth (Inderst et al., 2012). Green investment has also resulted in current financing lexicon such as green financing, green bonds, green stocks and green mutual funds (Stefan & Paul, 2008; Climent & Soriano, 2011). Within the power sector, green investment involves the use of technology to reduce carbon emission – low carbon power generation technology (Kannan, 2009; Chen et al., 2010) – also popularly referred to as renewable energy (Chen et al., 2010). Hence transition to a low carbon technology in current energy mix is seen as a catalyst toward achieving desired global carbon reduction (Chen et al., 2010; Kannan, 2009). This paper is thus focussed toward a nuanced discussion on green investment behavior in the energy or power sector under climate policy uncertainty.

1.3. Climate policy uncertainty. In the world of business, uncertainty is an important planning and decision constraint that has attracted much scholarly and professional discussion relating to the cost of uncertainty and its effect on investment (Arrow & Lind, 2014). Within the current era of sustainability and the pursuit for carbon reduction through a low carbon energy technology, climate policy uncertainty has come to lime light as a constraint to investment (Smulders et al., 2014). Climate policy uncertainty thus refers to uncertain expectations of climate policies that may have impact on sustainable or green investments (Smulders et al., 2014); such policies include inter alia government climate regulations, and international treaties on climate and/or carbon reduction (Niblock & Harrison, 2013; Kolk, 2013). Climate policy uncertainty thus results from the failure by policy makers to announce climate policies in advance of its implementation (Kolk, 2013). This is why the empirical research findings of Kolk (2013) show that carbon emission increases between the time of announcing climate policy and the actual time of implementation; this is because when climate policies are announced without a certain date of implementation, companies may continue their business-as-usual operations in high carbon intensity to make as much profit as possible before the yet unknown switching time to a low carbon policy. Thus given the innate investment behavioral implications, climate policy uncertainty is seen as a quandary for environmental economists

(Pindyck, 2013). Therefore uncertainties surrounding climate policy includes whether announcements may be made on some climate issues, when such announcements may be and the implementation time; and similar to the dominant power of uncertainties in the conventional business and market environment, green investment is seen to be influenced by climate policy uncertainty. The following section discusses some literature on green investment behavior under climate policy uncertainty.

2. Related literature

Although renewable energy has been widely recognized as a worthwhile investment that may foster environmental sustainability and as well assist in economic growth, there is still some seeming reluctance amongst investors (Masini & Menichetti, 2012) and it is believed that risk aversion inherent in green technology due to uncertainties coupled with little financing options contribute to slow down investors' appetite for green energy investments (Masini & Menichetti, 2012). In their research on green investment behavior, Yang et al. (2008) used the real option methodology to assess green investment behavior under future climate policy uncertainty which is regarded as an external risk to the investors. They – Yang et al. (2008) analyzed firms' investment options in coal, gas, carbon capture and storage options. Conclusively they find that climate policy uncertainty results in a risk premium for power generation investments (see also: Krey & Riahi, 2013; Shahnazari et al., 2014a). The risk premium is seen as a factor that triggers an increase in electricity price of between 5-10% – a price level that may motivate the investors to invest. On the other hand, investment in carbon capture and storage (CCS) would push an attractive investment price of carbon up between 16-37% before the investors would invest in (CCS). Yang et al. (2008) thus advise that minimization of risks in green investment requires policy makers to offer long-term regulatory certainty to investors, as such certainty would reduce the risk premium of investing in green energy, hence making the investors more willing to invest (Yang et al., 2008; Bistline et al., 2013). In their research on green investment decision in carbon policy uncertainty Shahnazari et al. (2014a) posit firmly that uncertain climate change policies pose a major risk in electric generation assets, thus the result of their model suggests that uncertainty in the political landscape regarding carbon pricing is a deterrent on investors' decision to convert to cleaner power generation technology. They however suggest that investors may reduce their uncertainty by forecasting the viability of their conversion to new technology by anticipating a higher carbon price (Shahnazari et al., 2014a). In another related study, Shahnazari et al. (2014b) posit that uncertain climate policy does not only delay investment in new technology but that additionally *"It may also incentivize short-lived, high-cost interim investments while businesses wait for the uncertainty to subside"*, (Shahnazari et al., 2014b, p.157). Given this uncertainty in climate policy Krey & Riahi (2013) thus caution that investors considering a switch to green power technology must integrate the risk of future uncertainty into current green investment decision; however they highlight that early diversification from old to new technology depends on the percentage of risk premium open to the choice of green investment decision ma-kers – attractive enough to lure them into conversion to green technology (Krey & Riahi, 2013). The quantum of diverse and associated risks of climate policy uncertainty informs Krey & Riahi (2013) position that for risk hedging to be cost effective, all assortments of climate policy uncertainty must be brought into the analysis of potential greener technology investments; this is imperative as assorted uncertainties interact in a synergistic fashion (Krey & Riahi, 2013). However, few risk takers venture into greener technology investment albeit the uncertainty in climate policy; these investors take greater investment risks in anticipation of either the adverse or favorable policy. It has also been argued that amongst these investors, though, are some who venture not for profit but for their love and concern for the environment (Miller & Merrilees, 2013); the extent to which the latter is plausible is subject to further study, this is because the organization is established to make profit and every other endeavor is regarded as secondary (Friedman, 2007; Jones & Felps, 2013). Whilst explaining investors' likely behavior under climate policy uncertainty, Fleten et al. (2011) explain that investors vary in their belief on climate policies and hence its effect on investment behaviors; some investors consider the likelihood of future carbon common markets whilst others do not. Equally, some investors trust the green political promises but some do not trust the political promises of climate policy; thus these differences manifest in different behavioral dispositions of green investors. These raging debates thus inform Fleten et al. (2011) suggestion that the prediction of investors' behavior under climate policy uncertainty is more suitable using the real option models – reason being that the real option integrates uncertainty whereas the net present value (NPV) method does not consider uncertainty. This is the reason why this paper is poised to make a modest suggestion of green investment profit estimation by using the Howarth (2003) risk free rate to adjust the Neuhoff (2007) economic model. Integration of risk premium is considered important since it has been highlighted in the literature as an important factor to consider in the green investment decisions (Krey & Riahi, 2013). This is perhaps why Blyth et al. (2007) use a real options approach (ROA) to analyze the impact of government climate policy uncertainty on investors' decision-making behavior in the energy sector with findings that yielded major conclusions including *inter alia*: that climate policy uncertainty results in a risk premium; green investment risks may be greater if there is short time-span between anticipated future climate policy and the time of green investment decision; government may reduce green investors' risks by decreasing climate policy uncertainty (Blyth et al., 2007). Apart from the choice of new technology, there is also a technical risk that may arise due to plant "*uncertainty over capital costs, efficiency, reliability, output, maintenance and decommissioning*" (IEA, 2007, p.106), and technical risk that may arise from obsolescence of technical aesthetics of renewable energy assets (Ernst and Young, 2014, p. 10). It is in consideration of these assortments of risks that the green investor would desire a risk premium to incentivize an investment into a green energy technology. This is important given the preceding discussion, under the conceptual framework of optional behavior of an investor under climate policy uncertainty; hence in order to obviate the option of opting out of investment in green technology or delaying investment in green technology, the green investor desires a profit in which a risk premium is integrated. Therefore a suggested profit model that integrates a risk premium for the green investor is thus presented in the following section.

3. A suggested adjusted model for estimating potential green investment profit under climate policy uncertainty

Annin & Falaschetti (2014) acknowledge the abundance of literature in several finance topics that have received unanimous agreement amongst authors; however they emphasize that the area of risk premium is still subject to scholarly debate:

While there are many topics in the area of finance upon which academics agree, a topic as basic as the equity risk premium still can produce some vigorous debate (Annin & Falaschetti, 2014, p. 1).

This assertion may be more plausible where the issue of risk premium is related to emerging issues regarding green technology with associated uncertainties in climate policy. Hence investors who embrace the courage to invest in somewhat risky green technology (Muñoz & Bunn, 2013) should deserve premium to compensate for uncertain policies with the concomitant latent risks. As highlighted in the previous sections under the conceptual framework, the real option theory suggests that investors have the right to exercise their option, to invest or not to invest and may withhold and/or delay investment under uncertainty; according to economic theory, potential green investors thus require a risk premium to incentivize them toward engaging in green energy investment (Kaufman, 2014).

Therefore given the uncertainties inherent in green technology investment, the paper suggests an adjusted model of estimating green technology investment profit by adjusting the Neuhoff (2007) economic model of estimating green investment profit through an addition of risk premium derived using the Howarth (2003) recommended risk free rate for green adjusting the profit of green investments.

3.1. Hypothetical demonstration of the adjusted model. According to Neuhoff (2007, p. 7) the future profit flows to an investor in green technology will depend on the severity of climate policy in place. Hence there is the uncertainty that future climate policy might be severe or not severe. The future profits streams will depend on the stringency of the country's climate policy.

Hypothetical example: adapted from Neuhoff (2007, p. 7).

Cost of investment in green energy technology: \$1800; Probability that country's climate policy will be severe: 50%, and profit: \$3000; Probability that country's climate policy will not be severe: 50%, and profit: \$1000; adapted from (Neuhoff, 2007, p. 7).

Two scenario profit expectation under climate policy uncertainty

Investment in green technology (cost)	C = \$1800
Scenario 1	
Severe future climate policy	
Probability	$1 - P = 0.50$
Profit	Pr_1 = \$3000
Scenario 2	
non-severe future climate policy	
Probability	$1 - P = 0.50$
Profit	Pr_2 = \$1000

From the above scenarios, the investor's expected profit (E) using the (Neuhoff, 2007, p. 7) economic model will be derived as follows:

Neuhoff (2007, p. 7) economic model:

$E = p * Pr_1 + (1 - p) * Pr_2 - C,$

$E = 0.5 \text{ x } 3000 + (1\text{-}5) \text{ x } 1000 - 1800 = 200.$

An adjustment to Neuhoff (2007, p. 7) economic model.

The literature review in the preceding section highlights the importance of attaching a risk premium to green technology investments which are regarded as risky investments due to uncertainty in climate policy (Yang et al., 2008; Krey & Riahi, 2013; Shahnazari et al., 2014a).

According to Finance Formula (2014, p. 1) a risk premium for an investment in a risky asset is derived by:

Risk premium = $(r_a - r_f)$.

Therefore the Neuhoff (2007, p. 7) economic model of green investment under uncertainty: ($E = p * Pr_1 + (1 - p) * Pr_2 - C$), is adjusted by integrating the above risk premium to derived the adjusted model of estimating green energy technology investment profit under climate policy uncertainty, thus this adjustment is referred to in this paper as an adjusted green investment profit under uncertainty (*AGIPUU*) as follows:

$AGIPUU = p \text{ x } Pr_1 + (1 - p) \text{ x } Pr_2 - c \text{ x } (1 + r_a - r_f)$,

here *AGIPUU* = adjusted green investor profit under uncertainty; r_a = return on investment of a risky asset (in this case assuming the climate policy will not be severe – using the minimum anticipated profit of \$1000); r_f = risk free rate (annual return on risk free asset); the Howarth (2003) risk free rate of 2.6% is used in this adjustment; P = probability that climate policy may be stringent; Pr_1 = profit if climate policy will be severe $1 - p$ = probability that climate policy will not be severe $(1 - p) = (1 - .50) = 0.50$; Pr_2 = profit if climate policy is not severe; C = cost of investment in green energy.

Howarth (2003) recommends that the benefit or profit arising from discounted green investment returns must be adjusted in recognition of known or potential green investment risk at an adjustment rate that is equal to annual return on risk-free assets, which according to his research ranges between 0 and 2.6%. In this suggested adjusted profit of Neuhoff (2007) economic model of green investment expected profit under climate policy uncertainty, the Howarth (2003) risk free rate of 2.6% is used to derive the risk premium required for the adjustment. A risk premium is the amount by which the return on investment of a risky asset investment exceeds the return on risk free asset investment (Financial Formula, 2014, p. 1).

3.2. Deriving the risk premium for the above hypothetical example. Risk Premium = $r_a - r_f$ (Finance Formula, 2014, p. 1).

The return on investment in the above example is thus: 1000/1800 = 0.56.

Therefore risk premium: $r_a - r_f = 0.56 - 0.026 = 0.53$.

Note that in this case, the lower return of \$1000 is used in the computation.

Therefore an adjustment to the Neuhoff (2007) economic model is undertaken by applying the Howarth (2003) risk free rate of 0.26 to derive a risk premium for green energy technology investment; we will therefore have an adjusted green technology investment profit – adjusted green investment profit under uncertainty (*AGIPUU*) as:

$AGIPUU = p \text{ x } Pr_1 + (1 - p) \text{ x } Pr_2 - c \text{ x } (1 + r_a - r_f)$

The above hypothetical illustration is thus substituted into the formula as below:

AGIPUU = [0.5 x 3000] + [0.5 x 1000] – 1800 [1+0.56 – 0.026].

Therefore:

AGIPUU = [0.5 x 3000] + [0.5 x 1000] – 1800 [1.53],

AGIPUU = 1500 + 500 – 1800 (1.53) = \$306.

Comparatively therefore, the AGIPUU model gives a higher expected profit given the inclusion of risk premium more than the Neuhoff (2007, p. 7) economic model:

Neuhoff economic model:	*AGIPUU* model
$E = p^* Pr_1 + (1 - p) * Pr_2 - C$ E = 0.5 x 3000 + (1 – 5) x 1000 – 1800 = 200	$AGIPUU = p \text{ x } Pr_1 + (1 - p) \text{ x } Pr_2 - c \text{ x } (1 + r_a - r_f)$ *AGIPUU* = [0.5 x 3000] + [0.5 x 1000] – 1800 [1.53] *AGIPUU* = 1500 + 500 – 1800 (1.53) = \$306

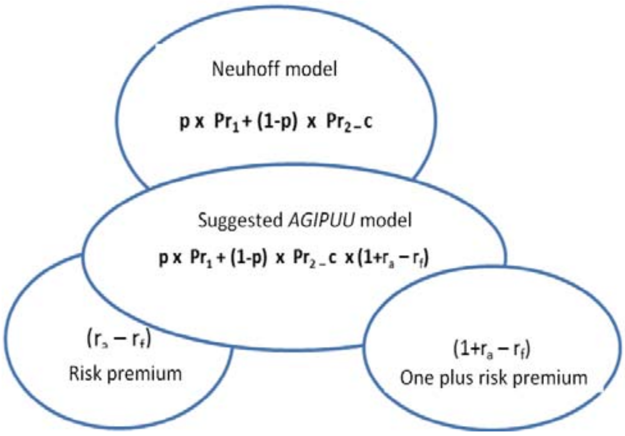

Fig. 1. Graphic representation of the adjusted profit model (*AGIPUU*)

It can be seen therefore that, whereas the Neuhoff (2007, p.7) economic model, without a risk premium gives an expected profit of \$200, this paper's suggested adjusted green investment profit under uncertainty of climate policy (*AGIPUU*) gives a higher profit estimation with an integration of a risk premium of 0.53. The addition of the risk premium is in adherence to literature suggestions that amidst the uncertainty in climate policy, a risk premium is desirable to motivate investors to adopt green technology investment; such premium is thus a compensation for venturing into the somewhat risky green investment. The above adjusted profit estimation model may be used for estimating the likely expected profit of green investors who want to exercise their option to invest in green energy technology whilst there is still uncertainty in a country's climate policy. The proposed model may be applied in a field research to ascertain investors' likelihood to invest using the percentage risk premium.

Conclusion

This paper considered green investment behavior under climate policy uncertainty; this was deemed necessary since achieving desired green economic development depends, to a large extent, on investors' willingness to embrace and to invest in green technology. A review of the literature indicates that although investors may be willing to invest in green energy technology, however, they may be risk-averters since the prevailing climate policy uncertainty makes the future of green energy investment hazy. The uncertainty in climate policy thus presents green investors with various risks such as the risk of fuel price, carbon price and technological risks. The International Energy Agency (2007) concurs that technical risk is perhaps one of the most important risks facing the green energy investors. The paper finds that these assortments of risks make the green investor to behave in a real option manner. Accordingly, due to uncertainty, the green investors may choose the option of not to invest, to delay and wait until climate policy becomes certain, or to pull out green investments. Exercising these options may not achieve anticipated green economic development, because the risks and behavioral options combined together may possess some propensity to delay required green investment and thus protract the timing of carbon reduction. Hence, the literature recommends that potential green investors need to be incentivized to engage in green energy technology investment by integrating a risk premium into the expected profit from green investment. Therefore in an attempt to make a contribution to existing literature, this paper presented a suggested adjustment to existing Neuhoff (2007) green investment expected profit to derive a simple adjusted model of estimating green investor's profit, referred to in this paper as an adjusted green investment profit under uncertainty (*AGIPUU*). The paper thus presents an agenda for further research to apply this model in a field case study research. It is also hoped that the suggested model may trigger some academic discussion and debate in scholarly research and in the classrooms.

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