



Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

A system dynamic approach for exploring the effects of climate change risks on firms' economic performance

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ARTICLE INFO

Article history:

Received 9 May 2014

Received in revised form

31 July 2014

Accepted 27 September 2014

Available online xxx

Keywords:

Climate change risks

Corporate sustainability

System thinking

System dynamic

Stella software

ABSTRACT

A number of studies have recently examined the potential relationships between climate change and the business community. The majority of such studies have emphasized statistical and benchmarking techniques to identify how climate change could have implications on firms' operations and their economic performance. These techniques draw primary data from questionnaire surveys and corporate environmental reports in an *ex post* basis, a fact that provide evidence in a linear, probabilistic and static character. These studies have provided limited insights regarding the future complex effects of climate change on corporate economic performance. This paper aims to contribute to this literature by developing a dynamic model to investigate the evolutionary trends of the relationships between climate change risks, financial performance and the operational processes of firms. The main scope is to identify how physical, regulatory, reputational and litigation risks will affect day-to-day operations. An integrated model will be established in order to improve managers' and academics' understanding of climate change and business performance. Four scenarios will also be tested to illustrate "what if" relationships in the presence of climate change risks. Finally, the proposed model is based on the corporate climate change management, system thinking, system dynamic and Stella software.

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1. Introduction

Climate change is one of the most urgent threats to modern societies with direct and indirect consequences (e.g. extreme weather events and a strict institutional regime) to the steady growth of global economies (Stern, 2008). A number of scholars suggest adaptation strategies to protect cities from climate change impacts. The severity of climate change impacts on business operations differs according to the economic sector to which the firm belongs, examples being the tourist and leisure industry and the agricultural sector. The shortening of ski seasons and the inability of agribusiness to produce specific agricultural products are some significant results of climate change. Scott and McBoyle (2007) identified that ski operators and their investors have recently realized the growing vulnerability of their operations to the negative effects of climate change and the higher costs of mitigation and adaptation strategies which are undertaken by firms to respond to these problems. Similarly, many adaptation options have been

undertaken by the agricultural sector to relieve climate change impacts such as technological developments, governmental and insurance programs and production and financial management techniques (Smit and Skineer, 2002).

The impacts of climate change are considered a potential financial risk for a number of industrial sectors. Some international organizations have classified climate change risks into the following categories: physical risks, regulatory risks, reputation risks and litigation risks (CERES, 2010). Depending on the sector and the frequency of the physical risks (e.g. droughts and floods), a series of consequences on the operations and production processes have been identified including an irregular supply of raw materials (supply chain risks), the relocation of their business units and interruptions to transportation. Proposed resilience thinking in order for firms to cope with physical risks. Regulatory risks are mainly associated with the types of mitigation and adaptation strategies which firms have undertaken to comply with the requirements of existing environmental legislation and regulations (Blyth et al., 2007). Reputation risks refer to the negative image of some firms stemming from the use of outdated equipment resulting in high levels of environmental pollution, energy consumption and Green House Gas emissions (GHG). Litigation risks may result in heavy

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finances paid by firms due to an inability or reluctance to comply with the requirements of climate change public policy.

The aforementioned risks emerging from climate change are likely to drive some firms to create new innovations and gain benefits. Pinkse and Kolk (2010) identified that many innovations have been created by various firms, mainly large, in their attempt to respond to climate change policy such as technological innovations, complementary capabilities and socio-technical innovations. Considered it vital for a firm's viability to incorporate the potential risks of an extreme weather event into their strategic management in an attempt to exploit some innovative resources and capabilities and reduce the risk of possible organizational collapses.

This paper aims to develop a system dynamic model to improve the understanding of academics and managers regarding the impact of climate change on business operations. The proposed model highlights the influences of climate change policy, stakeholders' perceptions (e.g. customers and investors) and of extreme weather events on business operations. The formation of the model is firstly based on some key propositions developed from the analysis of the current literature on corporate strategies and climate change. The proposed model was developed using the STELLA software program.

The rest of the paper includes five sections. The first section develops the methodology and the framework. The second section includes the analysis of the current literature on the potential effects of climate change on a company's operations. The third section provides a casual model diagram prepared using the STELLA software program. The next section tests some scenarios for the strategies undertaken by firms to avoid potential climate change risks and the final section analyzes the conclusions and discussion.

2. Methodology

The proposed methodology is structured as follows a) the proposition development and b) the system dynamic structure. The first part is based on literature review and case study research in order to identify the key variables of the proposed model. Important information emerges in case studies since the empirical description of a specific topic is developed from various data sources (Yin, 1994). This approach assists the researcher in examining a topic in the real world and derives information to build a general theory. Eisenhardt and Grabner (2007) argued that data arising from case studies, and current literature are very important to build explicit propositions and theories. A sufficient number of

cases range from 3 to 12 (Yin, 1994). This paper drew data from eight case studies carried out in the agribusiness and ski sectors. In particular, managers from agribusiness and the ski industry were questioned on their awareness of the risks of climate change on their firms' operations. Additional data was drawn from corporate climate change literature and similar academic reports. The decision to focus on these sectors is based on the higher threat which they face from climate change and the existence of significant scientific debate about these sectors. It is worth noting that the findings will improve the understanding of the potential climate change risks on other sectors.

The propositions are the base for identifying the key variable of the system and their feedback. Also, system dynamic thinking needs to use some particular examples for creating correct archetypes (stock and flow diagram and casual loop diagram) (Wolstenholme, 2003).

Fig. 1 illustrates in detail the schematic representation of the proposed methodology. The first step outlines the main sources of data for identifying the variables and developing the propositions for their relationships. The next step provides the connection of case study research and system approach by developing a system dynamic model through proposition development. Three case studies were conducted in ski resorts in Greece and over twenty cases studies in the agribusiness in Northern Greece where climate change impacts are more significant through extreme floods and droughts. An interview protocol was developed with questions assessing the perception of respondents about the importance of parameters and their connections as they arisen from current literature. Additionally, a number of scenarios are tested to identify the sensitivity of some key variables to the overall system.

3. Propositions development

Academics have examined how climate change might lead to costs and benefits to the business community and general economy (Levy, 1997; Tol, 2002). A number of potential positive and negative impacts on firms have been examined by the literature such as the possible financial costs, production and operation risks, the concern of stakeholders for business viability and the increase of the market share and the creation of new innovations. Two streams of thought can be identified in the relevant literature analyzing business and environmental issues; the one from environmental economics and the other from corporate environmental management (Reinhardt, 1999). The former, considers environmental

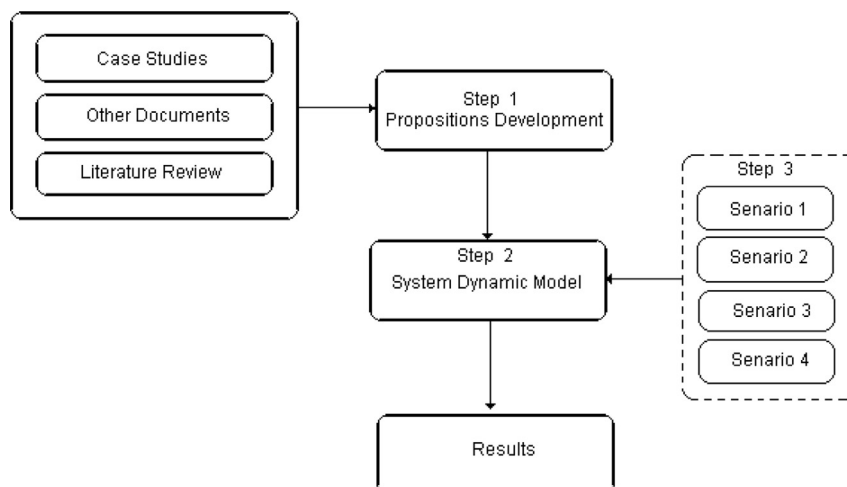


Fig. 1. Structure of the research framework.

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