Voluntary carbon offsetting and its contribution to sustainable development

A thesis submitted for the degree of Doctor of Philosophy

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April 2018

Declaration of Originality

I hereby confirm that this thesis is the result of my own work, except for those that have been appropriately cited and referenced.

E Feng Tan Loh

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Acknowledgements

To my supervisor, Dr. Ioannis Kountouris, many thanks for your invaluable support and guidance throughout my PhD study. Also to the CEP staff (a special mention to Shane Murphy) and my fellow PhD colleagues (especially those who shared the PhD room 1526 with me), thank you for your support and encouragement along the way.

I would also like to express my sincere gratitude to ICROA for making this research possible by providing financial support and assistance in data collection. A special mention to Sophy Greenhalgh, Laure Fievet and Andrea Abrahams for facilitating the first survey in this study, and Simon Henry and Fanny Guezennec for the second survey. Thank you all for the amazing opportunity for collaboration.

I am also very grateful to my husband, Jordan and my daughter, Ellie who arrived during my PhD, for going through this journey with me and for being patience with me. Also to my amazing friend, Rose for understanding what I was going through and cheering me on.

This thesis is dedicated to my mum, dad and sister for their unconditional love and support.

Abstract

Over the last decade, an increasing number of organisations are voluntarily offsetting their greenhouse gas (GHG) emissions through the voluntary carbon market (VCM). By investing in offset projects that deliver a range of co-benefits such as technology transfer, poverty alleviation and environmental conservation, voluntary carbon offsetting also helps promote sustainable development (SD). Proponents of the VCM often claim that the unregulated nature of the market, coupled with the unique motivations of its buyers provide it a greater capacity than the compliance Clean Development Mechanism (CDM) in promoting SD. However, these presumptions are yet to be empirical demonstrated. The purpose of this study is to assess the demand and supply of SD co-benefits in the VCM in order to challenge or validate these presumptions.

On the demand-side, stated preference (SP) survey results show substantial willingness-to-pay (WTP) exist among organisations for offset co-benefits, in the order of co-benefit verification, social co-benefit, economic co-benefit and environmental co-benefit. Furthermore, the WTP of organisations that are offset users are stable over a period of two and a half years (except for their WTP for environmental co-benefit, which has increased over the period). Significant WTP for offset co-benefits also exist among organisations that are offset non-users, thus promotion of offset co-benefits can encourage their future participation.

On the supply-side, based on a novel database of voluntary projects, this study found despite the VCM promotes a range of offset projects, it is at risk of being dominated by a few large-scale Land Use, Land Use Change and Forestry (LULUCF) projects. As SD contributions of LULUCF projects are uncertain, whether the VCM promotes SD remains inconclusive. This study also found the VCM is supporting a great number of pre-CDM projects, which undermines its capacity in mobilising further climate finance beyond compliance regimes to promote SD.

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Abbreviations

AAU	Assigned Amount Unit
ACR	American Carbon Registry
AFOLU	Agriculture, Forestry and Other Land Use
AIC	Akaike Information Criteria
AR	Afforestation and Reforestation
ARB	Air Resources Board
ASC	Alternate specific constant
AVC	Asymptotic variance covariance
BIC	Bayesian Information Criteria
CAR	Climate Action Reserve
CaT	Cap-and-Trade
CCBS	Climate Community and Biodiversity Standard
CCX	Chicago Carbon Exchange
CDM	Clean Development Mechanism
CDM EB	Clean Development Mechanism Executive Board
CE	Choice experiment
CERs	Certified Emission Reductions
CH_4	Methane
CL	Conditional logit
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSR	Corporate social responsibility
CVM	Contingent valuation method
DC	Dichotomous choice
DNA	Designated National Authority
DOE	Designated Operational Entity
EC	European Commission
ER	Emission reduction
ERPA	Emission Reduction Purchase Agreement
ERU	Emission Reduction Unit
ESMP	Ecosystem Marketplace
ETS	Emission trading scheme

EU ETS	European Union Emission Trading Scheme
EUA	European Union Allowance
FDI	Foreign Direct Investment
GHG	Greenhouse gas
GS	Gold Standard
HFCs	Hydrofluorocarbons
ICAO	International Civil Aviation Organisation
IIA	Independence of Irrelevant Alternatives
INDC	Intended Nationally Determined Contribution
IRR	Internal rate of return
ISO	International Organisation for Standardisation
ITL	International Transaction Log
JI	Joint Implementation
KP	Kyoto Protocol
LCL	Latent class logit
LDCs	Least Developed Countries
LoA	Letter of Approval
LULUF	Land Use, Land Use Change and Forestry
MAC	Marginal abatement cost
MCA	Multi-criteria analysis
MNL	Multinomial logit
MR	Monitoring report
MWU	Mann Whitney U-test
N_2O	Nitrous oxide
NDC	Nationally Determined Contribution
NF_3	Nitrogen trifluoride
NGO	Non-governmental organisation
NOAA	National Oceanic and Atmospheric Administration
OE	Open-ended
OTC	Over-the-counter
PC	Payment card
pCDM	Primary CDM
PDD	Project design document
PFCs	Perfluorocarbons

PIN	Project idea note
REDD	Reduced Emissions from Deforestation and Degradation
RP	Revealed preference
RPL	Random parameter logit
sCDM	Secondary CDM
SD	Sustainable development
SDG	Sustainable development goal
SF_6	Sulphur hexafluoride
SIDS	Small Island Developing State
SME	Small-to-medium sized enterprises
SO_2	Sulphur dioxide
SP	Stated preference
tCO2e	tonne of carbon dioxide equivalent
UN	United Nations
UNFCCC	UN Framework Convention on Climate Change
US	United States
VCM	Voluntary carbon market
VCS	Voluntary Carbon Standard
VCUs	Verified Carbon Units
WB	World Bank
WCD	Wold Commission on Dams
WTP	Willingness-to-pay

1 Introduction

1.1 Research premise

In the recent years, a growing public awareness of climate change issue has driven a number of individuals and organisations to voluntarily offset their private GHG emissions and contribute to climate mitigation. This is often done through purchase of voluntary offsets from the voluntary carbon market (VCM). Each offset represents one tonne of carbon dioxide equivalent (tCO_2e) emission reduction (ER). They are generated from projects that reduce or avoid greenhouse gas (GHG) emissions such as renewable energy, energy efficiency, GHG destruction projects, or projects that sequester carbon in the ground such as forest conservation, afforestation and reforestation projects. These projects, in addition to abating GHG emissions, also deliver a range of benefits to project host countries or local communities, including job creation, low-carbon technology transfer, enhanced local environment quality and biodiversity conservation. These positive externalities of offset projects are collectively known as the co-benefits of carbon markets. Through the generation of co-benefits, participation in voluntary offsetting not only contributes to climate mitigation at the global level but also helps promote sustainable development (SD) at the local level.

Studies on the potential of carbon markets in promoting SD exist, but they mainly focus on the compliance markets, namely the Clean Development Mechanism (CDM). The CDM is a flexible market-based mechanism set up under the Kyoto Protocol (KP) to enable the committed parties to meet their mandated ER target cost efficiently and help promote SD in developing countries (UN, 1998). However, studies have found the CDM fails to deliver its SD objective due to the inherent nature of offset projects that the market supports and the way that the market is governed. To ensure the integrity of KP, the CDM is highly regulated and has stringent project requirements in terms of demonstrating additionality and carbon accounting (Bumpus, 2011; Lovell, 2010; Lovell, Bulkeley & Liverman, 2009; Lohmann, 2009; Bumpus & Liverman, 2008). This has unintentionally resulted in lengthy bureaucratic process and high transaction cost that prohibit participations of small-scale community-based projects due to their lack of resources and economy of scale (Boyd et al., 2009; Ellis et al., 2007; Cosbey et al., 2005). In addition, although the mechanism is created with the twin objectives of enabling cost-efficient carbon abatement and promoting SD, only the carbon element is regulated at the KP level. The prerogative of letting CDM host countries to determine whether the project contribute to local SD has led to a *'race to the bottom'* as developing countries compete for CDM investments (Boyd et al., 2009; Sutter, 2003; Kolshus et al., 2001).

The CDM's failure to promote SD is often in reference to the project types and locations that the market supports. In particularly, the CDM has been criticised for financing industrial gas projects that

deliver large volume of cheap ERs but have very limited SD co-benefits (Schneider, 2007; Ellis et al., 2007; Davies, 2007; Cosbey et al., 2005). Industrial gas projects such as destruction of hydroflourocarbons in refrigerant manufacturing facilities and destruction of nitrous oxdie from adipic or nitric acid productions are very cheap to implement as they only involve minor adjustment to the existing process. However, they generate large quantity of offsets due to the high global warming potential of these GHGs. As the result, these projects are very cost effective but they deliver meagre co-benefits to local comunities (Alexeew et al., 2010; Olsen & Fenhann, 2008; Ellis et al., 2007; Sutter & Parreño, 2007; Schneider, 2007; Olsen, 2007). In addition, most CDM projects are hosted in large emerging economies such as China, India and Brazil that are already attracting considerable foreign direct investment (FDI), whilst African region that is most in need of carbon finance has largely been sidelined (Ellis et al., 2007). The uneven distribution of CDM finance is due to the lack of favourable investment conditions and institutional capacity in approving CDM projects in most African countries and Least Developed Countries (LDCs) (Ellis et al., 2007; Cosbey et al., 2005). The tension between abating GHG emissions and promoting SD is evident in the CDM (*ibid*). As only the carbon element is monetised in the market, it is expected that the market will prioritise ER delivery over promoting SD (Olsen, 2007). After revieiwing over 200 studies on the SD aspect of the CDM, Olsen (2007) concluded that if '*left to markget forces, the CDM does not signficiantly contribute to sustainable development*' (p.59).

In contrast to the CDM, the VCM has received very limited academic attention. Like the CDM, the VCM is also designed to enable cost-efficient GHG mitigation. However, the VCM places greater attention on offset co-benefits (Lovell, 2010). Grey literature have claimed that the market's unique conditions and demand drivers provide it greater capacity than the CDM to promote SD (Peters-Stanley et al., 2013; Harris, 2007; Taiyad, 2005). The unregulated nature of the VCM sidesteps complex bureaucratic process and provides it the flexibility to support small-scale community-based projects that have pro-poor quality (Benessaiah, 2012; Corbera, Estrada & Brown, 2009; Harris, 2007; Taiyad, 2005). More importantly, as a demand-driven market, offset co-benefits play an important role in promoting uptake of voluntary offsets (Lovell, Bulkeley & Liverman, 2009). Voluntary offsets are a novel and complex environmental good due to its intangibility and lack of direct benefits to its consumers (*ibid*). Therefore, the materiality of carbon offsets is mostly realised through the narrative of offset production that connects offset buyers to the beneficiaries of their contributions (Lovell & Liverman, 2010; Lovell, Bulkeley & Liverman, 2009). Empirical studies have found offset co-benefits can increase individuals' willingness-to-pay (WTP) for offsets (Blasch & Farsi, 2014; MacKerron et al., 2009). From organisations' perspective, purchasing offsets that also deliver co-benefits such as poverty alleviation and biodiversity conservation can portray them as charitable,

help engage their stakeholders and maximise their corporate social responsibility (CSR) impacts (Lovell & Liverman, 2010; Taiyad, 2005). Market reports indicate that demand exists among voluntary buyers for offsets that are generated from clean stove and water filtration dissemination projects and forestry projects that are certified by sustainability standards such as Gold Standard (GS) and Climate Community and Biodiversity Standard (CCBS) (Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013).

The main premise of this thesis says that theory and anecdotal evidence indicate that the VCM has greater potential to promote SD than the CDM, especially in countries where carbon finance is most needed, such as African countries and LDCs. However, this presumption is yet to be empirically demonstrated. The purpose of this study is to generate empirical data to validate or challenge the two main theoretical propositions put forward in existing literature: (1) the VCM has greater support for offset projects with SD co-benefits than the CDM, (2) demand and WTP exist among voluntary buyers for offset co-benefits. Therefore, this study assesses the market's promotion of SD from both supply- and demand-side. Findings from this study can provide valuable insights on the risks and opportunities the VCM have in promoting SD, which in turn can be used to inform the market on how to address any potential issues and maximise its potential to promote SD. Lessons learnt from the VCM can also inform the development of compliance offset mechanisms in the post-Paris climate regime in order to achieve both climate change mitigation and permanent transition to SD pathway.

1.2 Research questions

The main research question this thesis poses is: *"Does voluntary carbon offsetting contribute to sustainable development?"* To guide this study, further research sub-questions are developed under four explicit objectives as detailed in Table 1-1.

Table 1-1: Research objectives and research questions

Objective	**Research sub-questions**
1. To create an understanding of how offset markets can help promote SD.	1.1. What are carbon offsets and how are they created? 1.2. How do offset projects contribute to local SD? 1.3. What are the factors that lead to CDM's failure to promote SD? 1.4. Why the VCM is better positioned than the CDM in promoting SD?

Objective	Research sub-questions
2. To establish demand for voluntary offsets and offset co-benefits among organisations.	2.1. Why do organisations participate in voluntary offsetting? 2.2. What are organisations' demand and WTP for offset and offset co-benefits? 2.3. Are their demand and WTP for offset co-benefits stable over time?
3. To examine offset projects that the VCM supports.	3.1. Which project types and locations does the VCM promote? 3.2. Do the VCM and CDM support different project types and locations? 3.3. Does the VCM perform better than the CDM in promoting SD?
4. To generate policy and marketing recommendations.	4.1. How to promote organisations' participation in voluntary offsetting? 4.2. What are the implications for future international climate policies that involve offsetting mechanism?

In addition to the main objectives mentioned in Table 1-1, this study also explores some methodological issues associated with SP methods, in particularly the application of SP techniques on organisations, a comparison of different preference estimation models for analysing CE data and a comparison of CE and CVM results.

1.3 Research methods

Literature review

An extensive search of existing literature on the areas identified as relevant to the present research was undertaken. Key words used for literature search include carbon markets, voluntary carbon market, voluntary carbon offsetting, Clean Development Mechanism/CDM, sustainable development, offset co-benefits and willingness-to-pay for voluntary offset. Literature review is used for the following purposes (Hart, 1998):

- To establish context for the research topic

Literature review is used to build an understanding of the theories underlying carbon markets and more specifically, the offsetting mechanism, as well as the role of the VCM within the wider context of global carbon markets. This study also relies on grey literature, namely the World Bank (WB)'s annual report on the state and trends of the carbon market[1] and the Ecosystem Marketplace (ESMP)'s annual report on the state of the VCM[2], to develop a picture of how the compliance and voluntary markets have evolved over the years.

- To address some of the research questions

Research questions posed under the first research objective (research sub-questions 1.1 to 1.3) are addressed through critical review of existing literature. In particularly, existing studies on the SD contribution of carbon markets are analysed to explore the synergies and trade-offs between GHG mitigation and SD contributions.

- To help formulate research questions

Literature review helps identify gaps in existing literature and subsequently inform the formulation of research questions (under objectives 2 to 4) that are being investigated in the primary research of this study.

- To inform on the methods used for this study

Finally, literature review enables identification of methods appropriate for this study, as well as provides ideas on how to implement the chosen methods.

Empirical methods

In this study, stated preference (SP) methods, including choice experiment (CE) and contingent valuation method (CVM) are used to elicit organisations' preference for voluntary offsets and offset co-benefits. SP studies use survey techniques to directly elicit respondents' demand and WTP for the good in question. They are commonly used to evaluate non-marketed environmental or public

[1] Between 2003 and 2012, WB had published annual reports on the state and trend of the carbon market. However, WB stopped the report series in 2013 as the CDM market stalled. In the following year, WB launched another report series called the State and Trend of Carbon Pricing that covers international and national carbon markets and taxation, which runs until now. The reports can be accessed through: http://www.worldbank.org/en/research

[2] ESMP is a not-for-profit organisation that provides information about markets and payment schemes for ecosystem services. Since 2007, ESMP has initiated a report series called the State of the Voluntary Carbon Markets. Information about the VCM are obtained by ESMP through surveys of market actors, including project developers, aggregators, brokers and retailers across the world. Each year, the report reflects on the market state and trend in the previous year. The report series can be accessed through: http://www.ecosystemmarketplace.com/publications/

goods. Further discussions about SP methods and why they are chosen for this study are presented at the beginning of Chapter 5.

Over the course of this study, two SP surveys were undertaken. The first survey took place at the beginning of 2014 and only included organisations that are purchasing voluntary offsets (referred as offset users hereafter). The aim of the first survey is to generate empirical data to assess demand and WTP for offset co-benefits among offset users. The second survey was carried out towards the end of 2016 and the survey was extended to include organisations that are not purchasing offsets (referred as offset non-users hereafter). The purpose of the second survey is to examine the underlying determinants of organisations' participation in voluntary offsetting, as well as their preferences and WTP for voluntary offset and offset co-benefits. The preferences and WTP measures of offset users and non-users are also being compared to assess if they are significantly different. CE results of offset users from Survey 1 and 2 are also compared to assess temporal stability of offset users' demand and WTP for offset co-benefits.

To assess the extent of the VCM in promoting SD, I develop a novel database of voluntary offset projects to assess the project types and locations that the VCM promotes. The voluntary project portfolio is then compared to the CDM project portfolio to investigate the theoretical proposition that the VCM is promoting offset projects that have limited presence in the CDM, in particularly small-scale community-based projects that are commonly associated with a range of sustainability co-benefits and projects in Africa and LDCs.

1.4 Novel contributions

This study makes a number of contributions to existing literature. Firstly, this is the first study to analyse and synthesise all the factors that affect carbon markets' contributions to SD. Existing studies that evaluate carbon markets' contributions to SD generally fall into two groups. The first group consists of theoretical studies that discuss SD contributions of carbon markets from the governance perspective, in particularly the ER commodification process that results in a disconnection between the fully fungible carbon offsets that are traded at the international level and the local socioeconomic context that generates the ERs (Bumpus, 2011; Lovell, 2010; Lovell, Bulkeley & Liverman, 2009; Bumpus & Liverman, 2008). The second group of studies are empirical studies that assess SD contributions of CDM projects using desk-based multi-criteria analysis (MCA) (Drupp, 2011; Alexeew et al., 2010; Nussbaumer, 2009; Olsen & Fenhann, 2008; Sutter & Parreño, 2007). Most of these studies found project typology is a strong determinant that influences CDM's ability to promote SD. The present study collates findings from existing literature to provide an overview of all the factors at project- and market-level that affect carbon market's contributions to SD.

Secondly, this is the first study to explore the demand for voluntary offsets and offset co-benefits from organisations, which encompass private businesses, public sector and not-for-profit organisations. Existing studies on the consumption of voluntary offsets mostly focus on individuals and there is an obvious gap in the literature in terms of understanding organisations' offsetting behaviour. Considering corporate buyers are responsible for over 95% of the transacted volume in the VCM (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015), there is a need to understand the demand drivers of this buyer group. As the VCM is mainly driven by its consumers' demand, willingness to support and pay more for voluntary offset with co-benefits can drive the market to invest in offset projects that promote local SD.

In a broader sense, this study also contributes to the understanding of organisations as consumers of green products, which is lacking in existing literature (Lovell, Bulkeley & Liverman, 2009). Existing literature on the consumption of green or ethical products have mainly focused on individual and household level, such as purchase of organic or fairtrade products, energy efficient appliances, eco-labelled furniture, as well as voluntary carbon offsets. In contrary to existing studies, the present study provides some insights into organisations' engagement in environmentalism and their underlying motivations, using voluntary offsetting as the case study. This study is also one of the very few studies that use SP methods to elicit organisations' demand for environmental good. Most existing SP studies are applied on individual or household consumers. So far, I have only found one other SP study on organisations. The study is by Parnphumeesup & Kerr (2015) who used CVM to elicit Kyoto compliance buyers' WTP a premium price for GS certified compliance offsets. Thus, this study provides an opportunity to explore the advantages and limitations of using SP methods on organisations to elicit their demand for public and environmental goods.

Thirdly, this is the first study to examine the theoretical proposition that the VCM is promoting offset projects with sustainability co-benefits using offset generation data. It is commonly assumed that the VCM's less stringent project requirements allow the market to support community-based projects that deliver a range of SD co-benefits (Hamilton et al., 2007; Harris, 2007; Taiyad, 2006). However, empirical studies that substantiate such a claim are almost non-existent. Corbera, Estrada & Brown (2009) who compared voluntary projects with CDM projects found both markets promote similar project types and locations. However, their comparison was based on offset generation data for the CDM and offset transaction data for the VCM. Offset transaction data does not provide a true picture of the types of projects that the market support as once an offset is generated, it can be transacted multiple times until it is retired. Through the development of a novel voluntary project database, this study is able to make like-to-like comparison of the VCM and CDM based on offset generation data for both markets.

Finally, this study also contributes to the wider debates on the linkage between climate change and SD. Only until recently, efforts to curb climate change and promote SD have been separate discourses (Olsen, 2007). SD was first popularised by the Brundtland Commission in 1987 that defines the term as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p.41). Since then, other definitions of SD or sustainability have emerged as various parties interpret the concept based on their own interests or needs (Dryzek, 2013). It is widely recognised that sustainability is a difficult concept or idea to define, especially in a way that is sufficiently practical to be operationalised (Pope et al., 2004).

In 2015, facing the increasing tension between human development and environmental degradation, the UN has set up the 2030 Agenda for Sustainable Development that consists of a series of Sustainable Development Goals (SDGs) and targets to guide and stimulate actions towards achieving SD (UN, n.d.). The 17 SDGs and 169 targets cover a range of socio-economic and environmental issues, including poverty, inequality, health and environment. Climate action has also been included as one of the SDGs, which is linked to the Paris Agreement on climate change. This represents a significant step in recognising the linkage between SD and climate change.

The synergy between reducing anthropogenic GHG emissions and achieving SDGs are increasingly being recognised in the VCM. Many offset projects financed by the market can contribute to SDGs. For example, clean stove dissemination projects can reduce household reliance on traditional fuels (SDG 7) and improve indoor air quality (SDG 3), whilst forestry projects that involve local capacity building in sustainable farming practices and skills to generate alternative incomes can alleviate poverty (SDG1), improve food security (SDG2) and protect local forests (SDG15). GS recently launched their new standard - Gold Standard for the Global Goals (GS4GG), which requires offset projects to demonstrate their contributions to at least three SDGs (SDG13 Climate action plus two others). By assessing VCM's contributions to SD, this study sheds some light on the potential of voluntary contributions to promote SD.

1.5 Thesis structure

This thesis starts with an outline of concepts and background of carbon markets in Chapter 2. The chapter then discusses in detail the development and mechanics of the VCM, as well as its role within global carbon markets. It also touches on the criticisms surrounding voluntary carbon offsetting.

Chapter 3 presents the critical literature review that addresses research sub-questions 1.1 to 1.4. The chapter first explains how GHG ERs that are generated from a diverse range of project activities

are commoditised and turned into offsets that can be traded in international carbon markets. Then, the chapter systematically presents and discusses the various factors, both at project- and market-level that lead to the failure of CDM in delivering its SD objective. These factors that restrict CDM's contribution to SD are translated into opportunities that the VCM offers to promote SD.

Chapter 4 explores who are the consumers of voluntary offsets and what are their motivations for voluntary offsetting. It starts with an overview of different types of buyers, follows by a review of existing theoretical and empirical studies on voluntary carbon offsetting. Finally, the chapter focuses specifically on organisations as consumers of voluntary offsets and the relevance of offset co-benefits in the context of their motivations. This chapter addresses research sub-question 2.1 and 2.2 from the theoretical perspectives.

Chapter 5 describes the SP methods used in this study, namely CE method and CVM. It starts with a general introduction of the methods and justification for using these methods in the present study. Then the chapter discusses in detail the specific design of CE and CVM used in this study. Finally, the chapter also presents the methods for analysing CE and CVM data.

Chapter 6 presents the first SP survey undertook in this study. The survey mainly focuses on offset users and their WTP for offset co-benefits. The chapter first describes the survey questionnaire design and administration. Then, it presents and discusses the survey results in detail. Findings from this chapter addresses research sub-question 2.2.

The second SP survey is discussed in Chapter 7 and 8. The second SP survey was extended to include both offset users and non-users to examine organisations' demand for voluntary offset and offset co-benefits. Chapter 7 describes the survey questionnaire and administration. Then, it examines organisations' participation in voluntary offsetting on two levels: (1) propensity to offset and (2) WTP amount per offset. Findings from this chapter inform research sub-question 2.1.

Chapter 8 presents the CE results from Survey 2. The chapter first reports the joint CE results of offset users and non-users. Then, the CE results of offset users and non-users are analysed independently and compared on three levels: choice pattern, equality of preference parameters and equality of WTP measures, to assess if their demand for offset and offset co-benefits are significantly different. Findings from this chapter contribute to addressing research sub-question 2.2.

To establish if offset users' preference and WTP for offset co-benefits are stable through time, CE results of offset users from the first and second survey are being compared in Chapter 9. Again, the comparisons are made on three levels: choice patter, equality of preference parameters and equality of WTP measures. Analysis in this chapter addresses research sub-question 2.3 specifically.

Chapter 10 provides a quantitative analysis of offset projects that the VCM promotes. The chapter starts with a description of how the voluntary project database is developed. Then, it presents the descriptive statistics of voluntary projects in terms of number of projects and volume of ER generation. A comparative analysis is presented to assess if the VCM and CDM promote similar or different project types and locations. This chapter primarily addresses research sub-questions 3.1 to 3.3.

Finally, the thesis concludes in Chapter 11 by summarising the key findings under each research sub-questions. A set of recommendations are provided to address research question 4.1 and 4.2, based on findings from this study.

2 The voluntary carbon market

In carbon markets, buyers and sellers trade property rights for GHG emissions known as carbon credits[3]. There are two main types of carbon market, the regulated or compliance market and the voluntary market. In the compliance market, market participants trade carbon credits to meet their mandated GHG ER target, whilst the VCM covers all other transactions that are not for compliance purpose. To provide background to this study, I present in this chapter the theoretical basis underpinning emission trading schemes (ETSs) and the role of offsetting within an ETS, follows by the state and trend of global carbon markets. Then I discuss in more in-depth the offset market, which is a subset of carbon market, in both compliance and voluntary settings.

2.1 Carbon markets: Theory and background

2.1.1 Economic background

Climate change is an environmental cost associated with both externality and public good (Stern, 2007). Climate change is a negative externality because the private entity that emits GHGs and contributes to climate change does not directly bear the cost of climate change, therefore the entity has little or no incentive to reduce emissions. At the same time, one's effort to reduce GHGs is subject to free-riding as the benefit of climate change mitigation is non-excludable and non-rivalrous. As the result, contributions to climate mitigation are likely to be underproduced.

To further complicate the issue, climate change is an externality and public bad at the global level. Currently, almost all consumptive activities emit GHGs, from water to energy use, from food production to waste generation, from transport to land use. As the result, almost all humans on earth contribute to climate change. However, contributions to anthropogenic climate change are uneven across the world and this raises equality issue as climate change is transboundary irrespective of where GHG emissions take place. Whilst the rich developed nations are responsible for most of the GHGs accumulated in the atmosphere, poor communities in developing nations that emit considerably less GHGs are expected to be the most susceptible to climate change impacts (Stern, 2007). Climate change impacts not only span across space but also across time, resulting not only intra-generation inequality but also inter-generation inequality as future generations are more likely to bear the consequences of climate change (*ibid*).

As climate change awareness increases, governments around the world face growing domestic and international pressure to reduce their national GHG emissions. Many nations have started regulating

[3] In this study, the term carbon credit encompasses permits or allowances that are issued in a cap-and-trade system (which represent rights to pollute) as well as offsets that are generated from GHG emission reduction projects. Therefore, offsets can be considered as a sub-set of carbon credits.

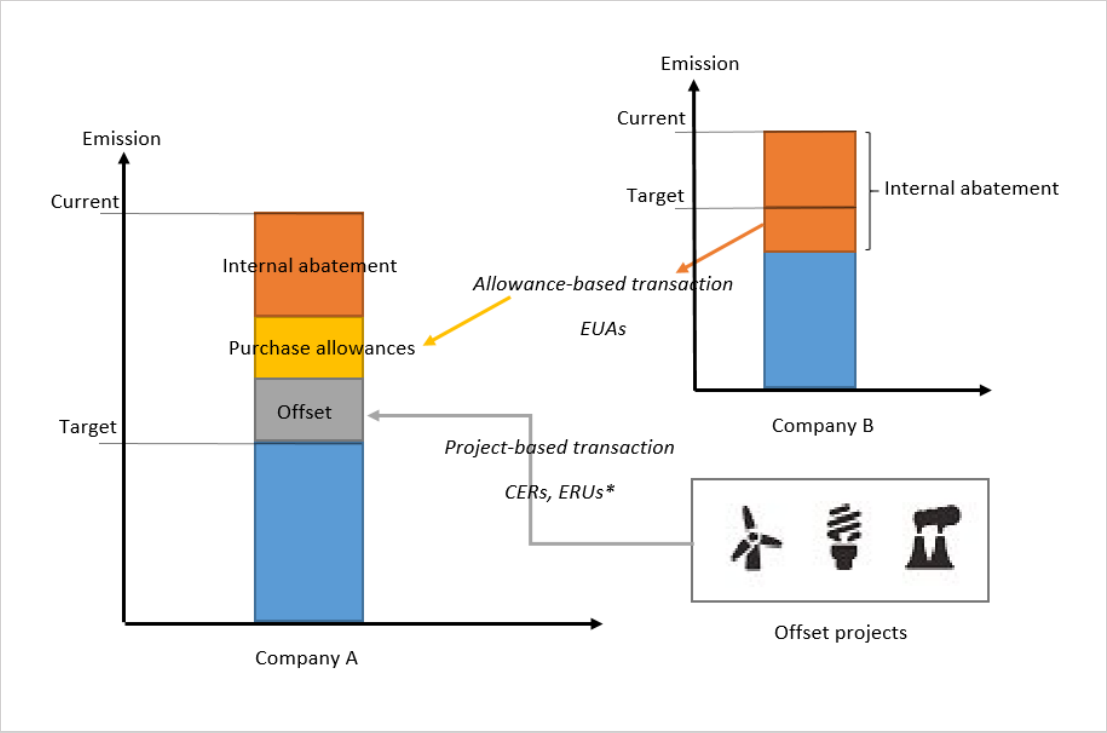
their GHG emissions. According to Zechter et al. (2017), around 8 Giga tCO_2 which corresponds to 15% of global GHG emissions are regulated under market-based instruments. Around 70% of them are covered under ETSs whilst the remaining 30% are regulated under carbon taxes (Kossoy et al., 2015). From an economist's point of view, market-based approaches to regulating environmental pollution are more cost-effective than the traditional command-and control policies. Carbon tax is a form of Pigouvian tax that uses financial penalty to internalise negative externality and correct market failure. The ETS, also known as the cap-and-trade (CaT) system is based on Coase theorem that involves assigning and trading of property rights to externality. Under taxation, the regulator sets the price level per unit of pollutant and the market determines the pollution level, whilst under ETS, the regulator caps the total quantity of pollution allowed and the market determines the price per unit of pollutant (Parson & Kravitz, 2013). Therefore, taxation is a price instrument whilst ETS is a quantity instrument (*ibid*). Nevertheless, both instruments rely on the efficiency of market to ensure abatement is undertaken where it is cheapest (Smith, 2011). Therefore, if the tax rate or cap level is set right, both systems are expected to yield socially optimal level of pollution at the minimal aggregate cost (Parson & Kravitz, 2013).

In an ETS, based on the cap set for the scheme, a limited number of permits or allowances are allocated among the scheme participants either through free allocation (also known as "grandfathering") or auction (Kill et al., 2010). As the cap level is usually below the business-as-usual level, this creates scarcity and by allowing polluters to trade the permits among themselves, theoretically market power ensures abatements take place where cheapest. The cost of achieving the scheme's overall cap can be further reduced by allowing polluters to use cheaper abatement options that are available beyond the ETS through offsets (Conte & Kotchen, 2010). Offsets are reductions from unregulated sources (Broekhoff & Zyla, 2008). The use of offsets essentially extends the sceheme's overall pollution cap (Lohmann, 2009). Offsetting is relevant for GHG ETS because GHGs are mixed throughout the global atmosphere, therefore it does not matter where ERs take place as long as there is an overall net decrease in GHG emissions.

As the result, transactions in carbon markets can be differentiated into allowance-based and project based (MacKenzie, 2009), which are also known as "credit" and "offset" systems (Parson & Kravitz, 2013). Allowance-based transactions are trading of permits distributed within an ETS, whilst project-based transactions are trading of offsets that are ERs generated beyond the ETS. For example, the UK power sector is regulated under the KP. A UK based power utility can meet its mandatory ER target through internal abatement, purchase of allowances from the European Union Emission

Trading Scheme (EU ETS)[4], or purchase of offsets created under the CDM and Joint Implementation (JI)[5] as illustrated in Figure 2-1. The UK government also introduces a carbon price floor, which is the minimum carbon price power producers have to pay when the market price of carbon falls below the price floor (HM Revenue & Customs, 2015). The carbon price floor effectively acts as a carbon tax that provides a degree of price certainty to ensure long-term investment in domestic GHG abatements. All these measures essentially put a price on carbon to internalise externality and leverage investment into low-carbon technology to decarbonise economy.

Figure 2-1: An illustration of how organisations meet their compliance target under the EU ETS



Source: Author's own. * Certified Emission Reductions (CERs) are offsets generated from CDM projects whilst Emission Reduction Units (ERUs) are from JI projects.

2.1.2 Global carbon markets

To-date, around 42 countries and 25 cities, states and regions have put a price on carbon (Zechter et al., 2017). The combined value of ETSs and carbon taxes around the world is estimated at US$52

[4] EU ETS is a trading scheme set up to allow installations in the EU that are regulated under the KP to trade their emission allowances called the EU Allowances (EUAs).

[5] Both the CDM and JI are project-based offsetting mechanisms set up under the KP to allow regulated parties to meet their emission reduction target cost effectively (UNFCCC, 2014). The CDM are offset projects that take place in non-Annex I or developing countries whilst the JI are offset projects that take place in Annex-I or developed countries (including European economies in transition). JI is designed to transfer excess emission allowances allocated to Eastern European countries such as Russia and Ukraine to Western Europe (Parson & Kravitz, 2013).

billion (*ibid*). The Kyoto market remains the most prominent carbon emission market to-date. The KP is an instrument under the United Nations Framework Convention on Climate Change (UNFCCC) that was signed at the Rio Earth Summit in 1992 as the result of the recognition that human-induced climate change is a global phenomenon and therefore global efforts are required to avoid the devastating effects of climate change. The aim of the Climate Convention is to achieve "*stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*" (UN, 1992: p.4). Agreed in 1997, the KP stipulates binding ER targets for Annex-I industrialised countries. In the first commitment period of 2008 to 2012, participating countries were required to meet an aggregate reduction of at least 5% relative to the 1990 base year (UN, 1998). Majority of industrialised countries ratified to the KP except the United States (US) and Australia. Canada withdrew from the KP in 2011 (BBC, 2011).

The 2012 Doha Amendment outlines the second commitment period of the KP (2013-2020) to bridge the end of the 1st KP period and the start of Paris Agreement that sets out a new global climate deal. In the 2nd KP period, committing parties have to reduce at least 18% below 1990 level (UNFCCC, n.d.c). Australia (that did not join the 1st KP period), together with the EU and other European countries have committed to the 2nd KP period whilst Japan, New Zealand and Russia that participated in the 1st KP period have not renewed their commitments for the second period (*ibid*).

During the negotiations leading up to the 1997 KP, the US heavily campaigned for flexible market-based mechanisms following the success of its domestic sulphur dioxide (SO_2) trading market[6] (MacKenzie, 2009). Both the United States and Brazil also pushed for the inclusion of developing countries in the international climate regime through carbon trading (Liverman, 2010). As the result, three flexible mechanisms have been set up under the KP: International Emission Trading[7], CDM and JI to allow the committed parties to meet their target cost effectively (UNFCCC, 2014).

Within the EU, an ETS has been set up to help regulated entities in the EU to meet their ER target cost efficiently. The EU ETS includes more than 11,000 installations across 31 countries and flights between airports of participating countries, covering around 2 Giga tCO_2, which corresponds to 50% of EU's GHG emissions (EC, 2015). Installations within the EU ETS are allowed to use CERs and ERUs to meet their compliance targets (as previously illustrated in Figure 2-1). So far, EU ETS installations

[6] The landmark US SO_2 Programme marks the start of the expansion of emission markets for pollution control (Parson & Kravitz, 2013). The market-based mechanism has been widely regarded as successful in reducing sulphur dioxide emissions from power stations in the US (MacKenzie, 2009).

[7] International Emission Trading allows Annex I countries to trade their allocated emission allowances known as Assigned Amount Units (AAUs) among themselves.

have used 1.5 Giga tCO_2 of CERs and ERUs to meet their compliance target, around 90% of the total 1.6 Giga tCO_2 allowed under the system between 2008 and 2020 (Zechter et al., 2016).

In contrast to Europe, participation of North America in international climate regime has been limited. In the most recent development, the US federal government intends to withdraw from the Paris Agreement (U.S. Department of State, 2017). Nevertheless, a number of states in North America have taken the initiative to implement their own regional CaT programmes. Nine Northeastern and Mid-Atlantic states in the US have come together to form the Regional Greenhouse Gas Initiative (RGGI), the first mandatory CaT programme in the US to regulate carbon emissions from power sector (Kossoy et al., 2015). California has also implemented its compliance CaT since 2012, which is linked with Quebec CaT in the following year and Ontario is due to join in 2018 (Zechter et al., 2017). Following the agreement to adopt the Pan-Canadian Framework on Clean Growth and Climate Change that requires all provinces to implement carbon price initiative by 2018 (Government of Canada, 2017), more ETSs are likely to emerge in Canada in the near future.

Implementation of ETS is also gaining momentum in developing countries. China has launched pilot ETSs in eight provinces and is aiming to move to a national programme. When the Chinese national ETS is implemented, it will surpass the EU ETS to become the world largest carbon market (Zechter et al., 2017). South Korea has also launched its national ETS in 2015 (Kossoy et al., 2015) and other developing countries that are in the process of launching ETS include Kazakhstan, Vietnam, Mexico and Columbia[8].

Beyond governmental initiatives, the International Civil Aviation Organisation (ICAO) has adopted Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) that aims to cap GHG emissions from international aviation at 2020 levels (Zechter et al., 2017). 72 countries that cover almost 90% of international aviation activity have indicated their intention to voluntary participate in the market-based scheme (ICAO, n.d.). Similar efforts have also been made by the International Maritime Organisation for the shipping sector (Zechter et al., 2017).

2.1.3 The Clean Development Mechanism

Almost all compliance markets allow participants to meet their targets using offsets to a certain extent. For example, RGGI allows regulated power plants to use offsets that are generated within the nine participating states to meet 3.3% of their targets (RGGI, n.d.), whilst participants of the South Korea ETS can use CERs that are generated domestically for up to 10% of their compliance

[8] For a comprehensive review of compliance ETS implemented or to be implemented around the world, see State and Trends of Carbon Pricing 2017 jointly prepared by the WB, Ecofys & Vivid Economics, which is available at: https://openknowledge.worldbank.org/handle/10986/28510

obligation (Kossoy et al., 2015). Nevertheless, the CDM set up under the KP remains the largest compliance based offsetting mechanism with 1.9 billion CERs issued to-date (UNFCCC, 2018).

The unequal distribution of abatement potential and cost across the world means that ERs that take place in developing countries are often less costly than in developed countries (Bumpus & Liverman, 2008). Recognising this, Article 12 of the KP allows compliance entities to use ERs generated from developing countries through the CDM to meet their target (UN, 1998). It is the first international law that generates environmental commodity through market mechanisms (Bumpus & Liverman, 2008). The CDM provides a channel for the transfer of international finance and technology from rich developed countries that have the technology to abate GHG emissions but exhausted of most low-cost abatement options to low-income developing countries that have the potential to develop in a low-carbon pathway but lack the resources to do so. Therefore, the mechanism not only enables cost efficient climate mitigation, but also helps catalyse transition to low-carbon development pathway among developing countries. Indeed, the CDM is set up with twin objectives of helping non-Annex I[9] (developing) countries to achieve SD and helping Annex I (developed) countries to abate their GHG emissions cost efficiently (UN, 1998).

The CDM also enables non-Annex I countries' involvement in the global efforts of reducing GHGs. Although these countries do not have mandatory ER target and therefore have no incentive to reduce their GHG emissions, they have an interest in pursuing the CDM to attract new FDI and technology transfer that contribute to local development (Chadwick, 2006). The CDM also provides developing countries the opportunities for climate related capacity building, including setting up the relevant institutions such as the Designated National Authority (DNA)[10] and training of various actors in both public and private sectors on the technical and economic aspects of climate mitigation and adaptation options (Ellis et al., 2007).

Development of carbon offset projects under the CDM started as early as 2000, mostly were funded by governments and public-private partnerships such as WB's Prototype Carbon Fund (Lecocq & Capoor, 2003). Figure 2-2 illustrates the trading volume and value in primary and secondary CDM (pCDM and sCDM respectively) markets between 2005 and 2011. When the EU ETS was launched in 2005, it sent a strong demand signal to the CER market. Thus, the pCDM market started to grow steadily. However, the market growth was constrained by the complexity and inefficiency of CDM

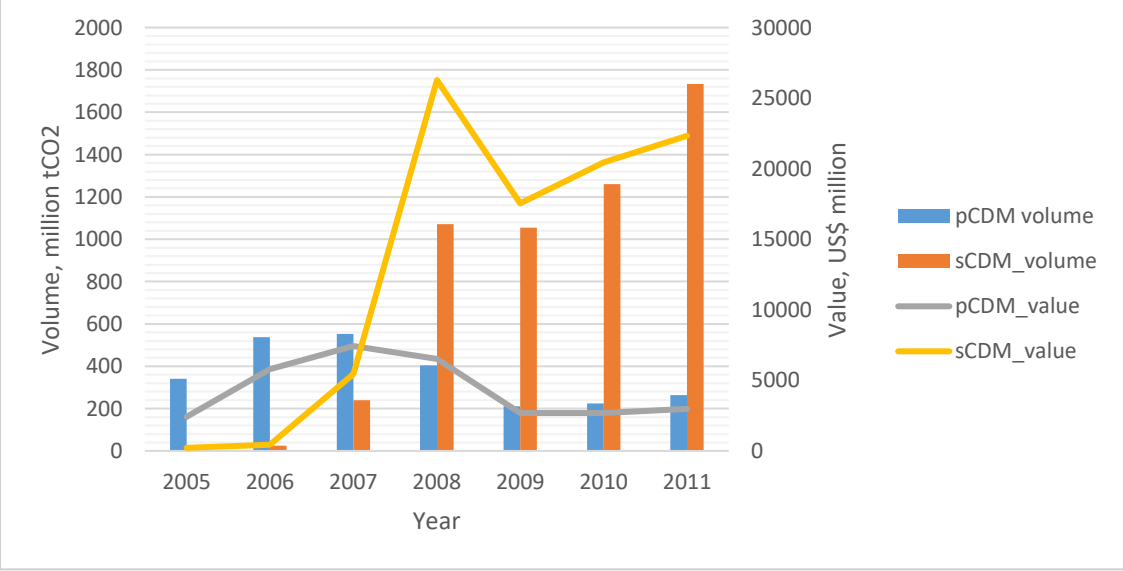
[9] For the lists of Annex I and non-Annex I Parties to the Convention, refer to UNFCCC's websites. For Annex I countries: http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php and for non-Annex I countries: http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php.

[10] DNA is the organisation set up by the CDM host country to approve projects based on their contribution to local SD.

regulatory procedure with projects taking an average of one to two years to be approved by the CDM Executive Board (EB)[11] (Capoor & Ambrosi, 2008). Starting from late 2008, demands for Kyoto carbon credits started to fall sharply due to global recession (Capoor & Ambrosi, 2009). The impacts of recession on the pCDM market were double-fold (Kossoy & Ambrosi, 2010). First, slowing economic activities and the resultant lower emissions led to oversupply of Kyoto carbon credits and diminishing demand for new CERs. Second, investors became more cautious and moved towards safer assets, thus CDM project developers struggled to obtain financial closure for their projects. CDM project origination has remained limited since 2009.

CERs started to enter the secondary market in 2006. The sCER market experienced drastic increase in trading volume and value between 2007 and 2008, in contrast to pCDM market that started to decline in the same year. The trading volume in sCER continued to grow as hedging, profit-taking, and arbitrage were driving the market (Capoor & Ambrosi, 2009). However, the market value has shrunk after 2008 as CERs lose value. In 2016, the average sCER price traded is €0.4 (Zechter et al., 2017), as compared to €24 during the height of the CDM market in 2008 (Hamrick, Goldstein & Peters-Stanley, 2015).

Figure 2-2: CER year-on-year traded volume and value



Data Source: WB report series on the State and Trends of the Carbon Market (Kossoy & Guigon, 2012; Kossoy & Ambrosi, 2010; Capoor & Ambrosi, 2009; Capoor & Ambrosi, 2008; Capoor & Ambrosi, 2007)

Since 2012, the CDM market activity has reduced considerably and WB has stopped tracking and publishing data on the market. The downward trend of CDM market post-2012 is attributed to the

[11] CDM EB is a body set up under the UNFCCC to administer the CDM.

oversupply of carbon credits in Kyoto markets (Kossoy & Ambrosi, 2010) and the lack of political commitment for the 2nd KP period (Linacre, Kossoy & Ambrosi, 2011). Based on the registered CDM projects to-date, CERs are likely to be oversupplied until 2020 (Kossoy et al., 2015). In addition, the EU ETS, the biggest buyer of CERs, is restricting its members' use of CERs for meeting their compliance target. For example, during the third phase of EU ETS that runs from 2013 to 2020, CERs from projects that are registered after 2012 are not being accepted unless they are generated from LDCs (EC, 2015). Despite Paris Agreement has revived global commitments to reduce GHG emissions, the fate of CDM in the new climate regime remains uncertain. The EU has indicated in its Intended Nationally Determined Contribution (INDC)[12] that they will not be using international credits such as CERs post 2020 (Kossoy et al., 2015). As the CDM is at risk of losing its largest buyer, the market turns to new prospects for CER demand, including national trading schemes (e.g. Colombia, South Korea, Mexico and South Africa), CORSIA and the VCM (Zechter et al., 2017). Nevertheless, demands from these sources are expected to be small and in recent years, market participants continue to exit the CDM market (Kossoy et al., 2015).

2.2 Development of the voluntary carbon market

2.2.1 State and trends

The world's first voluntary carbon offset transaction took place in 1989 when Applied Energy Services, an American electricity company paid US$2 million to farmers in Guatemala to plant 50 million pine and eucalyptus trees to compensate for the GHGs emitted from its proposed coal-fired power plant (Galatowitsch, 2009). However, the market remained small and unknown to the public until 2005, spurred by the emergence of Kyoto markets and growing public climate awareness, the market began to expand drastically in the following decade. Like the compliance market, transactions in the VCM can be in the form of allowance- and project-based. However, with the closure of Chicago Carbon Exchange (CCX)[13], the VCM now operates almost entirely on over-the-counter (OTC) transactions. OTC transactions, also known as the retail market allows individuals and organisations to participate in offsetting as a way to abate their private emissions on a voluntary

[12] According to Article 4 of the Paris Agreement, each Party shall prepare nationally determined contributions (NDCs) that outline its contributions to achieve the long-term temperature goal set out in the agreement and how it intends to achieve such contributions (UN, 2015). Intended Nationally Determined Contributions (INDCs) become NDCs after parties ratify the Paris Agreement.

[13] CCX was a major component of the VCM until its closure in 2010. It was a membership-based CaT system. Members that joined voluntarily had to commit to its legally binding reduction target. Majority of the credits traded were allowances issued based on the member's baseline emissions but members were also allowed to use CCX issued offsets to meet their targets (Hamilton et al., 2009).

basis. Offsetting activities in the VCM range from an individual neutralising his flight emissions to an organisation compensating for its Scope 1, 2 and 3 emissions[14].

OTC transactions take place outside of a formal exchange and are dealt on case-by-case basis, therefore the market is unregulated and highly fragmented. The VCM, especially in the early years, has attracted substantial negative publicity from the media due to concerns over its integrity (Dhanda & Hartman, 2011; Kollmuss, Zink & Polycarp, 2008; Hamilton et al., 2007; Taiyad, 2005). Most of the concerns stemmed from information asymmetry that plagues the unregulated market (Kollmuss, Zink & Polycarp, 2008). In general, offset suppliers know a lot about the offset projects that they market but offset consumers know very little and have no way of verifying whether their contributions yield real and additional ERs. Information asymmetry gives rise to market failure. If non-additional offsets enter the market and are undistinguishable from additional ones, a market driven race-to-the-bottom will occur as theoretically, non-additional offsets are cheaper than additional ones (Kollmuss, Zink & Polycarp, 2008). In the UK, such concern has prompted the government to establish voluntary code of best practice that advises consumers to only purchase offsets certified by the CDM (House of Commons, 2007).

Facing strong scrutiny regarding its integrity, several market actors including governance bodies, offset providers and non-governmental organisations (NGOs) have come together and develop independent standards that verify voluntary offset projects to provide some level of quality assurance to consumers (Lovell, Bulkeley & Liverman, 2009; Hamilton et al., 2007). As the result, several voluntary standards have emerged, including Voluntary Carbon Standard (VCS), GS, Climate Action Reserve (CAR) and American Carbon Registry (ACR). Many of these voluntary standards also accept CDM methodologies and use CDM approved auditors (Corbera, Estrada & Brown, 2009). The adoption of independent standards to verify voluntary offset projects is a major milestone for the unregulated market (Hamilton et al., 2008). Market uptake of voluntary standards has happened swiftly. By 2008, 96% of the volume transacted in the VCM were certified by third-party standards (Hamilton et al., 2009). In 2016, 99% of the transacted volume were certified by third-party standards (Hamrick & Gallant, 2017).

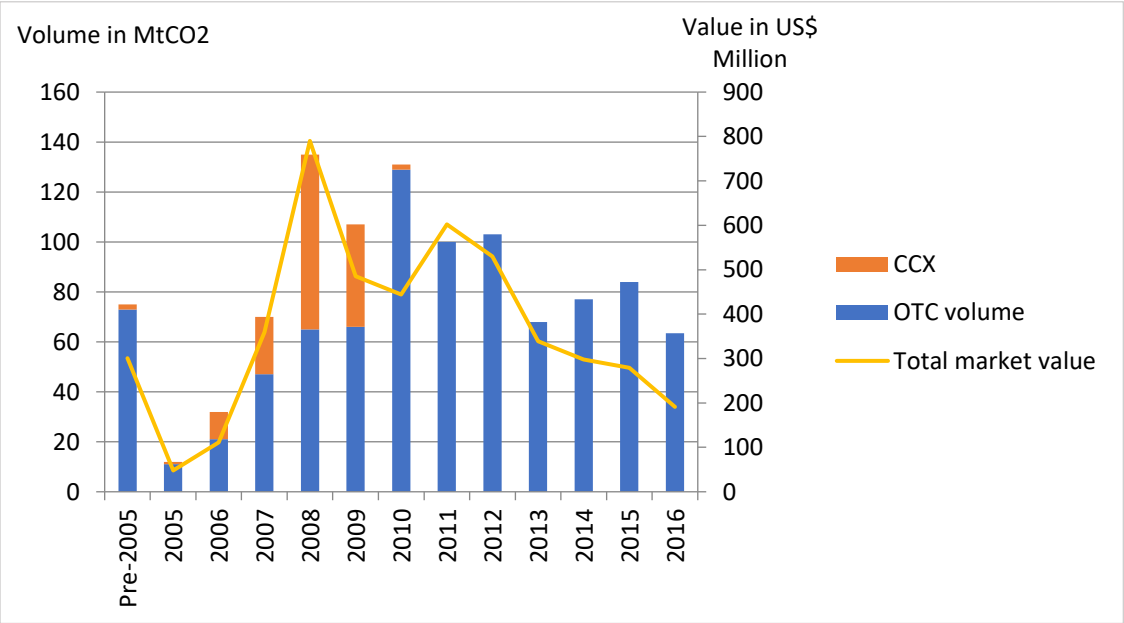
The non-tangible nature of offsets also raises the concern of double-counting (Lovell, 2010). Once an offset is generated, it can be sold many times or claimed by multiple entities. Double-counting compromises the integrity of the market to abate GHG emissions. To ensure accountability, most

[14] Scope 1 emissions are direct emissions from owned and controlled sources, such as fuel combustion and company vehicles. Scope 2 emissions are indirect emissions as the result of purchased electricity or other forms of energy. Scope 3 emissions are uncontrolled emissions indirectly caused, such as emissions arise from employees' travel, waste disposal and supply chain (Defra, 2009).

major voluntary standards have linked with registries, such as APX VCS Registry and Markit Environmental Registry, so that offset ownership can be clarified and offset transactions and retirements can be tracked transparently (Hamilton et al., 2010).

The development and adoption of third-party standards and independent registries show the market is self-regulating to improve its credibility and grow the market (Lovell, Bulkeley & Liverman, 2009). The VCM's potential to grow is substantial as voluntary carbon offsetting is relevant to all individuals and organisations as long as they have a carbon footprint. However, the market has remained relatively small. In terms of market volume, the VCM has issued around 330 million of offsets, which corresponds to around one-eighth of the combined CDM and JI issuance (Zechter et al., 2016). In terms of market value, the VCM's cumulative value since 2005 is US$4.8 billion (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016). In comparison, the cumulative value of the CDM market between 2005 and 2010, combining both the primary and secondary CDM markets is US$ 95 billion (Linacre, Kossoy & Ambrosi, 2011).

Figure 2-3: The voluntary carbon market year-on-year traded volume and value



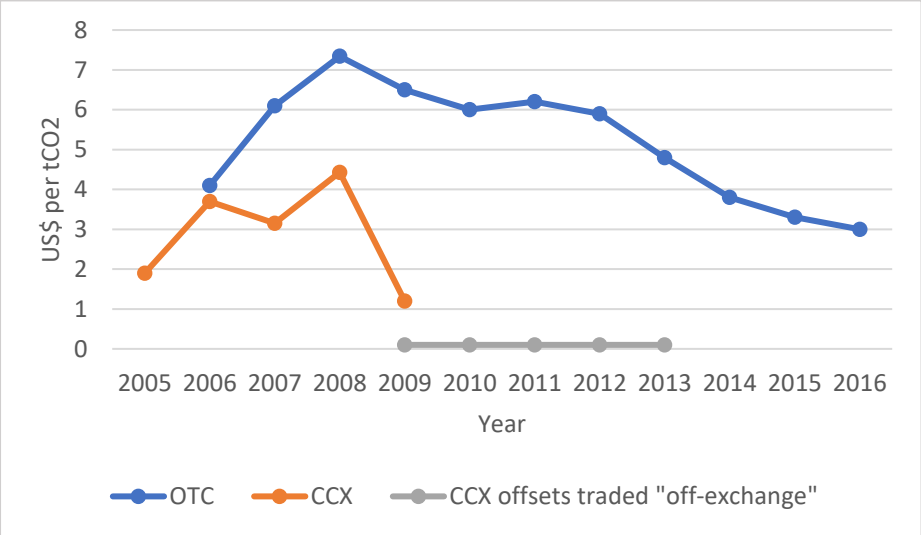
Data source: ESMP reports (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015)

Figure 2-3 depicts VCM's annual transacted volume and value. The market experienced a drastic growth between 2005 and 2008. Then in 2009, the market saw a significant dip that was mostly attributed to the ceasing of CCX trading (Hamilton et al., 2010). In 2010, the lack of progress in the US climate legislation (Maxman-Markey) led to an early closure of the CCX (Peters-Stanley et al., 2011). In the same year, the OTC market transacted volume doubled but its value decreased by 17%

as compared to the previous year. This was attributed to one large-volume but low-price deal where 59 Mega tCO_2e was traded at a price of less than US$0.02 per tCO_2e (Peters-Stanley et al., 2011). Excluding this particular deal, the market transacted volume was relatively stable between 2010 and 2012, until in 2013, the market experienced a 26% drop in volume as the California CaT went live and millions of offsets which were previously traded in the VCM as pre-compliance turned into compliance offsets (Peters-Stanley et al., 2014). Although the market volume continued to increase between 2013 and 2015, the market value had shrunk due to the falling offset price. In 2016, both the traded volume and value had dropped as compared to the previous year.

As shown in Figure 2-3, the market value has declined steadily since 2011. The downward trend can partly be attributed to the weak policy and carbon price signal from compliance markets but the main contributing factor is the market is heavily oversupplied (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015). Early batch projects are now maturing and issuing offsets but new market entrants have remained limited (Hamrick, Goldstein & Peters-Stanley, 2015). The supply-demand imbalance has led to steep market competition and the market is a buyers' one. The market-wide volume weighted average price of voluntary offset has dropped year-on-year since 2011 as shown in Figure 2-4, reaching a new low in 2016 at US$3 per tCO_2e (Hamrick & Gallant, 2017). It is worth noting however, that it is still above the sCER price level of less than US$1 (Zechter et al., 2017).

Figure 2-4: Year-on-year volume-weighted average price per voluntary offset



Data source: ESMP reports (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015)

In an effort to promote participation, offset co-benefits have become a prevalent discourse of the VCM in the recent years. A few studies have been commissioned in the market to quantify and

monetise offset co-benefits to capture and showcase the true value of the market. These reports show that for every tCO_2e emission reduced could potentially deliver hundreds of dollars' worth of co-benefits, especially in health benefits and local ecosystem conservation (ICROA, n.d.; Net Balance, 2014; ICROA, 2014)[15].

2.2.2 The role of voluntary carbon market

The VCM has always been seen as a market that complements the compliance market and its contribution in reducing GHGs is rather limited (Kotchen, 2009a; Kollmuss, Zink & Polycarp, 2008). Nevertheless, the VCM plays an important role in extending the effort of curbing climate change to individuals and organisations beyond compliance regimes. In addition, voluntary carbon offsetting can have an educational role in raising awareness about climate change and helping individuals and organisations to understand their climate impacts (House of Commons, 2007; Gössling et al., 2007).

The VCM can also help inform the development of future domestic and international climate policies. It can lay the foundation for emerging carbon markets, such as building market infrastructure, pilot activities and data collection. For example, in the US, CCX was used as a testing ground for companies to trade carbon credits in anticipation of nationwide climate legislation. California's compliance CaT has also adopted protocols from the VCM, namely CAR and ACR (Goldstein, 2015). In China, the Panda Standard that is developed domestically has helped train and build local capacity in Agriculture, Forestry and Other Land Use (AFOLU) projects through implementation of pilot projects and training workshops (Guigon, 2010).

Furthermore, the VCM provides space for innovation to test out new project types and methodologies or address issues faced in the compliance markets (Benessaiah, 2012). For example, methodologies for land-based carbon sequestration projects are developed by the VCS (Benessaiah, 2012; Hamilton et al., 2007). The VCM has also come up with the buffer pool mechanism, an innovative solution to address the risk of non-permanence that is commonly associated with forestry projects (Guigon, 2010). In addition, sustainability standards that enable measurement and verification of project's co-benefits are also developed within the VCM and then adopted by CDM projects, most notably the GS (*ibid*).

Finally, the VCM is a source of private funding for development and conservation projects, such as clean stove dissemination and forest conservation programmes that traditionally rely on public finance or charitable donations (Bumpus & Liverman, 2008). The flexibility of the market, combined with buyers' demand for offset co-benefits, provide it the capacity to support small-scale community

[15] These studies used Benefit Transfer method to provide high level indicative values of co-benefits per offset from a sample of offset projects, therefore should be interpreted with care.

based projects that deliver various co-benefits to local communities (Hamilton et al., 2007; Harris, 2007; Taiyad, 2006). In contrast to the CDM which stringent project approval process and high transaction cost have hindered the development of small-scale projects (Boyd et al., 2007), the VCM works to support small and micro-scale projects by removing bureaucratic hurdles to keep the transaction cost low. For example, GS offers micro-scale projects (<10 $ktCO_2$ per year) the option to be exempt from contracting third-party validation and verification but simply pay a flat fee that contributes towards the GS validation and verification fund. The fund is then used to pay for the validation and verification of randomly selected micro-scale projects (GS, n.d.a). Micro-scale projects located in LDCs and Small Island Developing States (SIDSs) also benefit from simplified rules with respect to the demonstration of additionality (*ibid*).

2.2.3 Criticisms of voluntary carbon offsetting

Since voluntary carbon offsetting emerged almost a decade ago, it has received substantial negative attention and criticisms from the media, environmental activists and some scholars. Their criticisms generally fall into two grounds. First is on the ethics of voluntary carbon offsetting and second concerns the credibility of the unregulated VCM (Skopek, 2010; Lovell, Bulkeley & Liverman, 2009). The most profound critique from ethical perspective is voluntary carbon offsetting appeases green guilt, thus it distracts individuals and organisations from making the more fundamental and challenging changes to reduce their consumption (Skopek, 2010; Kotchen, 2009a; Lovell, Bulkeley & Liverman, 2009; Bumpus & Liverman, 2008; Monbiot, 2006). It also makes consumers question less about their climate impact and whether such an impact can be avoided in the first place (Lovell, Bulkeley & Liverman, 2009; Rousse, 2008). Organisations that use voluntary offsets are also being accused of greenwash, which means they use carbon offsets simply as a marketing tool without making real carbon savings (Beder, 2014; Polonsky, Grau & Garma, 2010; Gray, 2009; Pearce, 2009). Skopek (2010) argues that under the market framework, environmental good that was previously protected by social norm (for example not being wasteful) may become something that can be bought[16]. This can also be viewed as the rebound effect of voluntary carbon offsetting, that it could potentially increase the consumption of polluting goods (Kotchen, 2009a). However, studies have found the rebound effect of voluntary carbon offsetting among individuals to be inconclusive (Blasch & Farsi, 2014; Kotchen, 2009b; Whitmarsh, 2008).

[16] Skopek (2010) draws a parallel comparison between voluntary offsetting and a study on "crowding out" at a day care centre whereby after the day care centre starts to impose a fine on parents for picking up their children late, the number of late pick-ups increases. It shows that transforming a previously non-monetary relationship (a social duty) into a monetary one can have a negative impact on motivation.

The offset market is a neoliberal approach to solving environmental problem and according to Lovell, Bulkeley and Liverman (2009) '*often through unequal relationships between North and South*' (p.2360). Dispossession of cheap ERs from South to North raises some equity issues and this applies to both the CDM and VCM (Bumpus & Liverman, 2008). First and foremost, is it fair for poorer countries that have considerably smaller emissions to clean up the waste of rich countries? In addition, the market has been criticised for its neo-colonial approach and unfair distribution of carbon benefits (Lovell, Bulkeley & Liverman, 2009). Many offset projects are found to lack local participation and consultation, whilst some projects even generate harm to local communities (Scheidel & Work, 2016; Vidal, 2010; Checker, 2009; Haya, 2007; Davies, 2007; Reddy, 2005; Brown & Corbera, 2003). For examples, the CDM has financed an industrial gas destruction project at a chemical plant in India that causes serious local water pollution and harms public health (Checker, 2009) and enabled the extension of a polluting landfill site in South Africa that has substantial negative health impacts on its surrounding residents (Reddy, 2005). Forestry projects that are especially popular in the VCM due to their potential for poverty alleviation and biodiversity conservation have also been accused of marginalising poor communities and increasing land use conflicts (Westoby & Lyons, 2016; Scheidel & Work, 2016; Cavanagh & Benjaminsen, 2014).

Second strand of criticisms mainly aims at the integrity of the VCM. There are scepticisms regarding the ability of the unregulated market to deliver real and additional ERs (Bumpus & Liverman, 2008). Lack of transparency and information asymmetry have led to a buyer beware market as there are concerns regarding the ethics of offset providers (Dhanda & Hartman, 2011; Kotchen, 2009a). Gössling et al. (2007) also found among voluntary offset providers, there is no standardised approach to calculate GHG emission, a prior step to purchase voluntary offsets. As the result, even with the same inputs, different online calculators hosted by different offset retailers generate very different amounts of emissions that need to be compensated (Bayon, Hawn & Hamilton, 2009, p.29). Another critical concern about the market is double-counting, that an offset that is intangible in nature can be sold many times and claimed by a number of entities (Lovell, 2010). Some of these concerns have been addressed through market self-regulation as discussed in the previous section.

Ultimately, whether offsetting contributes positively or negatively to climate mitigation comes down to the intention of offset users as Kotchen (2009a) concluded that offsetting is good provided that offset consumers follow the motto of Carbonfund (2016): "*Reduce what you can, offset what you can't*" and that offsets are sourced responsibly.

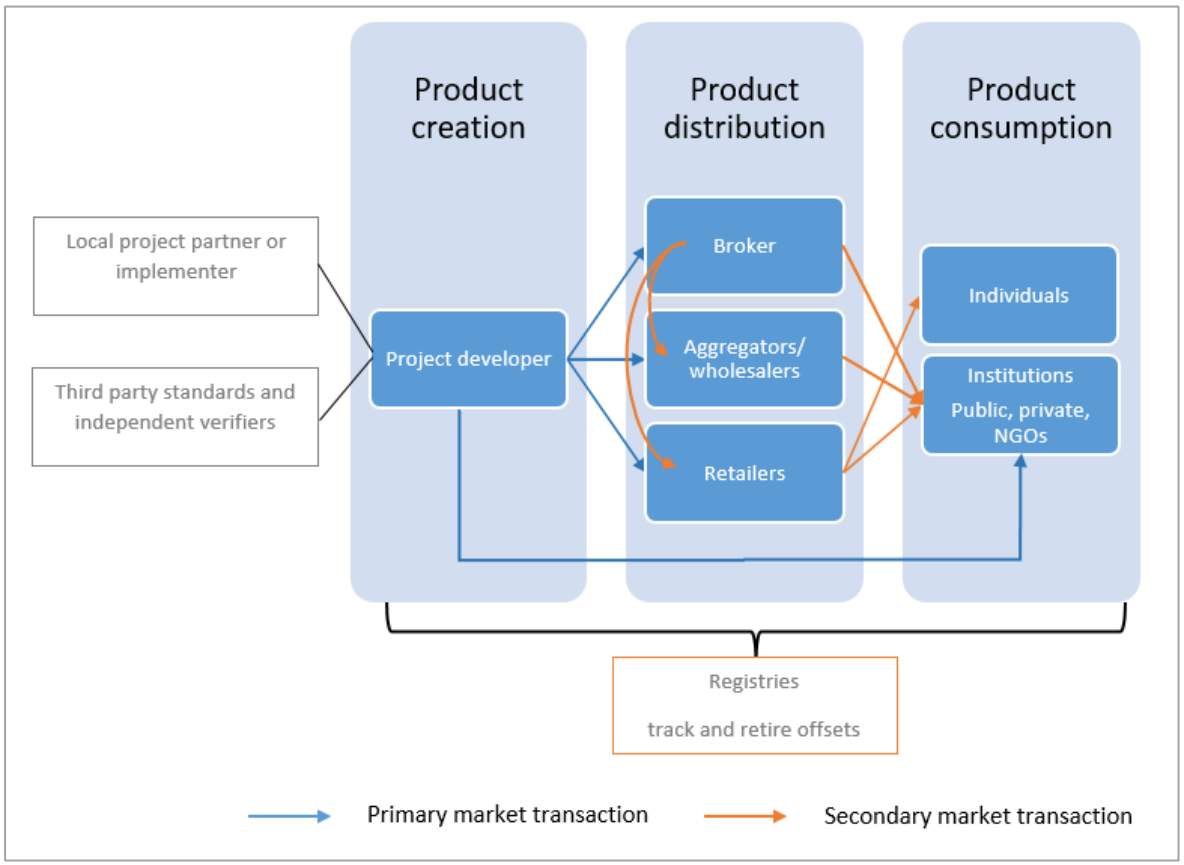
2.3 Market structure

2.3.1 Supply chain

With the creation of offset as a new commodity, a whole market has emerged to enable the production, distribution and consumption of the virtual good. Many organisations have taken advantage of the emerging market to make money (Bumpus & Liverman, 2008). Non-profit sector has also looked to the market as a new source of finance for development and conservation projects (*ibid*). According to Kotchen (2009a), offset suppliers operating in the VCM more than tripled between 2002 and 2009, with 97 offset suppliers operating in 2009. In 2015, the number of offset suppliers reached 150 (Hamrick & Goldstein, 2016).

In the VCM, the commodity chain can include owners of the sites where ERs take place, project developers that develop the carbon asset element of the project and their local partners who implement the project, financial institutions and brokers who hold the offsets as intermediates, and finally, individuals, corporations or governments who purchase and consume offsets (Bumpus & Liverman, 2008). Figure 2-5 illustrates the main stages of the supply-chain and the different market participants involved in each stage. Offset transactions between project developers and intermediaries or project developers and end users are referred as the primary market, whilst transactions between intermediaries and intermediaries or intermediaries and end users are referred as the secondary market (Peters-Stanley et al., 2013).

Figure 2-5: The supply chain of voluntary carbon offsets



Source: Author's own, informed by Bayon, Hawn & Hamilton (2009)

Depending on the project circumstance, the project developer may not always be the project owner or implementer. For example, the project developer could be a Chinese manufacturer that installs a piece of energy efficiency equipment at its factory, or it could be a European based carbon retailer that provides finance to a local NGO for distributing efficient stoves in an African country. In the first instance, the Chinese manufacturer is the project developer and owner, whilst in the second, the European carbon retailer is the project developer, the NGO is the project implementer and ERs are generated by stove beneficiaries. Therefore, although the project developer is the main entity often referred to in the development of a carbon offset project, other entities are involved in the process of carbon creation, including stakeholders such as project funders, local governments and communities.

Carbon retailers sell offsets directly to consumers who wish to compensate their GHG emissions. Their websites tend to have an online calculator to determine the size of the consumer's carbon footprint that needs to be offset (Gössling et al., 2007). Retailers that target at businesses also offer a range of services including in-depth calculation of the organisation's carbon emissions, carbon management advisory services and public relations or marketing related supports to promote the

organisation as carbon neutral (Peters-Stanley et al., 2013; Harris, 2007). There are various types of offset retailers, some take on the project developer role whilst others may simply act as an intermediary that buys offsets from project developers and sells them on to end-users (Lovell, Bulkeley & Liverman, 2009). Carbon retailers usually own a portfolio of offset projects which they source through their network of partners or NGOs (Bumpus & Liverman, 2008). Most carbon retailers are in the developed regions such as Europe and North America where majority of offset consumers are (Harris, 2007).

Besides carbon retailers, there are other intermediaries operating in the VCM, such as brokers that facilitate transactions between buyers and sellers but do not take ownership of the offsets (Peters-Stanley et al., 2013), aggregators that serve as the administrator and trading representative for multiple small-scale projects to reduce participation cost (Kollmuss, Zink & Polycarp, 2008), and wholesalers that buy and sell offsets in bulk (Peters-Stanley et al., 2013).

Finally, offset consumers buy and retire offsets against their emissions. Offset consumers are individuals or organisations from private, public or social sectors. For an offset to fulfil its goal of compensating a tCO_2e emission, it needs to be retired and cannot be resold. When retired, the materiality of an offset is realised through the substitution of one tCO_2e emitted with one tCO_2 reduced (Bumpus, 2011). Offset retirement is important as it represents the real contribution of the VCM in reducing GHG emissions (Hamilton et al., 2010). According to Hamrick and Goldstein (2016), around half of the total 330 million offsets that have been issued over the years are retired by 2015.

2.3.2 Contract structure

Transactions in the VCM are conducted under different contract structures. The contract types differ based on the delivery provision that entails different level of risk to the buyer. Kollmuss, Zink & Polycarp (2008) and Peter-Stanley et al. (2013) differentiate the contracts into three broad types as summarised in Table 2.1.

Table 2-1: Voluntary offset contract types

	Risk to buyers		
	Low	Intermediate	High
Kollmuss, Zink & Polycarp (2008)	Prompt delivery	Forward delivery	Forward crediting or ex-ante credits
Peter-Stanley et al. (2013)	Spot	Payment-on-delivery firm or unit contingent	Pre-payment

Prompt delivery or spot contracts entail transaction of issued offsets, therefore offset payment and delivery are instantaneous. In such contracts, buyers bear no project related risk, which means sellers assume all project and price related risks. The seller has to make the investment upfront to develop the project without having contracts that guarantee off-take in place. In return, if the project is successfully implemented and generates offsets, the seller can offer risk-free offsets at a higher price than non-guaranteed offsets.

In a forward delivery or payment-on-delivery contract, the offset's price and volume are agreed contractually for future delivery. Payment is made upon delivery. Such an arrangement eliminates market price risk for both the buyer and seller, and is suitable for those who want to secure a price ahead of actual delivery and payment date. The offset volume can be specified in exact amount (firm delivery) or in relative term to the project's successful delivery (unit contingent) (Peters-Stanley et al., 2013). In the case of firm delivery, the seller carries the risk of under-delivery and has to make up for the shortfall from other projects or be penalised, whilst for unit contingent contract the risk is shifted to the buyer who may have to source the shortfall elsewherre that could incur higher cost (Kollmuss, Zink & Polycarp, 2008).

Forward crediting or pre-payment contracts involve the sale of ex-ante offsets where payment is made at the time of contract closure for future delivery of offsets. This contract type is the riskiest for buyers. The purchase price is paid upfront and is not being repaid in case of delivery shortfalls.

In 2014, 84% of offsets transacted are issued offsets listed on a registry (Hamrick, Goldstein & Peters-Stanley, 2015). As the number of mature and issuing projects grows, buyers rarely take up forward contracts which means the market lacks new investments and is facing growing challenge to get new projects or methodologies off the ground (Peters-Stanley et al., 2014).

2.3.3 Offset price trends

Under the concept of offsetting, the price of offset should be determined by the intersection of the internal marginal abatement cost of the buyer and marginal abatement cost of offset projects (Conte & Kotchen, 2010). Offset values vary between the compliance and voluntary markets due to the different demand drivers (Bumpus & Liverman, 2008). In the compliance market, sCERs are traded on a formal exchange, which provides price transparency. In the absence of a formal exchange, how a voluntary offset price is determined is less clear. Over the years, the reported range of voluntary offset price varies widely as illustrated in Figure 2-6. It is worth noting that the reported annual price range includes large-volume low-price transactions contracted by offset retailers and intermediaries for resale purpose.

Figure 2-6: Historical voluntary offset price range by year



Data source: ESMP reports (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013; Peters-Stanley et al., 2012; Peters-Stanley et al., 2011; Hamilton et al., 2010; Hamilton et al., 2009; Hamilton et al., 2008; Hamilton et al., 2007)

According to Kollmuss, Zink & Polycarp (2008) and Bayon, Hawn & Hamilton (2009), voluntary offset price can be compared at two different levels: (1) the cost of offset production and (2) the market price of offset. The cost of production is determined by project implementation, transaction and administration costs and seller's profit margins. The difference between an offset's production cost and market price can be influenced by factors such as the number of intermediaries between the project developer and the end user (Hamilton et al., 2009; Hamilton et al., 2008; Hamilton et al., 2007) and scale of purchase with large-volume transactions are generally associated with lower offset prices (Hamrick & Gallant, 2017; Bayon, Hawn & Hamilton, 2009).

Sellers and intermediaries' profit margin is one of the main concerns of the unregulated market. Information asymmetry means that voluntary offset price structure lacks transparency and project developers and intermediaries have the liberty to adjust their mark-ups (Taiyad, 2005). Some revenue may also be spent on marketing and administrative work rather than investing in offset projects. For example, one carbon retailer that Taiyad (2005) interviewed indicated that only 25% of the company's revenue is spent on projects, while 25-30% is spent on marketing and advertising. However, market reports such as ESMP annual reports that provide information on offset prices by

project type, location and certification standard may promote transparency and competition in the VCM. Furthermore, with supply increasingly exceeding demand, the VCM is currently a buyers' market and sellers are under pressure to be competitive with their pricing (Hamrick & Goldstein, 2016).

Indeed, the voluntary nature of the market means it is primarily demand driven, thus the market price of offsets not only relies on their production cost, but also on how much the market would bear. In other words, how much buyers are willing to pay. Unlike the compliance market, voluntary buyers' WTP not only reflects their internal marginal abatement cost but also their preferences for various offset attributes to meet their specific objective for voluntary offsetting (Hamrick & Goldstein, 2016; Hamilton et al., 2010; Taiyad, 2006). For examples, rather than simply purchasing the cheapest offsets in the market, some buyers may specifically look for offsets that are relevant to their business (e.g. paper printing company purchase forestry offsets whilst power company purchase renewable offsets), whilst others may seek offsets with poverty alleviation and biodiversity conservation co-benefits to maximise their CSR impact. Expectedly, there are some voluntary buyers whose main aim is to abate their emissions cost efficiently, therefore they simply purchase the cheapest offsets without regarding the offset origin (Hamrick & Gallant, 2017). Thus, in addition to offset production cost, demand-side factors also influence the market price of offsets.

Conte & Kotchen (2010) examined the underlying determinants of offset price using hedonic price functions and data listed on the Carbon Catalog website[17]. They found that offset price is influenced by offset provider's location, offset project type and location, as well as offset certification. In particularly, they found offset providers in Europe are selling offsets at a higher price than offset providers in North America or Australasia; offsets that are generated from developing countries, especially from LDCs can fetch higher prices except for forestry offsets; offsets that are certified by the CDM can sell at a premium, whilst offsets that are certified by the VCS are associated with a price discount. Some of these findings are likely to have changed since the study was conducted due to the dynamic of buyers' demand. In the early years, buyers were willing to pay more for CERs sold in the VCM as they were considered as more credible (Hamilton et al., 2009). However, more recent ESMP reports show that on average, VCS certified offsets are transacted at a higher price than CERs (Hamrick & Gallant, 2017; Peters-Stanley et al., 2014). Whilst Conte & Kotchen (2010) found the controversial forestry offsets are generally sold for lower prices than other project types, Hamrick & Goldstein (2015) reported that between 2007 and 2014, the average prices of forestry related

[17] According to Conte & Kotchen (2010), Carbon Catalog is an online directory that provides comprehensive information on offset providers and their projects around the world. However, recent attempts to access its website: https://www.carboncatalog.org/ revealed the website is no longer working or publicly available.

offsets (avoided deforestation, tree planting and forest management) are greater than the average prices of renewable offsets (wind and hydro). It is worth noting however, these studies are based on different data sources.

In the VCM, offset co-benefits are one of the highly sought-after offset attributes (Lovell, Bulkeley & Liverman, 2009). In the recent years, voluntary offsets are increasingly being differentiated based on their associated co-benefits. In particularly, buyers are willing to pay more for projects that also deliver poverty alleviation and nature conservation co-benefits, such as GS certified clean stoves projects and CCBs certified forestry projects (Peters-Stanley et al., 2014; Peters-Stanley et al., 2013). Some buyers also specifically source offsets from LDCs (Peters-Stanley et al., 2014). These co-benefits are public goods in nature, but are being provided privately by individuals and organisations for reasons beyond their desire to abate their GHG emissions, such as to gain prestige or enhance public relations (Conte & Kotchen, 2010). Therefore, unlike compliance offsets, voluntary offsets are not being treated as homogenous goods, rather they are bundled with different attributes that can affect their market price.

3 Carbon markets in promoting sustainable development

Offsets are created from a range of projects such as renewable, energy efficiency, waste and forestry projects. These projects also generate co-benefits such as employment creation, promotion of technology transfer and local ecosystem and biodiversity conservation. Therefore, in addition to abate GHG emissions at the global level, offset projects also have the potential to promote SD at the local level. Contribution to SD in developing countries is one of the main arguments in favour of carbon offsetting (Liverman, 2010). Article 12 of the KP states that one of the objectives of the CDM is to help developing countries achieve SD (UN, 1998). However, the failure of CDM in promoting SD is well-documented (Olsen, 2007). Its failure is often in reference to the cheap large-scale industrial gas destruction projects that the market supports (Ellis et al., 2007; Davies, 2007). Drawing from two different fields of study: (1) theoretical studies on the governance of offset creation and (2) empirical studies that assess CDM projects' contribution to local SD, this chapter explores the synergies and trade-offs between abating GHG emissions and promoting SD at both project- and market-level. In particularly, this chapter addresses research sub-questions 1.1 to 1.4:

1.1. What are carbon offsets and how are they created?
1.2. How do offset projects contribute to local SD?
1.3. What are the factors that lead to CDM's failure to promote SD?
1.4. Why the VCM is better positioned than the CDM in promoting SD?

3.1 Offset projects

3.1.1 Offset project types

Existing studies have emphasised on the importance of recognising the diversity of projects that generate offsets that are supposedly to be homogenous[18] (Bumpus, 2011; Lovell & Liverman, 2010). Under the KP, seven GHGs have been identified: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3)[19]. Projects that reduce any of these seven GHGs can generate offsets. Over the years, a number of offset project types have been developed, one only has to look at the CDM methodology booklet[20] to get an idea of the complexity and diversity of offset projects in the market. As of March 2017, there are 26 project types and 154 subtypes listed in the UNEP DTU

[18] Based on the principle of carbon offsetting, all carbon ERs are the same regardless of how or where they are produced.
[19] NF_3 was later added into the list of GHGs in Doha amendment to the KP (UNFCCC, n.d.c)
[20] Available at: https://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf

Partnership (UNEP DTU)'s CDM project pipeline[21]. Offset projects are grouped differently in different studies and some studies refer project type as project technology or project sector (Bumpus, 2011; Lovell, 2010; Boyd et al., 2009). For simplicity and consistency, this study uses the term project type. Following Bayon, Hawn & Hamilton (2009)'s categorisation of offset projects, popular offset project types can broadly be distinguished into the following categories: emission destruction, emission avoidance and carbon sequestration.

Emission destruction projects capture and subsequently destroy GHGs that was previously released into the atmosphere. For example, industrial gas projects capture and destroy HFCs, N_2O, PFCs and SF_6 generated from chemical processes, whilst methane gas projects capture methane gas released from various sources, such as landfill site, coal bed/mine, wastewater, agriculture waste or manure, which is subsequently flared or used for power generation.

Emission avoidance projects involve displacing of fossil fuel combustion through installation of renewable or low-carbon technology in place of the more conventional carbon intensive alternative. In these projects, carbon revenue helps to leverage the more capital intensive but cleaner option. Examples under this category include renewable projects such as solar, wind, hydro and biomass to generate electricity, energy efficiency projects in industrial setting that involve technological improvement or alteration of existing process to reduce fossil fuel consumption, fuel switching projects that replace the use of carbon intensive fuel with a less carbon intensive option such as substituting coal with natural gas, and lastly, household energy projects that disseminate renewable or energy efficient appliances such clean stoves, energy efficient lightbulbs or solar powered water heaters to reduce household consumption of traditional solid fuels such as fuelwood or charcoal.

Carbon sequestration projects are forestry and landuse related projects that conserve or increase the amount of carbon held in the soil. This category is known as Land Use, Land-Use Change and Forestry (LULUCF) projects under the KP and Agriculture, Forestry, and Other Land Use (AFOLU) under the VCS (Bayon, Hawn & Hamilton, 2009). Examples in this category include Reduced Emissions from Deforestation and Degradation (REDD) projects that aim to conserve standing forests. REDD is a popular project type in the VCM but has not been approved in the compliance market due to concerns relating to leakage and permanence[22] (Corbera, Estrada & Brown, 2009).

[21] Over the year, UNEP DTU (formerly known as UNEP Risø Centre) has been tracking projects developed under the CDM. Its CDM pipeline analysis and database provides a full list of CDM projects at various stages of development. The database is updated on a monthly basis and is publicly accessible through: http://www.cdmpipeline.org/

[22] Leakage refers to the potential increase in emissions outside the project boundaries due to shifting of emitting activity to another location, whilst permanence refers to the risk of the vegetation sequestered CO_2 being released back into the atmosphere in the future due to natural events such as forest fires or disease

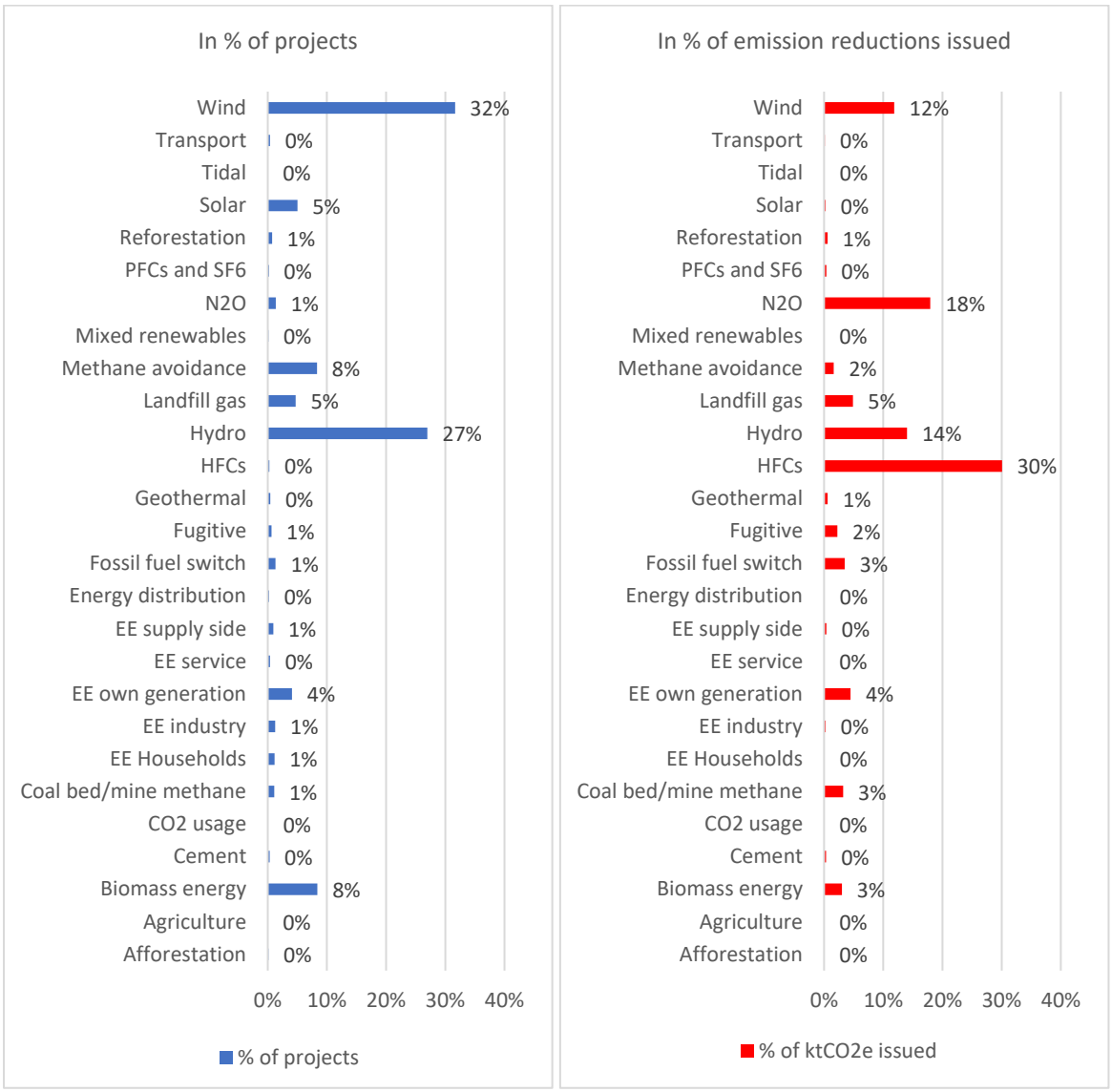
Other project types in this category include afforestation and reforestation (AR) projects that involves '*direct human-induced conversion of non-forest to forested land*' (Jung, 2005: p.89), improved forest management and implementation of sustainable agriculture practices to reduce or avoid land degradation. For simplicity, these land-based projects are collectively referred as LULUCF projects in this study.

3.1.2 CDM projects

As of March 2017, a total of 7761 projects have been approved by the CDM EB (UNEP DTU, 2017). Figure 3-1 depicts CDM project distribution in terms of number of registered projects and volume of CERs issuance to-date. The five most common project types are wind (32%), hydro (27%), biomass energy (8%), methane avoidance (8%), and solar (5%). Together these project types constitute around 80% of the total registered projects. However, examining the CDM portfolio from volume of CER issuance perspective tells a different story. The top five contributors of ERs in CDM market are HFCs (30%), N_2O (18%), hydro (14%), wind (12%) and landfill gas (5%), which together attribute to almost 80% of the total CERs issued to-date. This shows that despite the CDM has approved a great number of renewable energy projects, the market is flooded with CERs from a few large-scale industrial gas projects, namely HFCs and N_2O. HFCs projects especially generate significant volume of CERs as less than 1% of offset projects approved by the CDM are HFCs projects but collectively they account for 30% of the total CERs issued to-date.

outbreaks, or change of human activities such as illegal logging or reverting to slash-and-burn (Kollmuss, Zink & Polycarp, 2008)

Figure 3-1: CDM project distributions as of March 2017



Data source: UNEP DTU (2017). EE = Energy efficiency.

In terms of geography distribution, as of March 2017, 48% of CDM registered projects are hosted in China, follows by India (21%) and Brazil (4%). Only 3% of the registered CDM projects are in Africa. As for volume of CERs issued, China receives 58% of the total CERs issued to date, follows by India (12%) and South Korea (9%). Only 2% of the total CERs are issued to African countries. In both number of projects and volume of ERs, the CDM clearly only benefits large emerging countries, especially China. The uneven geographical distribution of CDM investment is expected as it is a channel for FDI, therefore are likely to benefit countries with favourable investment conditions, such as stable macroeconomy, low political risk and strong domestic institutions (Ellis et al., 2007; Cosbey et al., 2005).

3.1.3 Voluntary projects

Over the years, the ESMP's annual report on the VCM has been tracking voluntary offset transactions by project types. Review of the report series shows the most popular project types differ year-on-year depend on the dynamic of buyers' demand. Based on the cumulative value of offsets transacted between 2007 and 2014, the top seven most popular project types in the VCM are REDD (US$442 million), wind (US$384 million), landfill methane (US$285 million), AR (US$270 million) , hydro (US$170 million), clean stoves (US$162 million) and forest management projects (US$113 million) (Hamrick, Goldstein & Peters-Stanley, 2015). These project types remain the most popular in terms of volume transacted in 2015 and 2016 (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016).

Grey literature on the VCM often claim that the VCM is supporting offset projects that have been sidelined by the highly regulated CDM market, especially small-scale community-based projects and projects in the African region (Peters-Stanley et al., 2013; Harris, 2007; Taiyad, 2005). Corbera, Estrada & Brown (2009) challenged such presumption by comparing the expected volume of offset generation up to 2012 from CDM projects with the volume of offset transacted in the VCM for year 2006 and 2007. They found the two markets are relatively similar in terms of the project types that they support, with the exceptions of the CDM's support for industrial gas projects and the VCM's support for forestry projects. In terms of geographical distribution, both markets show uneven distribution of projects with African being the least benefited region. As the result, Corbera, Estrada & Brown (2009) concludes that '*the CDM and voluntary OTC markets may not be as different as they are often supposed to be*' (p.27).

Comparing offset generation with offset transaction as Corbera, Estrada & Brown (2009) have done can lead to wrong conclusions. Since 2005, around 330 million offsets have been issued in the VCM but the cumulative volume of offsets transacted has reached around 1 billion (Hamrick & Goldstein, 2016). This means once an offset is generated, it can be transacted many times until it is retired against one tCO_2e emission. Therefore, using offset transaction information does not provide an accurate picture of the project types and locations that the VCM supports. Furthermore, voluntary offset transactions reported by ESMP reports encompass projects that are hosted in developed countries namely in North America, whilst the CDM only focuses on projects in developing countries. Projects that are hosted in developed countries or economies in transition for Kyoto compliance purpose fall under JI. Therefore, CDM offset generation and VCM offset transaction data are not directly comparable.

The supply of voluntary offsets is also closely connected to the CDM market (Peters-Stanley et al., 2012; Lovell, 2010). Offsets transacted in the VCM comprise of CERs and ERUs as well. During the peak of CDM market, the stringent and lengthy CDM approval process resulted in many pre-CDM projects applying for voluntary standards to start generating carbon revenue in the VCM whilst waiting to be approved by the CDM (Lovell, 2010). Supporting pre-CDM projects raises question on the ability of the VCM in facilitating further climate finance beyond compliance regimes as these projects would have happened anyway under the CDM.

3.2 Offset creation

3.2.1 Commodification of emission reductions

Carbon offset is a novel and complex commodity because it is abstract and it does not deliver any physical benefit to its consumers (Lovell, Bulkeley & Liverman, 2009). An offset is abstract because GHG ER in the atmosphere is intangible and when it is achieved, it is non-existent (Bumpus, 2011). When individuals and organisations purchase offsets, they do not receive anything material in return of their payments, other than perhaps a serial number, a certificate or a carbon neutral logo (Lovell, Bulkeley & Liverman, 2009; Harris, 2007). Therefore, for ERs to be traded as offsets, they need to be '*brought into being: defined legally and technically, allocated to market participants, made transferable and tradable, and so on*' (Mackenzie, 2009: p.443).

Offset creation is governed by a set of principles, including they have to be real, additional, permanent and verifiable (Broekhoff & Zyla, 2008). According to Bumpus & Liverman (2008), '*carbon reductions should be additional to a baseline level of emissions and should be abstracted and converted into units of carbon that can be owned and traded*' (p.134). Based on these principles, the process of offset creation can broadly be divided into two stages. The first stage involves calculation of the expected ERs from the project and justification of the project's additionality (ex-ante), whilst the second stage involves monitoring and verification of the actual ERs following the project implementation (ex-post). After the ERs are verified as real, they need to be assigned property rights for them to be tradeable. These stages show that in addition to the physical implementation of project activities that reduce GHGs, offset creation requires a series of documentation and bureaucratic procedures (Bumpus, 2011).

The process of how offsets are being created and assigned ownership is being described as individuation of carbon reduction, which means separating the carbon reduction from its supporting context (Bumpus, 2011; Bumpus & Liverman, 2008). Carbon reduction is materially created through implementation of ER or sequestration projects and carbon individuation abstracts the carbon reduction from its material circumstance and turning it into a virtual good that can be transferred

across space to be consumed by organisations or individuals who want to compensate their emissions of equal amount (Bumpus & Liverman, 2008). As the result of carbon individuation, all offsets become the same. Each of them equals to one tCO_2e ER and are fully fungible despite they are being created from a diverse range of projects.

3.2.2 Ex-ante baseline definition and proving additionality

Offset is created based on a baseline-and-credit system (Bumpus, 2011; Bumpus & Liverman, 2008). Each offset represents an additional tCO_2e reduction as compared to the baseline level emission as the result of implementing the ER project activity. Establishing the baseline scenario and arguing project additionality are often done on the paper, through a document called Project Design Document (PDD)[23]. The baseline scenario is a hypothetical emission scenario constructed through an analysis of the socio-economic and political situation at the project location (Bumpus, 2011). It represents the most plausible scenario that would have happened in the absence of the proposed project. After the baseline is established, the project developer has to demonstrate that the project is additional. In other words, the project and the resultant ERs would not have happened without carbon finance. Greiner & Michaelowa (2003) explains the concept of additionality very well by saying '*baseline shall reflect the business-as-usual scenario, whereas the CDM project activity shall be one that requires extra incentives to come into being*' (p.1007) and the extra incentive in this case is the carbon revenue. If offsets are generated from projects that would have happened anyway, then they are not additional. The use of non-additional offsets to compensate for emissions elsewhere would undermine the integrity of carbon markets.

The idea is simple in theory but in practice, establishing the baseline and demonstrating project additionality have proven to be challenging and controversial (Broekhoff & Zyla, 2008). Firstly, the baseline scenario is counterfactual (Lohmann, 2005). Once the project is implemented, there is no knowing what would have happened in the absence of the project, therefore there is no way of verifying the baseline. Unfortunately, it is also in the project developer's interest to exaggerate the baseline emission level to enhance carbon revenue (Murray, Sohngen & Ross, 2007; Chadwick, 2006; Greiner & Michaelowa, 2003). As offsets are being used to compensate GHG emissions elsewhere, the artificially inflated volume of offsets allows offset consumers to emit more into the atmosphere elsewhere and the result is an overall net increase of GHGs in the atmosphere (Chadwick, 2006).

[23] In the CDM, PDD is a mandatory standardised document prepared by project developers that sets out the project activity, baseline scenario, additionality, ER calculation and monitoring procedure. The document is submitted to the CDM EB for review and approval. PDDs are made publicly available on UNFCCC's CDM website: https://cdm.unfccc.int/. In the VCM, similar document is used but may be called differently. For simplicity, the document is referred as PDD throughout this study.

Secondly, demonstrating project's additionality involves a complex process of arguments and justifications on the paper. Under the CDM, additionality assessment is done in various ways: (1) first-of-its-kind, where similar project activity has not been implemented in the relevant sector or region, (2) investment analysis where the project activity is financially unattractive without CDM revenue, (3) barrier analysis where the project implementation is hindered by local technological, economic or cultural barriers (UNFCCC, 2012). Projects that use investment analysis and barrier analysis to demonstrate additionality also have to undertake common practice analysis to show the extent of similar project activities have been implemented in the region (*ibid*). These approaches to arguing additionality are often subjective and lack credibility, especially where barrier analysis is used (Schneider, 2007). Investment analysis that assesses the impact of carbon revenue on project's IRR is considered less subjective and project developers have to provide financial calculation that is reproducible. Even so, there remains a risk of project developers manipulating the data for investment analysis (Bumpus, 2011; Haya, 2007).

Differentiating projects that are additional from non-additional ones is not always straightforward. In an example illustrated by Bumpus (2011), a Honduran hydropower project has to argue for and against the project's additionality to different investors in order to gain finance for the project. Bumpus seriously questions the impact of carbon revenue on the multi-million hydro power plant but the project is approved by the CDM EB. The CDM has been criticised for approving projects that are non-additional (Zhang & Wang, 2011; Schneider, 2007; Sutter & Parreño, 2007; Haya, 2007; Reddy, 2005). Using non-additional CERs to compensate Annex-I countries GHG emissions and meet their compliance caps compromise the integrity of the compliance market.

3.2.3 Ex-post emission reduction determination and ownership assignment

Baseline establishment and proving additionality constitute only ex-ante determination of ERs of an offset project. Material creation of ERs take place following the project implementation through monitoring and verification of ERs by a third-party organisation (Bumpus, 2011). According to Broekhoff & Zyla (2008), the performance of offset projects need to be readily measurable and verifiable. They even go further by saying that '*projects whose effects are difficult to measure or verify may not be suitable for generating carbon offsets*' (p.3). This has some implications on certain project types, such as household energy and forestry projects which ERs are inherently more challenging to measure and verify, making them riskier from the buyers' perspective.

After the generated ERs have been measured and verified, they need to be assigned ownership for them to be traded and consumed through offsetting. Assigning ownership of the virtual good is important to avoid double-counting (Broekhoff & Zyla, 2008). For example, consider a project that

reduces emissions by distributing clean stoves to households. The project implementer or stove distributor may lay claim to the resultant ERs, so might the households that use the stoves or the organisation that finances the project. In the pCDM market, Emission Reduction Purchase Agreement (ERPA) is used to define the property right of ERs (Bumpus & Liverman, 2008). ERPA usually involves forward selling of future CER delivery between the organisation that generates ERs (the seller) and the investor that claims the right to the ERs (the buyer), therefore the price agreed is usually below the price in the spot market at the time to account for the risk of project failure to deliver the CERs (Kill et al., 2010). After the CERs have been generated, the buyer can resell them in the secondary or spot market. Similar process is used in the VCM to define ownership although the agreement may be less formal (Bumpus & Liverman, 2008).

The intangible nature of offsets also means that their existence needs to be supported by regulations and systems that track the movement and ownership of each offset up to its retirement to avoid double-counting (Broekhoff & Zyla, 2008). In the CDM market, after CERs are issued by the CDM EB, they are listed in the International Transaction Log (ITL) hosted by the UNFCCC to track the movements of these virtual credits and to safeguard the integrity of KP accounting (Bumpus, 2011; Bumpus & Liverman, 2008). In the VCM however, there is no single centralised registry. Multiple registries have been developed by governance bodies, non-profits and private sector, with some tied to specific standards whilst others function independently (Kollmuss, Zink & Polycarp, 2008). When a verified offset is produced, it is assigned with a serial number and when it is sold, the serial number is transferred from the seller's to buyer's account, and when it is used to compensate the buyer's one tCO_2e emission, the registry retires the serial number so that it cannot be resold (*ibid*).

3.3 Project level trade-offs

Despite the wide range of projects that could generate offsets, carbon markets are dominated by few project types. Majority of CERs are generated from industrial gas (HFCs and N_2O), renewable (hydro and wind) and landfill gas (5%) projects, whilst most offsets transacted in the VCM are from LULUCF projects (deforestation and AR), renewable (wind and hydro), landfill gas and household energy (clean stoves) projects. These are also the mostly discussed project types in the existing literature that assess SD impacts of carbon markets. Thus, using these popular project types: industrial gas, landfill gas, renewable, LULUCF and household energy, I discuss in the following section the trade-offs between characteristics that are inherent to the project type, which have an impact the ability of carbon markets to promote SD.

3.3.1 Contributions to sustainable development

Offset projects contribute to SD through the delivery of co-benefits. Kollmuss, Zink & Polycarp (2008) describes offset co-benefit as the '*social and environmental benefits that go beyond the GHG reduction benefits of offset projects*' (p.92). Different offset projects have different impacts on the project host country or community. Review of existing literature shows there is a strong consensus that industrial gas projects have very limited co-benefits as these projects generally only involve end-of-pipe treatment of GHGs and do not generate additional employments or enhance local environment (Alexeew et al., 2010; Olsen & Fenhann, 2008; Ellis et al., 2007; Sutter & Parreño, 2007; Schneider, 2007; Olsen, 2007). In addition, Olsen & Fenhann (2008) found SD contributions of industrial gas projects, if any, are not inherent to the project activity but are indirect benefits attributed to the tax collected for SD purpose. For example, the Chinese government imposes 65% tax on the CDM revenue of industrial gas projects to fund SD programmes (Olsen & Fenhann, 2008; Schneider, 2007).

Theoretically, landfill gas projects that capture and flare methane gas are expected to deliver environmental co-benefits such as odour, water and land pollution reductions due to the associated improved waste management practices but very few social and economic co-benefits (Boyd et al., 2009; Cosbey et al., 2005). However, Olsen & Fenhann (2008) found landfill gas projects also improve public health, generate employments and improve landfill site working conditions. It is worth noting however, Olsen & Fenhann (2008)'s analysis is based on PDDs which may be subjected to project developers or carbon consultants' exaggeration of the SD contributions of their projects. Studies have found some CDM landfill projects to be highly controversial due to the co-costs they bring to local communities. For examples, the CDM has been accused of enabling the extension of an old landfill site in South Africa that has severe negative impacts on local communities (Boyd et al., 2009; Ellis et al., 2007; Reddy, 2005), whilst in another landfill site in India, implementation of CDM project has undermined the livelihood of local waste pickers whose source of income depends on salvaging recyclable material from the project site (Vidal, 2010). Therefore, offset co-benefits or co-costs may vary across landfill projects.

Most studies found renewable projects, such as solar, wind, small-scale hydro and biomass projects to deliver a range of co-benefits. At the local level, renewable projects create employment and improve air quality, whilst at the national level, they facilitate clean technology transfer, improve energy security and balance of payment (Drupp, 2011; Alexeew et al., 2010; Wang, 2010; Sutter & Parreño, 2007; Sirohi, 2007). Large-scale hydro projects that involve construction of dam however are controversial and the EU ETS requires hydro projects that are greater than 20 Mega Watt to meet the World Commission on Dams (WCD) criteria in order for their offsets to be used in the

compliance trading scheme (International Rivers, 2007). Renewable projects also have great potential for replicability (Ellis et al., 2007). Technology transfer and diffusion can facilitate local clean technology and market development, thus enable transition to low-carbon development pathway beyond carbon finance (Wang, 2010).

Household energy is a project type that is commonly associated with delivering positive outcomes to local communities (Ellis et al., 2007). They typically improve local living conditions and alleviate pressures on local forests. For example, stove projects that replace traditional solid fuel stoves with more efficient or clean stoves deliver significant health benefit that is associated with improved indoor air quality (Jeuland & Pattanayak, 2012; Arcenas et al., 2010; Hutton & Rehfuess, 2006; Mehta & Shahpar, 2004). In addition, they also relieve households from the drudgery of fuelwood collection and alleviate local deforestation (Thakuri, 2010; García-Frapolli et al., 2010; Habermehl, 2008; Habermehl, 2007). Domestic biogas or household biodigester projects is another example that deliver a range of co-benefits. Biogas technology utilises the natural bacterial digestion process that decomposes organic matter under anaerobic conditions. The process generates methane rich gas that can be used as household fuel for cooking, heating or lighting. Thus, household biogas projects not only provide a sustainable way for waste disposal but also help addressing energy shortage issue in rural areas of developing countries (Bond & Templeton, 2011; Arthur, Baidoo & Antwi, 2011; Katuwal & Bohara, 2009; ISAT & GTZ, 1999).

With regards to LULUCF projects, their co-benefits are expected to be highly context-specific due to the large variations and complexities in their design and implementation (Corbera, Estrada & Brown, 2009). Early LULUCF projects have caused controvery due to the negative environmental impacts associated with large-scale monoculture plantation, including reducing stream flows, altering soil nutrients and threatening local biodiversity (Randerson, 2005). More recently, a number of case studies have also found LULUCF projects to mainly benefit local land owners who are relatively well-off, whilst vulnerable groups such as women, poor landless households and indigenous people who rely on forest resources informallly have largely been sidelined (Benessaiah, 2012; Olsen, 2007). In the absence of formal institutions and intermediaries to ensure equitable distribution of carbon and SD benefits, power dynamic means these vulnerable groups are often marginalised in favour of cost-effective carbon mitigation (Benessaiah, 2012; Olsen, 2007; Brown & Corbera, 2003).

Nevertheless, the potential of well-design and executed LULUCF projects in delivering SD co-benefits is undeniable. According to Boyd & Goodman (2011), the first ever CDM registered LULUCF project, a reforestation project in India has been successful in benefiting local communities, especially women and young girls. The project reforests degraded cropland that spans 370 ha of land belonging to 227

famers across eight villages. Carbon revenue and forest products generated from the project are owned by the farmers. Women are also involved in skill building and income generating activities through working in nuseries and grass seed collection. Its success is attributed to a number of factors, including strong local participation, inclusion of women since early stage, and presence of an intermediary to manage and mediate between different stakeholders.

It is also worth noting, as Olsen (2007) pointed out that most LULUCF case studies focus on the fairness of carbon and SD benefit distribution among local stakeholders, which is a more critical approach to evaluating SD contributions as compared to most CDM sustainability impact studies that use MCA. Use of MCA and summing up the value assigned to each criteria to an aggregate value also represent the concept of "weak sustainability"[24] as poor or negative performance under one criteria can be compensated by positive performance under another (Alexeew et al., 2010). Both Schneider (2007) and Sirohi (2007) argued that eventhough renewable energy projects generate a number of SD co-benefits to their host countries, they do not directly benefit the poorest households that have limited access to energy services. Thus, criticisms on the failure of LULUCF projects in promoting SD could partly be attributed to the stricter approach used by existing studies in evaluating their SD contributions.

3.3.2 Cost efficient mitigation

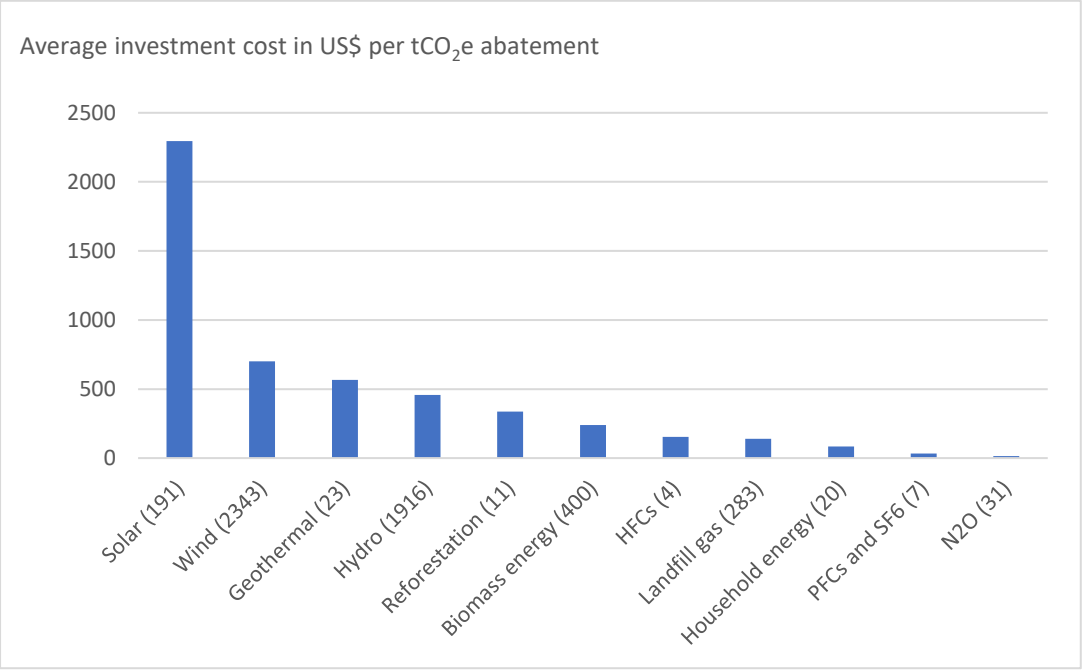
Empirical studies that assess SD co-benefits of CDM projects have found trade-off between cost efficient GHG mitigation and SD contribution. In other words, projects that are associated with greater SD contributions generally entail greater abatement cost per tCO_2e ER and vice versa. Olsen (2007), who reviewed over 200 studies on the SD aspect of CDM, found that earlier theoretical studies are generally positive about the market potential in promoting SD but later SD impact studies revealed otherwise. These SD impact studies mainly involve developing sustainability assessment methodologies and applying them to a sample of CDM projects. Despite the differences in the methodologies used, these studies generally found a trade-off between cost-efficient GHG mitigation and SD contributions with the former being prioritised over the latter. According to Olsen (2007), this is expected as only the carbon element is being monetised in the CDM market, thus if '*left to market forces, the CDM does not signficiantly contribute to sustainable development*' (p.59).

Cost efficiency of GHG mitigation projects relates to the cost of reducing one tCO_2e emission (Alexeew et al., 2010). Therefore it is determined by the project's implementation cost and scale of

[24] The concept of "weak and "strong" sustainability is originated from Pearce, Markandya & Barbier (1989). Weak sustainability assumes that the natural capital can be substituted indefinitely whilst strong sustainability assumes that critical natural capital cannot be easily substitutable, therefore has to be maintained.

ERs. Figure 3-2 depicts the average investment cost per tCO_2e abatement for different offset project types. The investment costs are obtained from UNEP DTU (2017)'s CDM project database as of March 2017 and only registered projects are considered based on the assumption that as these projects are verified and registered, their reported investment costs are deemed credible. Figure 3-2 shows that renewable energy projects, in particularly solar are expensive in comparison to other project types. Greenfield renewable energy projects are generally more capital intensive and have long lead-times (Ellis et al., 2007), but their resultant volumes of tCO_2e reduction are relatively small as compared to industrial gas projects (Bumpus, 2011).

Figure 3-2: The average investment cost per tCO_2e abatement for different project types



Data source: UNEP DTU (2017). Number in parentheses indicates the number of projects used to calculate the average abatement cost per tCO_2e reduction.

As expected, industrial gas projects (N_2O, PFCs and SF_6, and HFCs) and landfill gas projects, which are known as the low-hanging fruits of carbon markets entail lower abatement cost per tCO_2e in comparison to other project types. These projects generate large volume of offsets due to their high global warming potential (GWP)[25]. Combined with their low investment cost, these projects are highly cost effective. According to Schneider (2007), the destruction of HFC-23 in HCFC-22[26]

[25] GWP over a 100-year period of 1 HFC-23 = 11,700 CO_2, 1 N_2O = 310 CO_2, 1 SF_6 = 23,900 CO_2, 1 CH_4 = 21 CO_2 (Houghton et al., 1996). This means that industrial gas and methane destruction projects can generate high volume of offsets. For example, every tonne of HFC-23 destroyed generates 11,700 offsets.

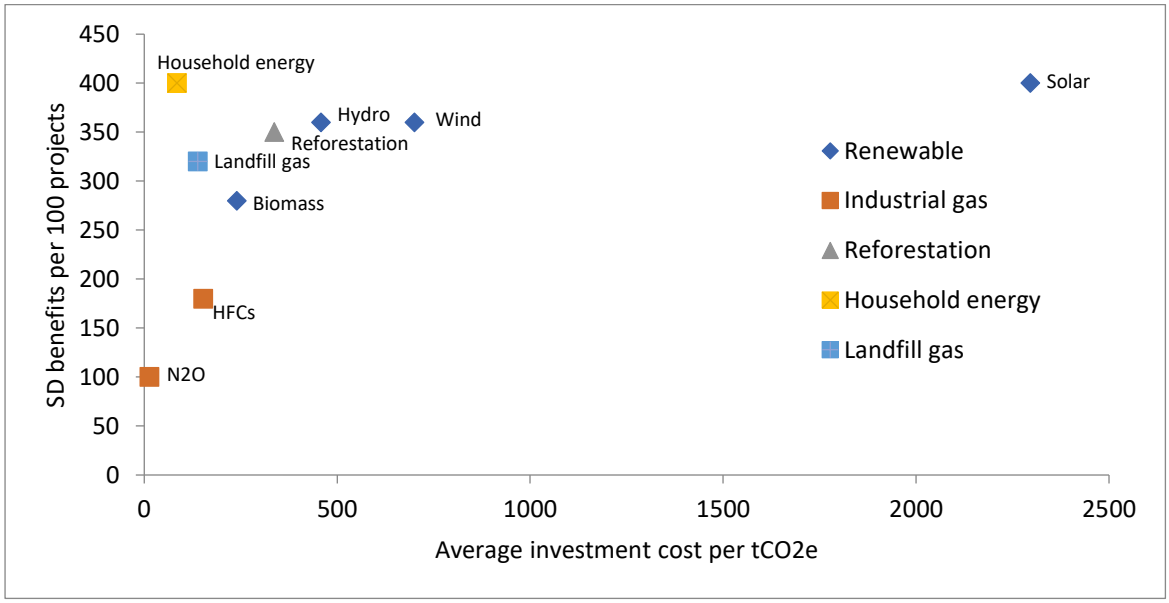
[2626] HCFC-22 is a type of refrigerant and HFC-23 is a by-product of the manufacturing of HCFC-22. Under the Montreal Protocol, HCFC-22 is banned in OECD countries. In developing countries, such as China, India and Brazil, HCFC-22 is to be phased out by 2030, therefore only existing plants that retrofit HFC-23 decomposition can apply for the CDM (Cosbey et al., 2005).

manufacturing facilities and the destruction of N_2O from adipic or nitric acid production costs less than US$1 per tCO_2e abatement. A large HCFC-22 facility in China can earn back the installation cost of HFC decomposition in just a few months and continue to earn carbon revenue in over a million dollars each month (MacKenzie, 2009).

Household energy projects have relatively low investment cost per tCO_2e abatement. This explains the popularity of household energy projects in the VCM as they represent low-cost abatement opportunity but have high SD co-benefits (Simon, Bumpus & Mann, 2012). As for LULUCF projects, Figure 3-2 shows that on average, reforestation projects entail greater cost than the low-hanging fruits and similar to the cheaper renewable projects.

Trade-off between cost efficient mitigation and SD contributions is revealed when Olsen & Fenhann (2008)'s SD profiles[27] are plotted against the average investment cost per tCO_2e. This is depicted in Figure 3-3. It shows that the trade-off is evident in industrial gas projects which are relatively cheap to implement but have low SD scoring. On the other hand, renewable projects such as solar, wind and hydro that have greater SD co-benefits require greater investment cost. Hosuehold energy is the only project type that entails relatively low investment but deliver considerable SD co-benefits.

Figure 3-3: SD benefit vs. average investment cost for different offset project types



Data source: SD scoring is obtained from Olsen & Fenhann (2008) and average investment cost is from UNEP DTU (2017)

[27] Through text analysis of 296 CDM PDDs that are sampled from 744 CDM projects listed as of 3rd of May 2006, Olsen & Fenhann (2008) evaluated SD co-benefits of CDM projects using MCA and generated SD profiles for different project types at the aggregated level.

The trade-off between cost efficient mitgation and SD contribution is also found in LULUCF projects (Benessaiah, 2012; Olsen, 2007). Incorporating multiple objectives that include livelihood improvement and biodiversity conservation into a LULUCF project is inherently costly and inefficient (Benessaiah, 2012). As the number of parties that a LULUCF project needs to engage and negotiate increases, so does the transaction cost (Jindal, Swallow & Kerr, 2008). Therefore, community-based LULUCF projects that involve multiple small-holders are likely to be costly to implement and most investors prefer to work with large land owners (Benessaiah, 2012; Jindal, Swallow & Kerr, 2008). The trade-off in forestry projects has also led to SD contributions being sidelined to achieve cost-efficient carbon mitigation (Olsen, 2007). Melo, Turnhout & Arts (2014) who used Foucauldian discourse analysis to examine CCBS[28] approach to certify LULUCF projects found that the use of market-based mechanism to abate GHGs means even for projects that are certified CCBS, there is still a risk of local communities being marginalised to reinforce offset delivery.

3.3.3 Additionality

Empirical studies also found trade-off exist between project's additionality and SD contributions. Sutter & Parreño (2007) assessed SD contribution of 16 registered CDM projects based on employment generation, distribution of CER returns and improvement of local air quality. They also assessed project's additionality based on the impact of CER revenue on the project's Internal Rate of Return (IRR), with greater the impact corresponding to greater possibility of the project being additional as carbon revenue is a critical enabling factor of project implementation. They found projects that are highly additional are associated with low SD contributions and vice versa. More specifically, they found CER revenue has the greatest impact on the IRR of HFC-23 destruction projects, follows by landfill gas projects, making these project types highly additional. However, they found these projects to deliver very limited co-benefits. For renewable projects that they analysed, including wind, hydro and biomass, the impact of CER revenue on the project's IRR is limited, thus putting their additionality into question. However, they found renewable projects to generate greater SD co-benefits.

Alexeew et al (2010) also examined the relationship between project's additionality and SD contributions using a sample of 40 registered CDM projects in India. Similar to Sutter & Parreño (2007), they assessed project's additionality based on the impact of CER revenue on project's IRR. As for project's contributions to SD, they used MCA based on 11 social, economic and environmental criteria. They found CER revenue improve the IRR of HFC-23 projects by 30%, but only improve the

[28] CCBS is Climate Community Biodiversity Standard that certifies forestry projects based on their sustainability contributions.

IRR of renewable projects (biomass, hydro and wind) by 5-10%. On the other hand, they found renewable projects have greater SD scoring than HFC-23 projects. As the result, the study drew the same conclusion as Sutter & Parreño (2007) that trade-off exists between additionality and SD contribution at the project level.

Both Sutter & Parreño (2007) and Alexeew et al (2010) found HFC-23 destruction projects display very clear additionality. Consider a HCFC-22 manufacturing facility that has been operating and emitting HFC-23 into the atmosphere for several years. In the absence of national or international environmental law to regulate its emissions, it has little incentive to do otherwise. The ability to generate offsets that can be sold in carbon markets is the only motivation for the plant to invest in HFC-23 abatement. As carbon revenue is the project's sole revenue, its impact on the project's IRR is significant. In addition, as these projects take place in brownfield sites that have a track record of historical emissions levels, establishing baseline is also relatively easy as compared to greenfield projects (Ellis et al., 2007).

Sutter & Parreño (2007) also found landfill gas projects have clear additionality (Alexeew et al (2010) did not analyse landfill gas projects). Similar to industrial gas projects, landfill gas projects that capture and flare methane do not generate alternative revenue, therefore CER revenue is the only incentive to implement the project. However, landfill-to-energy projects which use the captured methane for power generation generate profit from the sale of electricity, thus making the project's additionality less clear. However, projects that use methane for power generation are expected to have greater SD contributions than those simply flare the methane (Cosbey et al., 2005). The trade-off between project's additionality and co-benefits therefore exists within landfill gas projects.

Renewable energy projects generate significant portion of their income from the sale of electricity, thus the impact of carbon revenue on the project's IRR is relatively small which implies that these projects may not necessarily rely on carbon revenue to be implemented, making their additionality questionable (Alexeew et al., 2010; Sutter & Parreño, 2007). In addition, most renewable energy projects are greenfield projects. They do not physically replace exisiting fossil fuel power plants, rather they claim to avoid future hypothetical emissions which may or may not be true (Bumpus, 2011). Thus, establishing hypothetical baseline scenario and emissions require substantial justifications (Ellis et al., 2007).

For household energy projects, their non-carbon benefits means they could be eligible for alternative funding avenues. However, household energy projects that are funded by multiple avenues could experience greater difficulty in demonstrating additionality (Bumpus, 2011).

The additionality of LULUCF projects is often controversial due to the high level of uncertainty associated with the baseline scenario (Broekhoff & Zyla, 2008; Chomitz, 2002). There are too many factors, including national regulation, local socio-economic dynamics and natural events, that could influence land use and its capacity to store carbon (Murray, Sohngen & Ross, 2007). As the result, the baseline is very difficult to predict and many project developers resort to using simplified or convenient baseline which undermine the additionality of LULUCF projects (Seyller et al., 2016; Murray, Sohngen & Ross, 2007; Chomitz, 2002).

3.3.4 Measurement certainty

As previously mentioned, it is important that the amount of ERs generated from an offset project are quantifiable and verifiable. However, for some projects, the generated ERs are materially easier to quantify than others (Bumpus, 2011; Broekhoff & Zyla, 2008). Project types which ERs can be easily measured and verified are industrial gas destruction, landfill gas and renewable projects as they typically involve a centralised point source of ERs (Bumpus, 2011). The volume of industrial gas or methane destroyed at a project site can be easily measured using a gas meter (Broekhoff & Zyla, 2008). For renewable projects, the amount of electricity generated and exported to the grid is recorded for the sale of electricity. The amout is then converted to ERs using the grid emission factor pre-determined in the PDD.

In household energy projects, ERs are achieved through decentralised and dispersed sources, therefore are more difficult to measure (Chomitz, 2002). For example, in a clean stove dissemination project, the amount of ERs achieved by each stove cannot be directly measured but need to be estimated by monitoring a statistical sample of beneficiery households and then applied to the whole population (Bumpus, 2011). Project developers are also required to estimate the amount of non-renewable biomass fraction in the fuelwood and/or charcoal which involves complicated scientific calculation to determine the amount of carbon savings from the stoves (Bumpus, 2011; Lovell & Liverman, 2010). Finally, non-standard usage behaviour across the beneficiery households further complicates the calculation and verification of ERs (Bumpus, 2011; Broekhoff & Zyla, 2008).

Measuring carbon stocks in LULUCF projects is also intrinsically difficult (Broekhoff & Zyla, 2008). To quantify the amount of carbon sequestered requires statistical sampling of biomass in the forests, plantations and soils, and converting the biomass into the amount of carbon stored (Chomitz, 2002). In addition to ground-based data collection and monitoring of project activities, some projects may require remote sensing system to estimate tree coverage which entails high upfront cost (Jindal, Swallow & Kerr, 2008).

Measurement uncertainties associated with household appliances and LULUCF projects incur a negative financial cost on these project types (Broekhoff & Zyla, 2008). To increase the measurement accuracy, projects need to use more rigorous sampling strategies or more complicated modelling methods, which increases transaction costs. Alternatively, project developers may choose to apply the most conservative estimate, which may result in underestimating the amount of ERs realised and reduce carbon revenue.

3.4 Market conditions

3.4.1 Governance of offset creation

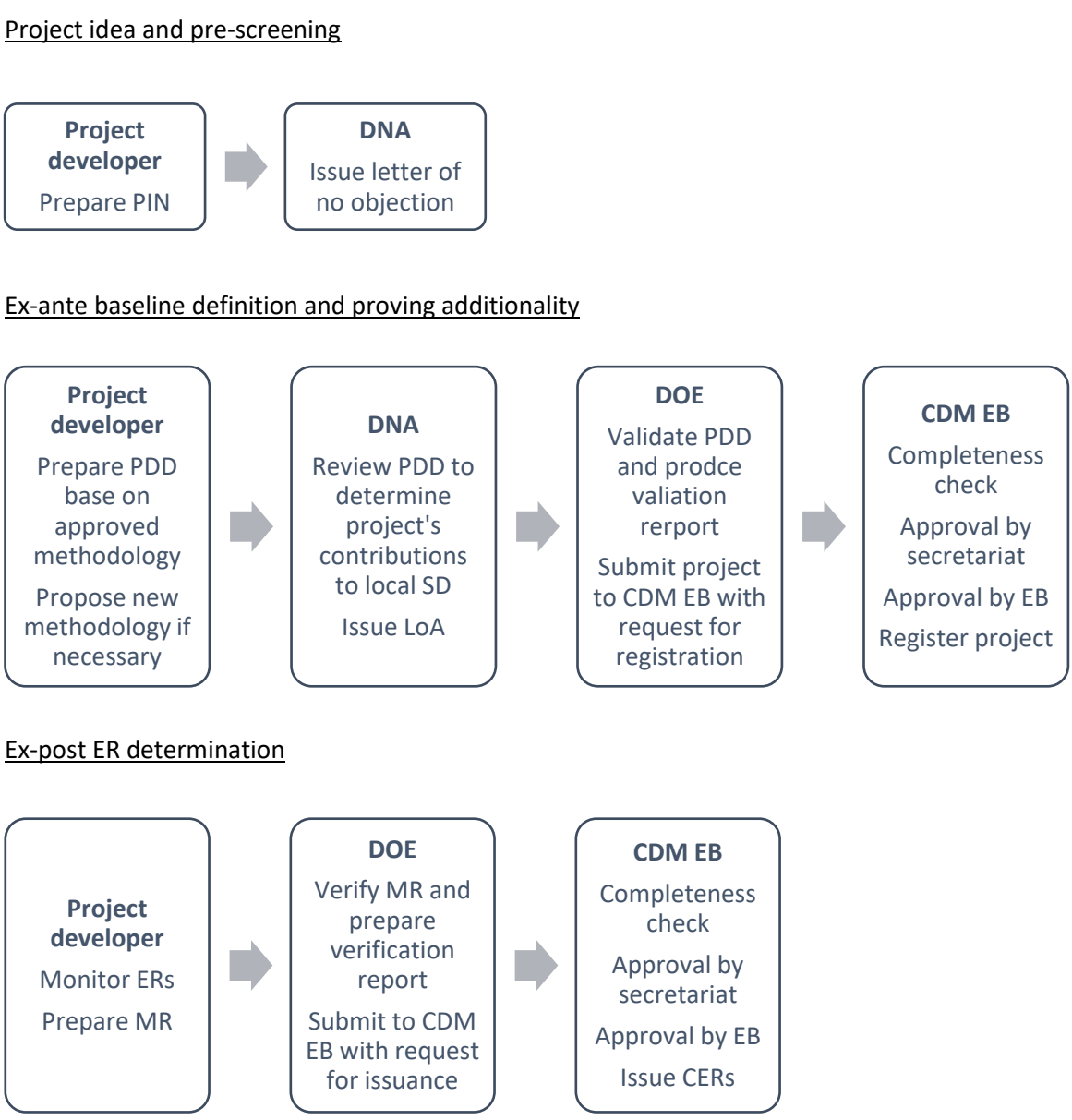
According to Lovell (2010), the governance of carbon offset markets refers to the '*broad processes of framing and managing the production and consumption of carbon offsets, with close attention to how power and authority are exercised by a range of different actors, both state and non-state, to realise their objectives and interests'* (p.2).The key distinction between the governance of CDM and VCM is the amount of bureaucracy involved in the production of fully fungible offsets (Lovell & Liverman, 2010).

The CDM is highly regulated and exhibits multilevel governance structure that incorporate private sector, national and international regulators (Bumpus & Liverman, 2008). The compliance mechanism is administered by the CDM EB set up by the UNFCCC and is regulated by a complex array of rules at the international level. The CDM EB is supported by various committees and working groups (UNFCCC, n.d.d). Under the CDM, CERs are well defined and there are strict guidelines for demonstrating baseline and additionality (Lovell, 2010; Bumpus & Liverman, 2008). Various methodologies for different project types have also been developed by project developers or carbon consultants and approved by the EB.

All CDM projects must be registered with the UNFCCC to receive CERs that can be used by regulated entities to meet their Kyoto compliance targets. Figure 3-4 illustrates the stages that a CDM project has to go through before generating CERs. First, the project developer has to submit a project idea note (PIN) to DNA to ensure no objection to the proposed CDM project. Then, the project developer can start developing the PDD based on the appropriate methodology for his project. The PDD describes the project activity, baseline scenario, additionality, estimated ERs and monitoring plan. The PDD is submitted to a CDM approved auditor called the Designated Operational Entity (DOE) for validation. The project developer also has to obtain a Letter of Approval (LoA) from the project host country's DNA that approves CDM projects based on their contributions to the national SD. After the project is validated, the validation report prepared by the DOE, together with the validated PDD and LoA are submitted to the CDM EB for review and approval. To request for CER issuance, the project

developer has to first prepare and submit a monitoring report (MR) to a DOE for verification. The DOE then prepares a verification report and submits it together with the verified MR to EB for CER issuance.

Figure 3-4: CDM project cycle



Data source: UNFCCC (n.d.b) and UNFCCC (n.d.f)

Throughout the process, the DOE or CDM EB may raise questions about the project that the project developer has to address, which subsequently delays project registration or CER issuance. On average, offset projects could take one to two years to be approved by the CDM EB (Capoor & Ambrosi, 2008). The process is further lengthened if new methodology needs to be developed for the proposed CDM project. The lengthy bureaucratic procedures and high transaction costs have attracted strong criticisms as this creates disincentives for certain project types (Boyd et al., 2007).

Small-scale community-based projects especially do not have the resources or economy of scale to overcome the high transaction cost (Ellis et al., 2007).

The VCM operates outside of compliance markets, therefore the market is unregulated and purely demand-driven. In contrast to the CDM's formal and hierarchical structure, the VCM is more informal and horizontal oriented without a central governing body (Bumpus & Liverman, 2008). Offset organisations that have been active since the early development of the VCM such as Climate Care and the Carbon Neutral Company consider themselves as the market leaders and are actively promoting best practices in the unregulated market (Lovell, Bulkeley & Liverman, 2009). In the VCM, there is no standard definition of voluntary offsets and there are several competing voluntary standards for certifying voluntary projects (Bumpus & Liverman, 2008). Each standard has its own set of rules and criteria for offset generation but most are modelled on the CDM (Bumpus, 2011; Lovell, 2010; Broekhoff & Zyla, 2008). In general, all standards require projects to adhere to the standard's accounting methodology, demonstrate permanent and additional ERs, and prevent double-counting and leakage. Some standards specialise in certain project types, whilst others emphasis on project's SD contributions. Description of popular voluntary standards, their SD requirements and market shares are presented in Table 3-1.

Table 3-1: Voluntary standards

Standard	Accepted project type	Additional co-benefit requirements?	Transacted volume in 2016 (market share in %)	Offset price in 2016
Verified Carbon Standard (VCS)[29] The VCS was founded in 2005 by not-for-profit organisations, The Climate Group and the International Emissions Trading Association (IETA). The standard aims to simplify the CDM procedure but at the same time provide basic assurance to offset quality. The standard becomes the leading international voluntary standard and has accumulated considerable market share over the years. It has also been credited as the early mover for REDD projects, pioneering methodology for REDD projects that have been shun by the CDM. In 2012, VCS registry[30] was approved by California Air Resources Board (ARB) as one of its offset project registries for California compliance CaT. Since November 2014, the VCS has also gained full management of CCBS.	Any except HFC-23 destruction from new HCFC-22 plants.	No The VCS is developing The Sustainable Development Verified Impact Standard (SD VISta) but it is not compulsory for VCS projects to apply for the SD standard.	25.4 $MtCO_2$ (40%)	US$2.3

[29] VCS website: http://www.v-c-s.org/
[30] VCS registry: http://www.vcsprojectdatabase.org/#/home

Standard	Accepted project type	Additional co-benefit requirements?	Transacted volume in 2016 (market share in %)	Offset price in 2016
Gold Standard (GS)[31] The GS was established by WWF in 2003. It has received strong supports from NGOs. The standard has an emphasis on delivering sustainability co-benefits to local communities. Offsets generated under GS are commonly perceived as quality offsets. The standard is used by project developers for market differentiation and to gain premium price in both the VCM and CDM.	Renewable (except large hydro projects >15MW) Energy efficiency LULUCF	Yes	9.9 $MtCO_2e$ (16%)	US$4.6
Climate Action Reserve (CAR)[32] Since established in 2008, CAR has developed several protocols, mostly for US-based projects and some for projects in Mexico. Some of the protocols are later adopted by California ARB to approve offsets that can be used in California compliance CaT. CAR is also one of the approved offset project registries of California compliance CaT.	LULUCF Industrial gas destruction Methane gas destruction Energy efficiency	No	4.4 $MtCO_2e$ (7%)	US$3.0

[31] GS website: https://www.goldstandard.org/
[32] CAR website: http://www.climateactionreserve.org/

Standard	Accepted project type	Additional co-benefit requirements?	Transacted volume in 2016 (market share in %)	Offset price in 2016
American Carbon Registry (ACR)[33] ACR was founded in 1996 by the not-for-profit Winrock International as the world's first private voluntary GHG registry. Similar to CAR, ACR also has a strong focus on the US domestic carbon market and has recently shifted its focus from the VCM to supporting the development of California's compliance CaT. ACR also serves as one of the offset project registries for California compliance CaT.	LULUCF Industrial gas and methane destruction Household energy renewable and energy efficiency Transport	No	1.8MtCO (3%)	US$4.7
ISO-14064 An offset protocol launched by the International Organisation for Standardization (ISO) in 2006. It is a voluntary standard that provides guidelines on quantifying, reporting and verifying GHG inventories or reductions. However, it does not have specific requirements for offset approval. The standard has been used by many regulatory and voluntary schemes as the building block for developing offset standards.	Any	No	2.1 $MtCO_2e$ (3%)	US$0.4

[33] ACR website: http://americancarbonregistry.org/

Standard	Accepted project type	Additional co-benefit requirements?	Transacted volume in 2016 (market share in %)	Offset price in 2016
Plan vivo[34] Plan vivo is an offset project standard for small-scale LULUCF projects with a focus on improving rural livelihoods and ecosystems. It works closely with rural communities to ensure the offset project deliver high level of co-benefits to local community and environment. Plan Vivo certified offsets were first sold in 1997. Although Plan Vivo was initiated much earlier than other offset standards, its project portfolio and market share have remained small as Plan Vivo projects are expensive to implement.	Small-scale community-based LULUCF projects	Yes	0.3 $MtCO_2e$ (<1%)	US$8.0
The Climate, Community & Biodiversity Standards (CCBS)[35] The CCBS was developed by non-profit Climate, Community and Biodiversity Alliance. It is not a carbon accounting standard, rather it is commonly used as an add-on to VCS LULUCF projects to demonstrate the project's sustainability outcomes. CCBS provides guidance that need to be adopted since project design and development stage to ensure delivery	LULUCF	Yes	CCBS + VCS 7.7$MtCO_2e$ (12%)	US$3.9

[34] Plan Vivo website: http://www.planvivo.org/
[35] CCBS website: http://www.climate-standards.org/ccb-standards/

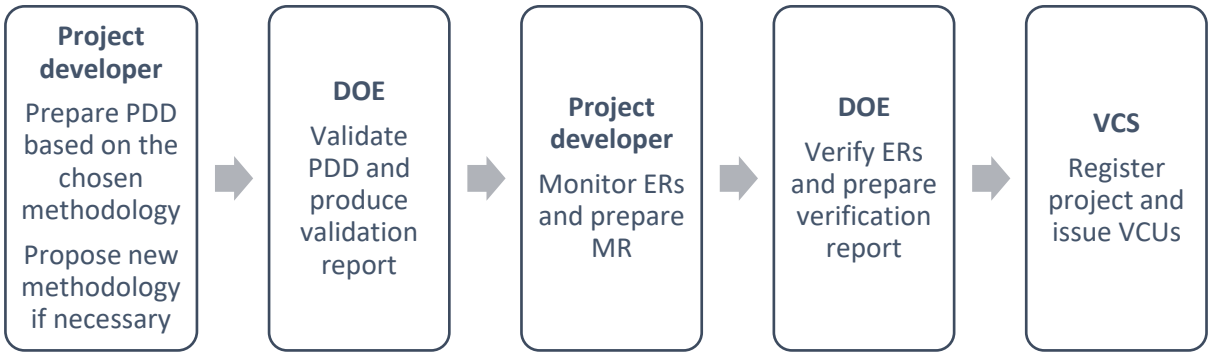
Standard	Accepted project type	Additional co-benefit requirements?	Transacted volume in 2016 (market share in %)	Offset price in 2016
of co-benefits to local community and biodiversity conservation. Since 2014, it is managed by the VCS.				
Social carbon (SC)[36] Social carbon is a co-benefit standard developed by not-for-profit Instituto Ecológica Palmas. Similar to CCBS, it is an add-on sustainability standard that is adopted in conjunction with a carbon accounting standard. SC is linked to Markit environmental registry. Review of the registry shows the number of SC certified projects is small. Only 31 SC projects are listed on Markit environmental registry as of September 2017 and all of the projects are certified in conjunction with VCS.	LULUCF Fuel switching Composting and landfill Hydro	Yes	1.2 $MtCO_2e$ (2%)	US$1.8

Source: ESMP reports (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013; Peters-Stanley et al., 2012; Peters-Stanley et al., 2011; Hamilton et al., 2010; Hamilton et al., 2009; Hamilton et al., 2008; Hamilton et al., 2007), Lovell (2010) and Kollmuss, Zink & Polycarp (2008)

[36] SC website: http://www.socialcarbon.org/

Most voluntary standards have a list of approved auditors known as validation and verification bodies (Kollmuss, Zink & Polycarp, 2008). For a project to generate offsets under its chosen standard, it needs to be approved by the validation and verification bodies. VCS project cycle is depicted in Figure 3-5. It shows the five stages that a project has to go through in order to generate Verified Carbon Units (VCUs). Not only it has less stages than CDM project cycle, it involves almost no state actors. The VCM's freedom from higher institutional levels of governance and regulatory constraints results in a less bureaucratic process and lower transaction cost, thus providing it the capacity to support small-scale community-based projects (Peters-Stanley et al., 2013; Harris, 2007; Taiyad, 2006). Indeed, voluntary market actors often position the VCM as countering some of the problems experienced in the governing of the CDM, in particularly, too much bureaucracy, CDM EB's slow decision-making in project approval and insufficient attention to SD (Lovell, 2010).

Figure 3-5: VCS project cycle



Data source: VCS (n.d.b)

3.4.2 Uniform vs. differentiated offsets

The carbon market is designed to enable cost-efficient GHG mitigation. Therefore, for the market to function as it should, all offsets need to be the same. In other words, they need to be fully fungible and can be traded on a like-to-like basis. To achieve this, offsets need to be actively dissociated from the projects that produce them (Lovell, 2010). The CDM market has been striving to produce uniform offsets from diverse project types through elaborate procedures of calculating, measuring and auditing (Lovell, 2010; Lovell & Liverman, 2010). As the result, the CDM has unintentionally shifted its focus from the fundamental objective of reducing GHG emissions to strengthening the accounting and auditing of ERs (Lovell & Liverman, 2010). Its obsessions with the accuracy of ER calculation and measurement have been criticised for becoming too cumbersome (Lohmann, 2009). The inherent variation in the calculability of ER at project level, combined with the CDM's obsession with the accuracy of ER measurement has led to the prioritisation of project types that can be relatively easy to measure and control such as industrial gas, landfill and renewable projects. On the

other hand, it creates challenges for small-scale projects that deliver greater co-benefits to local communities (Olsen & Fenhann, 2008). In addition, the administrative works of carbon accounting are often conducted in the west by carbon consultants and regulatory officials, away from where the physical project takes place, which often results in a disconnection of offsets from the local social-economic context that generates the ERs (Bumpus, 2011; Lohmann, 2009). The fully fungibility of CERs is shown in the sCDM market where the price of spot CERs is deteremined by supply and demand (Bumpus, 2011).

In contrast to the compliance market that strives to create uniform offsets that are fully fungible, the VCM places greater focus on the story behind offset production (Lovell & Liverman, 2010). In the VCM, offsets are not being treated as homogenous good and there is demand for charismatic offsets that alleviate poverty and protect biodiversity (Peters-Stanley et al., 2014; Peters-Stanley et al., 2013). Information about how and where the offsets are produced is more visible and subject to scrutiny by potential buyers as well as the media (Lovell & Liverman, 2010). Voluntary buyers are particularly attracted to offset projects that have a story to tell, like clean stove projects that improve the living conditions of the poor or REDD projects that conserve local endangered species. This is because voluntary buyers can relate to these 'stories' more easily than projects that capture and destroy industrial gas (Lovell, Bulkeley & Liverman, 2009). As the result, the discourse about how offsets are generated and the co-benefits they deliver are particularly important in the VCM.

3.4.3 Drivers for sustainable development contributions

According to the Marrakesh Accords (UNFCCC, 2001), the task of assessing CDM project's contributions to SD falls on the host country's DNA. Whilst such approach is considered as pragmatic as SD requirements vary across countries, without defining what contributing to SD entails at the KP level and giving the host country the complete prerogative of deciding whether a proposed CDM project contributes towards local SD have yielded undesirable outcomes.

Firstly, variations in SD assessments across host countries are expected as different countries have different development priorities (Olsen & Fenhann, 2008; Ellis et al., 2007). However, this has also led to different levels of stringency in SD assessment and the phenomenon known as a 'race to the bottom' as host countries compromise long-term SD benefits to attract short-term FDI (Boyd et al., 2009; Sutter, 2003; Kolshus et al., 2001). In addition, DNA's decisions in approving projects often lack transparency (Ellis et al., 2007) and project approval may be influenced by the more powerful stakeholders (Olsen, 2007).

Secondly, the institutional set up and capability of DNA vary across CDM host countries with many African countries lagging behind (Ellis et al., 2007). Setting up national DNA to oversee the CDM can

be cumbersome and many poorer countries do not have the resources to set up such institutional infrastructure. As the result, there is a lack of capacity to identify and assess potential CDM projects in these countries as well as a lack of awareness of the benefits of the CDM in financing potential development projects. Such institutional barrier has prevented a more widespread of CDM projects in the African region and LDCs (Ellis et al., 2007).

Lastly, SD assessments are generally done through the review of PDDs (Olsen & Fenhann, 2008). The PDD presents SD co-benefits that are expected to be realised, which may be subjected to the project developer or consultant's exaggeration to make the project more attractive. Whether the claimed co-benefits are being followed through during project implementation remains questionable as SD components of CDM projects are not subjected to ex-post monitoring and verification process (Nussbaumer, 2009; Olsen & Fenhann, 2008). After reviewing the PDDs of 65 CDM projects in India, Sirohi (2007) commented that '*PDD offer just lip service regarding expected contribution to socio economic development of the masses, particularly in rural areas*' (p.104).

Offset projects developed under the VCM do not require approval from the project host country although most standards may require the project to comply with local regulations (Corbera, Estrada & Brown, 2009). Nevertheless, standards with a focus on project's SD contributions such as GS, CCBS and SC have been developed in the voluntary space that enable the measurement and verification of offset project's co-benefits. Adoption of such sustainability standards increases transaction cost but anecdotal evidence shows demand and WTP a premium price exists in the VCM for offsets that are differentiated by sustainability standards (Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013). Therefore, the VCM's support for offset projects that deliver SD co-benefits and voluntary adoption of sustainability standards are mainly driven by demand from investors.

3.5 Conclusions

This chapter examines in detail factors that influence carbon market's potential in promoting SD. Trade-offs between characteristics that are inherent to specific project types are among the contributing factors. These project characteristics and trade-offs are summarised in Table 3-2. It shows low-hanging fruits of carbon markets, mainly industrial gas and landfill gas projects inherently have fewer SD co-benefits. However, the materiality of their ERs as defined by additionality and measurability are more obvious than other project types. On the other hand, project types that have greater SD contributions face challenges in demonstrating ER materiality. In particularly, the additionality of renewable projects is difficult to substantiate as carbon revenue only constitutes a small portion of project's income. Renewable projects are also more capital intensive and have

longer lead time, therefore are not as cost-efficient as industrial gas projects in mitigating GHGs. Household energy projects may be cost-efficient but their resultant ERs are dispersed and difficult to quantify. LULUCF projects face both additionality and measurement uncertainties, as both the baseline and amount of carbon sequestered are difficult to determine. Furthermore, LULUCF projects also have leakage and permanence issues.

These project-level trade-offs, combined with market conditions can determine a carbon market's ability to promote SD as illustrated in Table 3-3. The CDM, in its attempt to protect the integrity of the compliance market, has devised stringent additionality assessment and ER calculation. However, no equal emphasis has been placed on the SD element. From a compliance buyers' perspective, they are being penalised for falling short of achieving their ER target within the set commitment period but not for failing to contribute towards SD. Therefore, expectedly, they favour cheap, low-risk and high-volume projects such as industrial gas projects (Boyd et al., 2007; Ellis et al., 2007). In a market where only the carbon element is commoditised and enforced, it is expected that the market will prioritise ERs over SD contributions (Olsen, 2007). This is also an indication that the market that is designed for efficiency is functioning as it should be as ERs are achieved where they are cheapest (Ellis et al., 2007). However, the CDM's support for cheap large-scale ERs have secondary impacts. Firstly, flooding the market with large volume of cheap offsets will deter investments into renewable and household energy projects (Ellis et al., 2007). Unlike industrial gas and landfill gas projects, renewable and household energy projects have greater replicability, therefore can facilitate long-term transition to low-carbon development (*ibid*). Secondly, there are concerns that the CDM will exhaust cheap abatement options in developing countries and when these countries are also required to regulate their GHG emissions in the future, they will be left with the more expensive options (Olsen, 2007).

In the VCM, the materiality of carbon offsets is mostly realised through the narrative of offset production that connects offset buyers to offset projects (Lovell & Liverman, 2010; Lovell, Bulkeley & Liverman, 2009). Therefore, in contrast to the CDM's 'top-down' approach, the VCM is 'bottom-up' with greater focus on the diversity of offset project types (Lovell & Liverman, 2010). The voluntary nature of the market also provides it the opportunity to experiment with projects that are shun by the CDM, such as LULUCF projects. Despite the complex nature of LULUCF projects that make them risky in terms of offset delivery, demand for forestry offsets exists among voluntary buyers due to their desire to invest in pro-poor development and environmental conservation projects (Benessaiah, 2012). Thus, voluntary buyers' demand is a strong driver of the market's support for promoting local SD.

Table 3-2: A summary of offset projects' inherent characteristics

	Industrial gas	Landfill gas	Renewable	Household energy	LULUCF
SD contributions	**Low** Industrial gas projects generally only involve end-of pipe treatment of GHGs, thus they have very limited co-benefits.	**Medium to low/negative** Landfill gas projects generally improve waste management and reduce localised pollutions. Projects that capture and use methane for power generation also provide clean energy. However, some controversial landfill gas projects generate co-costs to the surrounding residents.	**Medium to high** Renewable projects generate employment and improve air quality at the local level, as well as promote technology transfer, energy security and BoP at the national level. Off-grid renewable projects are expected to deliver greater co-benefits, especially to rural communities.	**High** Household energy projects generate direct benefits to the beneficiary households including reduced dependency on traditional dirty fuel, health benefit associated with improved indoor air quality, reduced drudgery of sourcing fuelwood or water, and alleviation of pressure on local forests.	**High to low/negative** Co-benefits of LULUCF projects are highly context-specific due to the large variation in project designs. Well-design community-based projects are expected to generate high number co-benefits, including poverty alleviation, improved food security, women and children empowerment, and local ecosystem and biodiversity protection. Poorly designed or executed projects may generate co-costs.

	Industrial gas	Landfill gas	Renewable	Household energy	LULUCF
Potential contributions to SDGs *In addition to SDG 13 – climate action	None	SDG 11 – sustainable cities and communities SDG 7 – affordable and clean energy (where use of methane for power generation is involved)	SDG 3 – good health and well-being SDG 7 – affordable and clean energy SDG 8 – decent work and economic growth SDG 9 – industry, innovation and infrastructure	SDG 3 – good health and well-being SDG 4 – quality education SDG 5 – gender equality SDG 6 – clean water and sanitation SDG 7 – affordable and clean energy SDG 15 – life on land	SDG 1 – no poverty SDG 2 – zero hunger SDG 4 – quality education SDG 5 – gender equality SDG 15 – life on land
Cost-efficient mitigation	**High** The high GWP of industrial gases combined with the low upfront investment costs make these projects highly cost-effective.	**High** The high GWP of methane makes landfill gas projects cost effective.	**Medium to low** The high upfront investment cost, especially for wind and solar projects and relatively low ERs makes renewable projects less cost effective.	**High** Household energy projects general entail low investment cost and therefore are cost effective.	**High to low** Implementation cost is highly context specific. Community-based projects that have greater SD co-benefits are expected to be more expensive.

	Industrial gas	Landfill gas	Renewable	Household energy	LULUCF
Likelihood of being additional	**High** Carbon revenue is the only incentive to abate GHGs, therefore industrial gas projects are highly additional.	**High to medium** Landfill gas projects that capture and flare methane are highly additional as the sale of offsets is the only revenue, however projects that use the methane to generate power reduces the project's likelihood of being additional.	**Low** Renewable projects generate considerable revenue from the sale of electricity and the impact of carbon revenue on the project's IRR is marginal, thus putting the additionality of RE projects into question.	**High to medium** The likelihood of household energy projects being additional is relatively high unless the project also receives alternative funding avenues.	**Low** Additionality of forestry projects is controversial due to the difficulty of establishing baseline scenario. There are too many factors that could affect land use and the rate of deforestation which are difficult to account for in the baseline.
Measurement certainty	**High** Industrial gas projects have point source ERs that can be measured straightforwardly using a gas meter.	**High** Landfill gas projects also involve point source ERs that can be measured using a gas meter.	**High** Renewable projects also represent point source ERs and their generated electricity can be measured and converted into ERs using local grid emission factor.	**Low** Household energy projects involve multiple and disperse sources of ERs, therefore are difficult to monitor the resultant ERs.	**Low** Determination of carbon sequestered in a forestry project is intrinsically difficult and involves complex calculation and modelling.

Source: Author's own

Table 3-3: A summary of factors that affect carbon market's ability to promote SD

Project's inherent trade-off	**The CDM**	**The VCM**
Cost-efficient mitigation vs. SD contributions	Monetisation and enforcement of carbon element but not the SD element has resulted in the market prioritising ERs over SD contributions.	Strong emphasis on offset co-benefits to promote uptake of voluntary offsets.
Additionality vs. SD contributions	Stringent requirements for baseline and additionality demonstrations create favourable conditions for projects that have clear additionality but limited SD contributions such as industrial gas and landfill gas projects.	Less stringent project requirements due to the voluntary nature of the market allows projects which additionality is difficult to demonstrate, such as LULUCF projects to participate in carbon market.
Measurability vs. SD contributions	Strive for accurate carbon accounting has unintentionally incentivised projects which ERs are difficult to quantify and verify such as household energy projects that deliver a range of co-benefits to local communities.	Less vigorous carbon accounting requirements due to the voluntary nature of the market, thus reduces transaction costs and benefits household energy and LULUCF projects which ERs are difficult to quantify but generate a range of co-benefits to local communities.

Source: Author's own

Overall, findings in this chapter show that from theoretical point of view, the VCM is expected to have greater capacity than the compliance CDM to promote SD. However, this is yet to be demonstrated using empirical evidence. This gives rise to research sub-questions 3.1 to 3.3 that are being investigated in the primary research of the present study. In particularly, this study develops a novel database of voluntary offset projects to investigate the project types and locations that the VCM supports and if they are different from those promoted by the CDM.

Furthermore, this chapter finds that VCM's investment in offset projects that promote local SD is strongly driven by demand from voluntary offset buyers due to their unique motivations that are different from their compliance counterparts. The motivations of voluntary offset buyers and their demand for offset SD co-benefits are further explored in the following chapter.

Finally, it is important to note that this study recognises that generalisation of SD contributions and other characteristics by project types may not always be true. Through an illustrative review, Boyd et al. (2009) argued that there is no causual relationship between projects types and SD contributions. Corbera, Estrada & Brown (2009) has also highlighted that many studies that conclude project type is a determinant of SD contributions are mostly based on desk-based analysis of PDDs and further field-based research is required to validate such a claim. Nevertheless, the tension within the carbon market between abating GHG emissions efficiently at the global level and promoting SD at the local level is unquestionable and needs to be addressed (Ellis et al., 2007).

4 Voluntary buyers' motivations and preferences

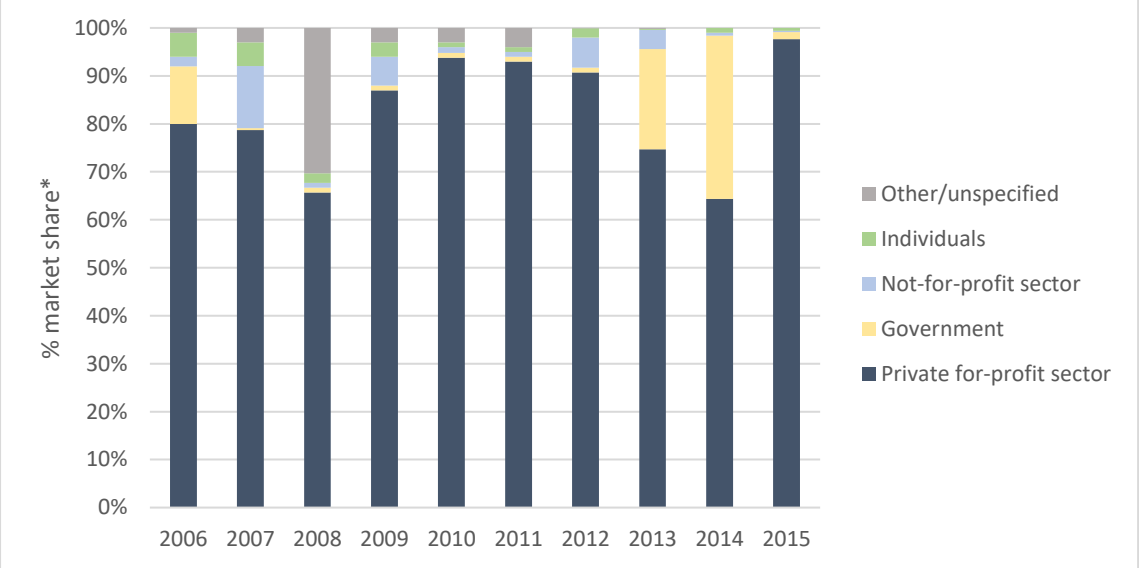
Customers of the VCM are made up of organisations from private for-profit, public and not-for-profit sectors, as well as individuals. Voluntary offset consumers purchase offsets to compensate a wide range of activities, from an individual compensating his flight emission to an organisation compensating the whole of its operational emission or an event organiser making a high-profile international event carbon neutral such as the Olympics and World Cup. Its voluntary nature means the market is mainly demand driven. In the past, buyers' demand for credible offsets has driven the market to self-regulate through independent standards and registries. In the more recent years, voluntary buyers are increasingly differentiating offsets based on their SD co-benefits. Voluntary buyers' demand for quality offsets helps drive the market to invest in offset projects that have positive impacts on local communities. Voluntary buyers' demand for offset co-benefits could be attributed to their unique motivations for voluntary offsets. For example, corporate buyers are actively seeking voluntary offsets that also deliver social and environmental co-benefits to improve their brand image. To better understand voluntary buyers' demand for offset co-benefits, this chapter examines the different types of buyers, their motivations for purchasing offsets, and the relevance of offset co-benefits in the context of their motivations.

4.1 Voluntary buyers

4.1.1 Buyer types

Figure 4-1 depicts VCM's market shares by buyer types. Over the years, private for-profit sector has been the main source of demand for voluntary offsets. This buyer group includes offset retailers who are prominent buyers of voluntary offsets but are not offset end-users themselves. Based on ESMP report series, between 2007 and 2015, offset retailers were responsible between 14% to 51% of the annual market transacted volume. Some of these offset retailers are operating in the not-for-profit sector. This study only concerns with offset end-users who purchase and retire offsets against their emissions as they represent the underlying demand of the market. Excluding offset retailers, organisations in private-for-profit sector that purchase offsets to retire against their emissions remain the VCM's biggest buyer (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015).

Figure 4-1: VCM's market shares by buyer types



Data source: ESMP reports (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013; Peters-Stanley et al., 2012; Peters-Stanley et al., 2011; Hamilton et al., 2010; Hamilton et al., 2009; Hamilton et al., 2008; Hamilton et al., 2007)
*Market shares for year 2006 to 2013 are based on volume of offset contracted whilst for year 2014 and 2015, it is based on value of offset transacted. No data is available for year 2016.

In comparison to private for-profit sector, the market shares of public and not-for-profit sectors are considerably smaller. The unusually high public sector's market shares in 2013 and 2014 were attributed to the large government-to-government REDD Early Movers agreement[37] that took place in the respective year. Both governments and not-for-profit organisations often participate in offsetting to demonstrate that they are taking personal responsibility for their climate impacts and that they are 'walking their talk' (Kollmuss, Zink & Polycarp, 2008; Taiyad, 2005).

The market share of individuals is often made up of a large number of very small transactions as GHG emissions associated with individual activities tend to be small in volume (Peters-Stanley et al., 2012). Some individual purchases have also been captured by private for-profit sector as companies procure and bundle offsets into their carbon neutral products or services, and the cost of offsetting is passed on to the end users who are willing to pay a premium price for climate neutral products and services (*ibid*). Individuals' demand for voluntary offsets is key to the VCM as in addition to being a primary demand for the market, their demand for climate neutral products and services can

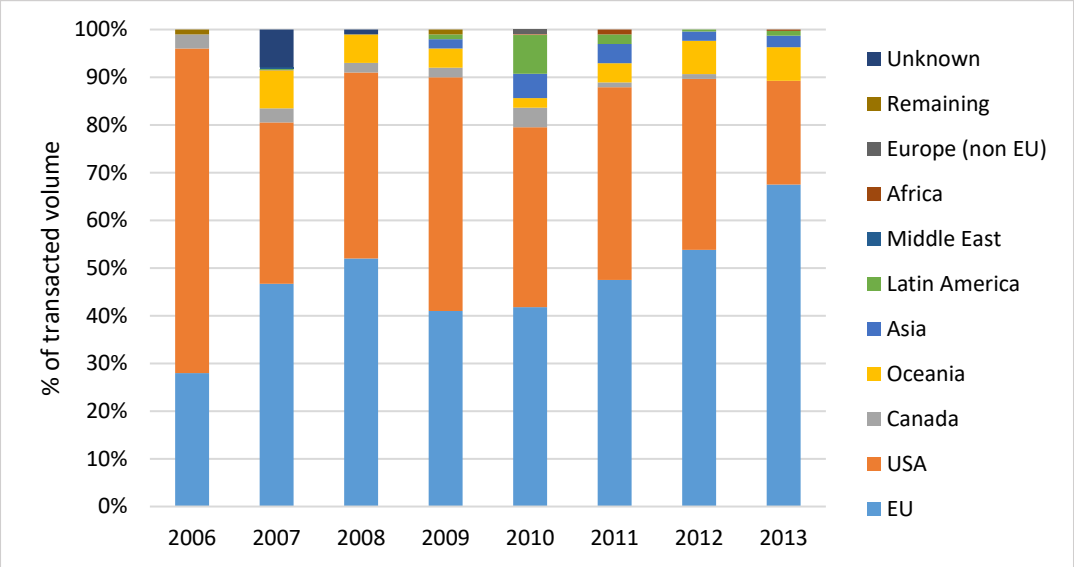
[37] In 2013, Germany made a bilateral deal with Brazilian state of Acre to deliver 8MtCO_2e ERs from a REDD programme (Peters-Stanley et al., 2014). In 2014, Norway contracted 10MtCO_2e ERs from a REDD programme in Ecuador (Hamrick, Goldstein & Peters-Stanley, 2015). However, from 2015 onwards, ESMP has not included these result-based payments among governments as part of the VCM as they do not involve transfer of ER ownership and the funder does not intend to retire them against their own emissions (Hamrick & Goldstein, 2016).

drive organisations to increase their participation in voluntary offsetting for positive public image (Harris, 2007).

4.1.2 Buyer location

Figure 4-2 illustrates VCM's market shares by buyers' locations. It shows EU is the most prominent source of demand for voluntary offsets, whilst the US is the single country with the largest demand for voluntary offsets. Trailing behind Europe and the US are Canada, Australia and New Zealand. Demand from the rest of the world remains limited. This is expected as ERs that take place in developing countries are often less costly than in developed countries (Bumpus & Liverman, 2008). Thus, demand for carbon offsets is likely to come from high-income developed countries whilst developing regions, such as Asia, Latin America and Africa are more commonly known as the supplier of carbon offsets.

Figure 4-2: VCM's market shares by buyers' locations

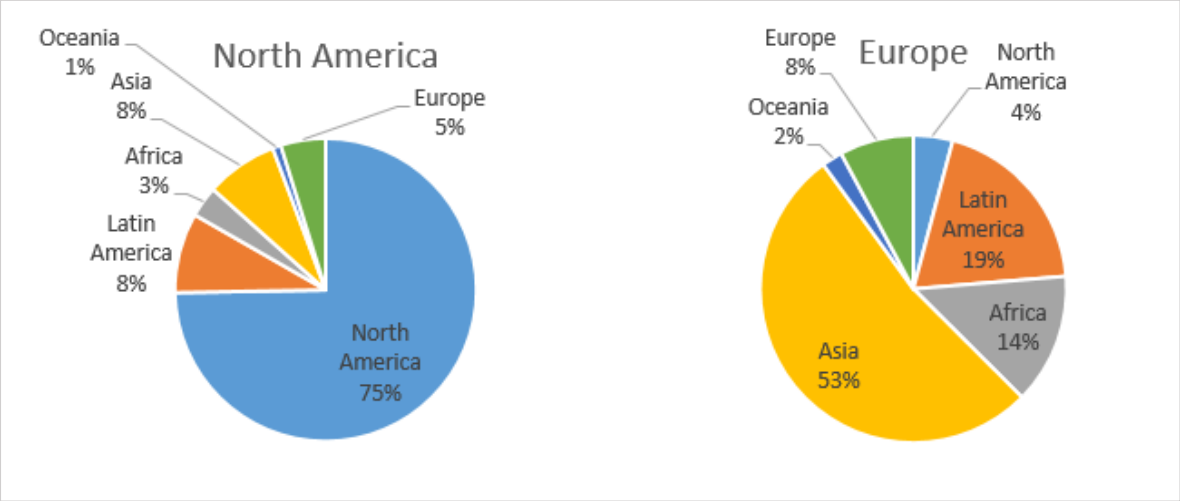


Data source: ESMP reports (Peters-Stanley et al., 2014; Peters-Stanley et al., 2013; Peters-Stanley et al., 2012; Peters-Stanley et al., 2011; Hamilton et al., 2010; Hamilton et al., 2009; Hamilton et al., 2008; Hamilton et al., 2007). Data not available from 2014 onwards.

Europe is responsible for nearly half of all voluntary demand over time (Goldstein, 2015). Many businesses that take part in voluntary offsetting in this region are domestic small-to-medium sized enterprises (SME) that are not regulated under the KP (Peters-Stanley et al., 2013). Therefore, the VCM can be seen as a complement to Kyoto market by extending mitigation efforts to beyond the compliance regime. The presence of compliance market in the region helps promote participation in voluntary offsetting by raising public awareness about climate change issues and the use of market-based mechanism as a viable way to abate GHG emissions (Hamrick, Goldstein & Peters-Stanley, 2015; Goldstein, 2015; Taiyad, 2006). European voluntary buyers source majority of their offsets

from developing regions, especially Asia, Latin America and Africa as shown in Figure 4-3. They also source offsets within Europe, mainly from Turkey that is not participating in the CDM[38], as well as offsets from North America which are perceived as lower-risk to counterbalance buyer's portfolio of riskier African and Southeast Asian projects (Peters-Stanley et al., 2011; Hamilton et al., 2010).

Figure 4-3: Locations of offsets sourced by North America and Europe between 2007 and 2014



Data source: Hamrick & Goldstein (2015)

Unlike its European counterpart, the US market reflects more of a closed market as it sources most of its offsets domestically as shown in Figure 4-3. As the result, the US is a major offset consumer as well as supplier. Much of the investments in the US VCM have been driven by the anticipation of national or regional carbon CaT system. For example, expectation of the Waxman-Markey's national CaT system that was planned to allow the use of up to 2 billion tonnes of offsets per year spurred interest in domestic offsets, especially landfill gas projects that were speculated to be eligible for the national CaT scheme (Hamilton et al., 2010). The bill was passed in the US House of Representative in June 2009 but failed to reach the Senate (*ibid*). This caused a drop in the transacted volume and price of US-based landfill gas offsets in the following years (Peters-Stanley et al., 2012; Peters-Stanley et al., 2011). As federal legislations lack progress, pre-compliance offset buyers and investors turn their attention to regional CaT system, namely the California CaT and subsequently, interest in eligible offsets generated from ozone-depleting substances destruction, forestry and livestock methane projects increases (Peters-Stanley et al., 2012; Peters-Stanley et al., 2011). As California CaT went live in 2013, millions of pre-compliance offsets that were previously considered as

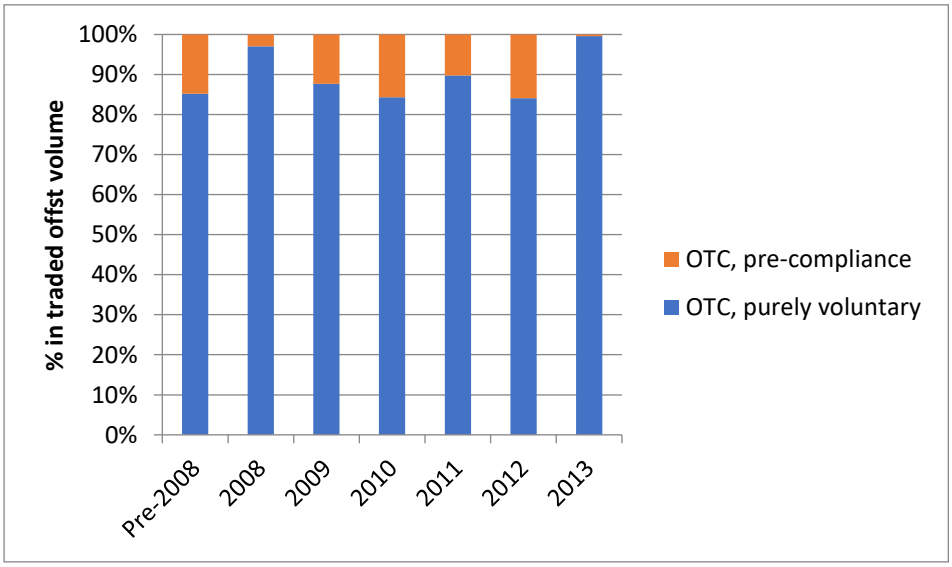
[38] Under the KP, Turkey is considered an Annex I country but it does not have an official cap on its GHG emissions due to its special economic circumstances. It is also not eligible to host CDM or JI projects. For detailed discussion regarding Turkey's position under the KP, refer to Erdogdu (2010)

voluntary turned into compliance offsets and the US VCM experienced a significant drop in both transacted volume and price due to the absence of higher-priced pre-compliance offsets (Peters-Stanley et al., 2014). Besides pre-compliance buyers, many multinational corporations in the US such as Microsoft, the Walt Disney Company and Chevrolet are major, high-profile voluntary offsetters (Peters-Stanley et al., 2014). Multinational corporations are more likely to source offsets from developing countries as part of their wider CSR strategy (*ibid*).

4.1.3 Pre-compliance vs. purely voluntary

Based on offsetting motive, voluntary buyers can be broadly separated into 'pre-compliance' and 'purely voluntary' buyers. Pre-compliance buyers invest in offsets that are likely to be eligible in a future regulated CaT system. They could be entities that will be regulated in the future or financial institutions with the intention of reselling them at a higher price to regulated entities in the future (Hamilton et al., 2009). Purely voluntary buyers purchase offsets simply to compensate their own GHG emissions. Figure 4-4 illustrates volumes of voluntary offset transaction by buyers' motivations. It shows majority of voluntary offsets transacted are for purely voluntary purpose. Pre-compliance transactions cease after the California CaT becomes live since January 2013 as the previously voluntary 'pre-compliance' transactions become compliance.

Figure 4-4: Year-on-year transactions by buyers' motivations



Data source: Peters-Stanley (2014). Data not available from 2013 onwards.

Whilst the intentions of pre-compliance buyers are either regulatory or economic driven, the motivations underlying purely voluntary offset purchases are less clear. The yearly ESMP's survey on the VCM reveals that demonstrating CSR is a prevalent purchasing motivation for purely voluntary buyers. In the recent decades, climate change has emerged as a critical risk that businesses have to

address in their strategic management (Lash & Wellington, 2007). A number of companies have made voluntary commitments to manage and reduce their GHG emissions (Goldstein, Peters-Stanley & Gonzalez, 2016). A carbon management strategy typically starts with calculating the organisation's operational related emissions, followed by abatements through installing energy efficient measures, purchasing renewable energy and engaging their employees to reduce emissions. Offsetting tends to be the last resort to abate the residual emissions to meet the internally set reduction target or become carbon neutral (Ceppi, 2006).

Other motivations for voluntary offsetting include demonstrating leadership on climate change, pursuit of GHG emission targets and public relation/brand image (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015), green product offering to gain market advantage (Peters-Stanley et al., 2013), employee engagement on the cost of carbon emissions (Hamilton et al., 2009) or tendering as some companies in developing countries are required to purchase offsets by their multinational corporate clients who intend to green their supply chain (Peters-Stanley et al., 2012). This shows that motivations underlying organisations' participation in the VCM are diverse but mostly overlap with CSR. It also shows that most organisations are driven by motivations beyond merely taking responsibility of their climate impacts. Rather, they are expecting some returns in the form of enhanced reputation, positive public image or market differentiation.

4.2 A review of existing studies on voluntary carbon offsetting

4.2.1 Theoretical studies

From an economist's point of view, voluntary carbon offsetting can be considered as a form of private contribution to environmental public goods. The benefits derived from climate change mitigation is non-excludable and non-rivalrous, therefore are subject to free-riding. Private contribution to public goods on a voluntary basis is a prominent area of research in the field of economics. Among existing economic literature that focus on the motivations underlying private provision of public goods, two main theoretical models emerge: pure altruism model and impure altruism model (Kotchen, 2009b). In the pure altruism model, agents contribute towards public goods only to benefit from the increase aggregate level of the public goods. Thus, the model predicts that private and government's provisions are perfect substitute and government's provisions will completely crowd out, dollar-for-dollar, private contributions (Bergstrom, Blume & Varian, 1986). In addition, as the economy grows and the number of individuals approach infinite, free-riding dominates and the average level of giving converges to zero (Andreoni, 1988). However, empirical observations often do not conform to these theoretical predictions and private provisions often exceed the level predicted by the pure altruism model (Andreoni, 1990; Andreoni, 1988). This

indicates that individuals derive additional private utilities that drive them to contribute towards public goods beyond the level they would have contributed if they were pure altruists. Andreoni (1990) famously attributes this apparent paradox to the 'warm glow of giving'. Other explanations of non-altruistic motives for private contribution to public good include social approval (Holländer, 1990), prestige (Harbaugh, 1998) and internalised norm (Nyborg, Howarth & Brekke, 2006). The impure altruism model reconciles the difference in the observed level of private provision to the level predicted by pure altruism model, thus provides better understanding and predictions of voluntary contribution to public goods.

Research on private provision to public goods specifically in the context of environmentally offsetting has only emerged in recent years. Environmental offsetting such as carbon offsetting and biodiversity offsetting has one distinctive feature that sets it apart from other forms of private contribution to public goods such as donating to charities, giving bloods and volunteering, which is the level of contribution is equivalent to the level of public good consumed by the private entity. Kotchen (2009b) describes environmental offsetting as '*voluntary provision of public goods for bads*' (p.883). This suggests that one's contribution to the public good is motivated by the idea of compensating or neutralising the damage (or negative externality) caused in the first place. This is in line with the polluters-pay-principle as private entities internalise the environmental cost of their actions but on a voluntary basis.

One of the earliest theoretical studies on environmental offsetting is by Vicary (2000) who modified the impure public good model to account for impure public bad and examined what happen to donations in a large economy. He found that a substantial proportion of the population can be donors in a large economy and direct provisions do not converge to zero when the economy grows large. Kotchen (2009b) also developed a model based on the same basic idea. His study confirms Vicary (2000)'s finding that in large economies, environmental offsets will always persist as compensating for consumption of the polluting good becomes even more important. Kotchen (2009b) also demonstrated that individuals' direct donations and net contributions depend on wealth and heterogenous preferences, with some individuals will purchase offsets whilst others will not, but both offset users and non-users can still have either a net positive or negative impact on emissions.

Lange & Ziegler (2012) developed a model for individual offsetting behaviour based on individuals are impure altruists who may have internalised a norm to avoid pollution. If an individual has developed an internalised norm and does not act according to the norm, that individual will experience disutility or a sense of self-sanctioning such as guilt, low self-esteem or bad conscience

(Nyborg, Howarth & Brekke, 2006). Baron (2010) describes such behaviour as '*morally motivated self-regulation*'. Consumers with internalised norm often regard themselves as socially responsible individuals (Brekke, Kverndokk & Nyborg, 2003). Studies show that environmental friendly behaviours such as recycling and consuming green goods are often associated with internalised norm (Nyborg, Howarth & Brekke, 2006; Brekke, Kverndokk & Nyborg, 2003).

Lange & Ziegler (2012)'s model shows that increase in the individual's feeling of personal responsibility for the environmental pollution can affect the purchase of offsets or decrease consumption of the polluting good. In addition, their model shows that purchase of offsets increases with income and then decreases, which resembles the Kuznets curve effect for an effective pollution level. They found that the use of offsets does not necessarily lead to an increase in consumption of the polluting good, rather the availability of offsets will reduce the effective environmental pollution level. Lange & Ziegler (2012) also examined the relationship between carbon offsetting and alternative mitigation activities to reduce carbon emissions. Their found that initially, only the mitigation channel will be used, but for sufficiently large feeling of pollution responsibility, individuals will extend to the purchase of offsets but potentially will not further increase the use of the mitigation channel or reduce consumption of the polluting good.

Blasch & Ohndorf (2015) used empirical data derived from a CE to test the validity of impure altruism model in predicting voluntary offsetting behaviour. They found that the impure altruism model that incorporates internalised norm is sufficient to explain the level of WTP for voluntary offsets, but not the propensity to purchase voluntary offset. To explain the propensity to offset, the model needs to be extended to include social approval as one of the motivations. Social approval or social norm is different from internalised norm as it is sanctioned externally. Individuals act according to the social norms to be accepted or to avoid disapproval by their social peers (Holländer, 1990). Bicchieri & Xiao (2009) found that empirical expectation, what we expect others to do, plays an important role in individual's decision making as we often do the right thing when others do so too. Blasch & Ohndorf (2015) conclude that to investigate individual voluntary offsetting behaviour, a combined model that incorporates both internalised norm and social approval is required.

4.2.2 Empirical studies

A search of literature shows there is a growing number of empirical studies that investigate the demand for voluntary offsets. Many studies attempt to elicit individual's WTP for offsets using SP preference methods such as CVM and CE, including Blasch & Farsi (2015), Diederich & Goeschl (2014), Lu & Shon (2012), Mackerron et al. (2009) and Brouwer, Brander & Van Beukerting (2008). The estimated WTP values range from €6.30 (Diederich & Goeschl, 2014) to €25 (Brouwer, Brander

& Van Beukering, 2008) per offset. Based on a WTP of €25 per offset, Brouwer, Brander & Van Beukerting (2008) estimated contributions from air travellers to offset their flight emissions could generate around €23 billion to finance GHG ER projects. In reality, however the uptake of voluntary offsets by air travellers is very low, only in the magnitude of 2 to 10% of air travellers (Mair, 2011). This is expected due to the voluntary nature of the scheme which means individuals are likely to free-ride, especially if the perceived individual contribution is marginal (Kotchen, 2009a). Many studies have instead focused on the underlying determinants for positive WTP. Review of these studies indicates that individual offsetting behaviour is heterogenous. Factors that contribute to positive WTP for offset are described below.

Internalised norm. Through a survey of international air passengers at Amsterdam Schiphol airport, Brouwer, Brander & Van Beukering (2008) found respondent's awareness of the climate impact of flying and recognition of own contribution to the impact are the main underlying factors of their positive WTP for a mandatory carbon tax to compensate their flight emissions. Lindman, Ek & Söderholdm (2013) also found that awareness of climate change problem and recognition of personal contribution to the problem have positive impact on Swedish students' WTP to reduce GHG emissions through purchase and retirement of EUAs under the EU ETS. Jacobsen (2011) found a positive causal relationship between viewing of Al Gore's documentary, An Inconvenient Truth and households' purchase of voluntary offsets, indicating raising climate change awareness have a positive impact on offsetting behaviour. However, he found such effect to be short-lived as there is little evidence that shows households that purchase offsets due to the film have repeated such purchase in the following year. Through an internet survey of German voters, Diederich & Goeschl (2014) found acknowledgement of personal contribution to climate change has a positive impact on respondents' WTP to retire an EUA under the EU ETS. These studies collectively show that awareness of the environmental problem and recognition of own contribution to the problem contribute positively to individuals' WTP.

Social norm. Review of empirical studies show that social norm can affect individual's purchase of offsets in two ways. Some individuals may purchase offsets to maintain a self-image as a responsible person and to be approved by his social circle, whilst others may purchase offsets if they perceive majority of the people also purchase offsets as they feel the need to contribute their fair share (empirical expectation, also being described as conditional co-operators by Blasch & Farsi (2014)). Blasch & Ohndorf (2015) conducted a survey on Switzerland and the US residents' WTP to offset different consumption activities and found that respondents' WTP amount is mainly driven by internalised norm to avoid carbon emissions, but their propensity to purchase offset is influenced by social recognition by their peer group.

As voluntary contribution to climate mitigation is subject to free-riding, collective participation effect may play a part in an individual's decision to purchase offset. The free-riding problem is particularly significant for individual offsetting as individual contributions tend to be small, especially in comparison to the scale of ERs required to curb climate change. Therefore, individuals may question if their contributions make any difference in addressing climate change problem (Kotchen, 2009a). Brouwer, Brander & Van Beukering (2008) attributed the poor performance of numerous voluntary flight offset schemes to the free-riding issue, whilst Lu & Shon (2012) found, through a survey of international air travellers at the Taiwanese international airport, that air travellers are more willing to pay for offset if the responsibility for reducing GHG emissions is shared between them and the airlines. On the other hand, Araghi et al (2014) found collective participation rate has no statistically significant impact on the WTP for offset among air travellers surveyed at two Dutch airports.

Other motivations. In addition to the presence of norm, individual's WTP for offsets to abate GHG emissions could also be driven by altruistic motives or perceived personal benefits from climate mitigation. For example, Brouwer, Brander & Van Beukering (2008) found air passengers' WTP for carbon tax to fund offset projects are also motivated by their concerns for the environment and future generations (existence and bequest values). Those who perceived climate change as a risk are also willing to pay for climate mitigation to avoid such a risk (personal benefit). Diederich & Goeschl (2014) also found respondent's perceived benefits from climate mitigation for themselves and for future generations have a positive impact on their WTP to reduce GHG emissions, with altruistic motivation (benefit to future generation) outweighs personal benefit. Interestingly, this study also found exogenous environmental factors to have an impact on WTP, with ambient temperatures around the time of the experiment positively affect WTP.

Awareness of offsetting*.* In addition to individuals' motivation to abate their emissions, their positive WTP for offsets need to be supported by their awareness about the offsetting market. For example, Lu & Shon (2012) found that the more respondents know about carbon offsetting scheme, the more they would be willing to pay to offset their flight emissions. In addition, Brouwer, Brander & Van Beukering (2008), Lu & Shon (2012) and Char-lee et al. (2014) found lower WTP among Asian travellers as compared to western travellers, which could be attributed to the general lack of awareness about climate change and offsetting mechanism in the former.

Perceived effectiveness of offsetting. In addition to awareness of the carbon market, belief in its effectiveness to reduce GHG emissions is also a significant factor underlying positive WTP. Brouwer, Brander & Van Beukering (2008) found that respondents' belief in the effectiveness of carbon tax to reduce GHG emissions has a positive impact on WTP. Lu & Shon (2012) also found that respondents

who believe in the offsetting scheme to reduce emissions have greater WTP. Akter et al. (2009) used the same dataset as Brouwer, Brander & Van Beukering (2008) to assess respondent uncertainty in a contingent market. They found that only a third of the air passengers are willing to pay the stated WTP when the mandatory carbon tax is converted into voluntary contribution. They also found respondents' belief in the effectiveness of the offsetting programme is a significant factor underlying the self-reported uncertainty. Lindman, Ek & Söderholdm (2013) found that respondents who believe their purchase of EUAs has a real impact on reducing GHGs are more willing to pay.

Offset attributes. Empirical studies also found offset's attributes can influence respondents' WTP for offsets. Mackerron et al (2009) used SP techniques to elicit the WTP among young adults in the UK for offsetting a hypothetical flight between New York and London. They found respondents are willing to pay significantly more for offsets with co-benefits such as biodiversity conservation, human development and poverty reduction. Therefore, promotion of offset co-benefits can potentially encourage participation in voluntary offsetting. They also found offset certification can add value to offsets after respondents are being made aware of the offset certification scheme. Blasch and Ohndorf (2014) also found their survey respondents prefer offsets from afforestation and renewable projects hosted in developing countries, as well as offsets that are provided by not-for-profit organisations. Propensity to offset also increases if the offsets are certified by government.

4.3 Organisations' participation in voluntary offsetting

4.3.1 Voluntary offset as demonstrating corporate social responsibility

Existing theoretical and empirical studies on voluntary offsetting are mostly derived from individual consumers. Studies on organisations' participation in voluntary carbon offsetting are very limited. The yearly ESMP survey results suggest that CSR is the most prevalent motivation among organisations for purchasing voluntary offsets. Thus, organisations' participation in voluntary offsetting needs to be examined in relation to the wider discussion about CSR.

In the recent decades, CSR has become a global phenomenon and there is a vast body of academic literature being published on the topic. However, there is no consensus in the definition of CSR in both practice and academic papers[39]. This is due to the diversity of CSR programmes that have different objectives and target at different stakeholders (Sprinkle & Maines, 2010; Weber, 2008; Matten & Moon, 2008; Campbell, 2007). Academic papers also tend to define CSR in relevance to their research field or aim of the study. For example, in a management paper, Mcwilliams & Siegel (2001) define CSR as '*actions that appear to further some social good, beyond the interests of the*

[39] See Dahlsrud (2008) that collated and analysed various definitions of CSR.

firm and that which is required by law' (p.117), whilst in an economic paper, Besley & Ghatak (2007) define CSR as '*the creation of public goods and curtailment of public bads jointly with the production of private goods*' (p.1646). Voluntary is also key to a CSR programme or activity, as it shows organisations are performing a duty that is beyond their legal obligations (Bénabou & Tirole, 2010; McWilliams & Siegel, 2001). Therefore, in a nutshell, CSR can be considered as '*voluntary firm endeavours which benefit society*' (Sprinkle & Maines, 2010: p.446) or firms voluntarily '*sacrificing profits in the social interest*' (Bénabou & Tirole, 2010: p.2).

Based on Besley & Ghatak (2007)'s economic approach to defining CSR, I argue that voluntary offsetting is inherently a CSR activity. During the production of private services or goods, organisations generate GHG emissions that contribute to climate change. Through voluntary offsetting, these organisations are able to abate the climate impact of their operations (curtail negative externality or public bad) and through careful selection of offset projects, their investment in voluntary offsetting programmes also deliver a range of SD co-benefits to local communities (generate positive externalities or public goods). In addition, organisations' participation in the VCM is entirely voluntary as they are not required by law to curb their emissions. Therefore, rather than considering CSR as a motivation for organisations to purchase offsets, I approach voluntary offsetting as inherently a CSR activity that organisations undertake for various reasons.

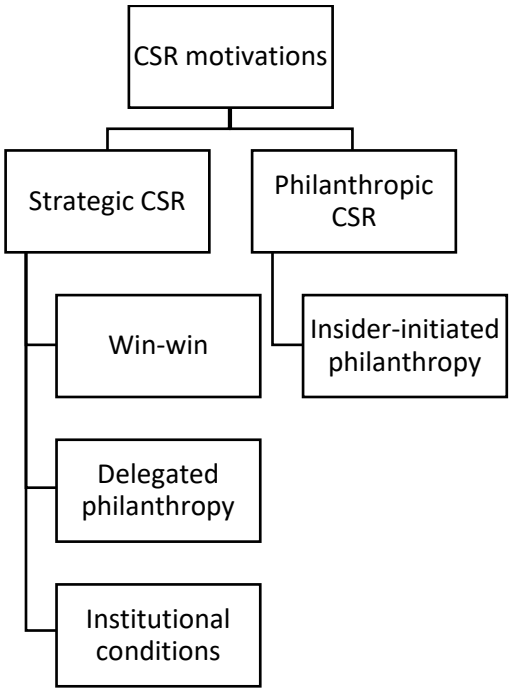
Most economic papers tend to depict CSR either as corporate philanthropic or a strategic tool in line with profit maximisation (Sacconi, 2012). Bénabou and Tirole (2010) envisage three versions of CSR: (1) win-win, (2) delegated philanthropy and (3) insider-initiated corporate philanthropy. Delegated and insider-initiated philanthropy are derived from individual's motivations. Delegated philanthropy is driven by stakeholders' desire for the corporate to do good on their behalf, therefore the cost of undertaking the CSR activity can be passed on to them. The stakeholders could be investors, customers or employees. Insider-initiated philanthropy reflects the management or board members' wish to contribute to a good cause, without being requested by their stakeholders. Therefore, organisations may make unpublicised contributions or donations. Such action was famously criticised by Milton Friedman (1970). According to Friedman, a private corporation's responsibility is to maximise its shareholders' profits and not to use their monies for eleemosynary purposes. It is the government's responsibility to deal with externalities and provision of public goods.

Later studies however claim that CSR is actually in line with long-term profit maximisation. According to these studies, undertaking CSR activities could deliver a range of benefits to organisations, such as promoting positive image, employee retention, risk management and drive efficiency (Weber, 2008, Sprinkle and Maines, 2010). This fits into Bénabou and Tirole (2010)'s version of win-win CSR.

Undertaking CSR could also be a cost for organisations to stay in business. For example, institutional conditions such as level of public and private regulation, pressure from NGOs, media and other independent bodies that monitor corporate behaviour and other stakeholders may drive organisations to engage in CSR in order to appease these stakeholders (Campbell, 2007). These institutional conditions are usually stronger in developed countries. On the other end, organisations may be operating in a region where institution capacity is so weak that organisations have to perform the functions expected from the government (Margolis & Walsh, 2001). For example, big corporates that operate in rural areas of developing countries may be required to provide basic needs such as clean water and sanitation services, or transport infrastructure in order to maintain operation.

In reality, division between different motivations of CSR is elusive. For example, undertaking CSR due to demand from customers can be considered as delegated philanthropy but it is also in-line with win-win version of CSR as organisations may gain market share or obtain premium price for their differentiated products or services. Baron (2001) categorises all CSR that are driven by motivations other than pure corporate philanthropy as strategic CSR. Baron describes strategic CSR as a self-interest instrument used to appease a particular stakeholder group, whether it is the shareholders, customers, government, NGOs or the general public, in order to increase demand for its products or services, or to mitigate costs or risks for continual operation in long-term. Under philanthropic CSR, organisations do not expect return from their actions, therefore organisations undertake voluntary offsetting purely because they want to abate their emissions. Based on Baron's description, the various motivations underlying CSR activities are summarised in Figure 4-5.

Figure 4-5: CSR motivations



Source: Author's own

In the context of voluntary offsetting, profit maximisation organisations may participate in the VCM for strategic motivations. For examples, there is a demand from their customers for carbon neutral products or services. In this case, the cost of offsetting can be passed on to the end-users. Another example is where companies purchase voluntary offsets on behalf of their multinational clients who intend to green their supply chain (Peters-Stanley et al., 2012). Other reasons to purchase offsets include to improve efficiency and save energy cost, to enhance reputation and gain competitive advantage, or to avoid more stringent future regulation (Bradsher & Revkin, 2001). Organisations may also participate in voluntary offsetting as a way to advertise themselves as 'green' and socially responsible to existing and potential employees. Employee recruitment, motivation and retention has recently emerged as a prominent reason for organisations to engage in CSR (Sprinkle & Maines, 2010).

Alternatively, organisations may purchase offsets to abate emissions as management or board members have a sense of responsibility towards the climate impact of their organisations. Based on companies that disclosed their carbon emissions to CDP[40] in 2015, around 11% of them indicated voluntary offsetting as part of their carbon management strategy (Goldstein, Peters-Stanley & Gonzalez, 2016). According to Goldstein (2016; 2015), companies that voluntarily offset their

[40] CDP, formerly known as Carbon Disclosure Project is a non-profit organisation that runs international environmental disclosure programmes (https://www.cdp.net/en)

emissions have deeper cut of their scope 1 & 2 emissions than companies that do not engage in voluntary offsetting. This indicates that in contrast to the common perception that companies use offsets as a way to avoid the more challenging internal emission cut or as corporate greenwash, companies that participate in voluntary offsetting have more ambitious ER commitments and offsetting is part of the strategy to achieve their ambitions. In addition, Goldstein (2016; 2015) also found companies that voluntarily offset have greater perceived climate related risk, including reputation, extreme weather events and consumer behaviour.

Nevertheless, empirical studies that demonstrate the benefits incurred to firms from undertaking voluntary offsetting remain limited. A few empirical studies that use event study method have found companies' proactive response to climate change has a negative or no significant impact on their share prices. Focusing on Financial Times (FT) 500 companies, Kim & Lyon (2011) found that companies' voluntary carbon disclosures through the CDP have no significant impact on their share values. However, they found that Russia's ratification to the KP in 2004, which result in the KP entering into force, has a positive impact on the share values of CDP participating companies. Their findings indicate that external conditions, especially government's commitment to combat climate change can increase shareholders' value on companies' positive response to climate change. Hsu & Wang (2013) investigated the US stock market's reaction to media coverage on corporate response to climate change. They found the market reacts positively to negative media exposure of corporate response to climate change. Their finding suggests that investors are concerned with the cost of companies taking proactive steps to address climate change, therefore they perceive companies' inaction as good news. In another study, Lee, Park & Klassen (2015) also found the Korean stock market reacts negatively to companies that voluntarily disclose their carbon information through CDP. Despite results from these studies implying that undertaking CSR activities can be costly to companies, it is worth noting that these studies only represent the view of one group of stakeholders, that is the shareholders. CSR activities are often influenced by multiple stakeholders, both internal and external, including governments, customers, employees, NGOs and local communities (Freeman, 2010). In addition, as shown by Kim & Lyon (2011), shareholders' view can be influenced by other stakeholders, especially the government.

4.3.2 Demand for offset co-benefits

In the compliance market, buyers are mainly regulatory and economic driven. Compliance buyers are expected to meet their mandatory targets within the set commitment period at the least cost possible. However, Parnphumeesup and Kerr (2011) found a premium market within the compliance market for GS certified CER in recognition of the associated SD co-benefits. Using CVM, they found that 56.4% of their survey respondents are willing to pay a price premium for GS certified CERs and

the estimated average WTP is €1.12 more per CER. They also found that organisations that are more willing to pay premium price for GS certified offsets are more knowledgeable about the sustainability label. They also perceive that projects that are certified by sustainability label generate greater SD co-benefits and return of investment than non-labelled projects. In addition, they pay more attention to ethical purchasing policy when sourcing offsets and their least preferred projects are industrial gas projects. These buyers are also more willing to participate in the VCM.

In the VCM, voluntary buyers have very diverse preferences when purchasing offsets due to their unique motivations for voluntary carbon offsetting. Offset buyers often search for offsets that are in line with their business sector or objectives for voluntary offsetting (Hamrick & Goldstein, 2016; Hamilton et al., 2010; Taiyad, 2006). For example, paper and printing sector may prefer offsets from forestry projects whilst energy sector prefer offsets from renewable or energy efficiency projects. This practice is described as sectoral offsetting by Peters-Stanley et al. (2013). Buyers who specifically look for co-benefits mostly purchase offsets from LULUCF or clean stove projects (Hamrick & Goldstein, 2016). However, some buyers intentionally avoid LULUCF projects due to the non-permanence issue and negative media attention surrounding the project type (Hamilton et al., 2010). As the result, there is no "typical" preference in the VCM (Hamilton et al., 2010).

Despite the differences in organisations' preference for offset types, in general they are likely to seek offsets that deliver co-benefits to maximise the return on their investment in offsetting programme. As organisations participate in voluntary offsetting for CSR related motives, sourcing offsets that also deliver co-benefits become important as ultimately, they aim to communicate their voluntary emission abatement and offsetting efforts to their stakeholders (Lovell & Liverman, 2010). Indeed, in contrast to the compliance market that places greater emphasis on the regulatory and credibility of the system, the VCM focuses on how the offsets are produced, as Lovell, Bulkeley & Liverman (2009) describe '*it is through stories about particular carbon offset projects that these products [voluntary carbon offsets] have meaning and value. It is through images, brochures, website devices, and offset packaged products that the consumption of offsets is made easy and habitual for consumers*' (p.2358). Thus, it is through offset narratives that make this complex and intangible product more material and relatable to its consumers. In addition, purchasing cheap offsets that generate meagre co-benefits or co-costs to local communities may draw negative media attention or risk being accused of green wash by NGOs (Taiyad, 2005).

More recently, "insetting" has become a prominent discourse in the VCM (Davies et al., 2016; Peters-Stanley et al., 2013). There are different definitions to insetting. According to Davies et al (2016), insetting is '*the development of a carbon offset project within a company's own supply chain*

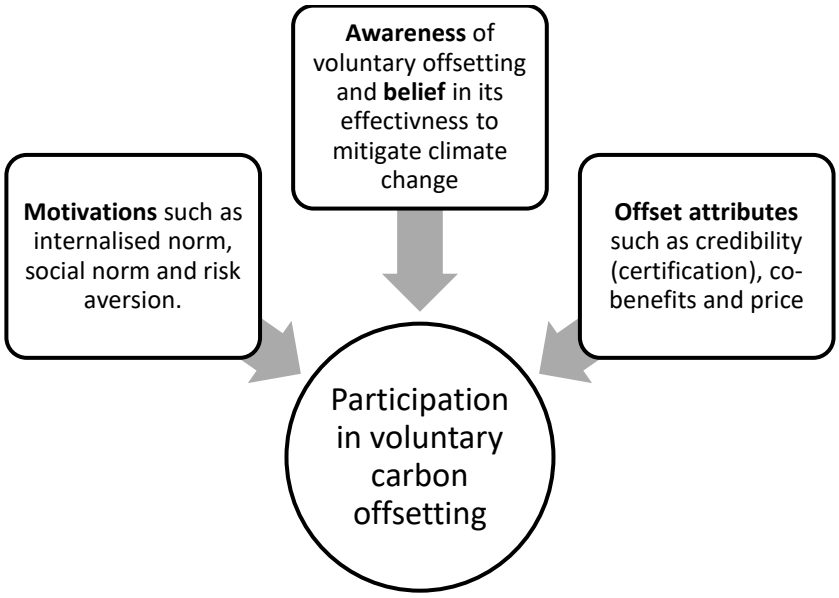
and supply chain communities' (p.9), whilst Goldstein (2016) describes insetting as *'verifying emission reductions within their operations or supply chain for the purpose of meeting an internal greenhouse gas target, with no intention of transferring those tonnes*' (p.10). Examples of insetting include an US-based energy utility investing in a wetland restoration pilot project that also provides flood defence to their operations (Peters-Stanley et al., 2013), a Swiss retail group supporting a clean stove project in its supply-chain region (*ibid*), an American coffee chain working with Mexican coffee farmers to protect local forests (Goldstein, 2015), and a water bottling company investing in rainforest conservation projects to preserve global water cycle (Davies, 2016). These examples demonstrate that through insetting, companies can utilise offset co-benefits to meet other CSR objectives or to strengthen their supply chain. In this case, offset co-benefits increase the return of their investments and therefore is in line with win-win version of CSR.

In addition to offset co-benefits, there is also demand in the VCM for verification of these co-benefits to ensure they are real. Within the VCM, sustainability standards that enable the measurement and verification of offset project's co-benefits have been developed and adopted by voluntary and CDM projects, including GS, CCBS, Plan Vivo and SC. Adopting these sustainability standards could increase transaction cost as project developers are required to meet the sustainability criteria set by these standards, as well as to monitor the co-benefits of their offset projects. However, use of these sustainability standards helps differentiate quality offsets from the more generic ones and can achieve a premium price. In recent years, there is a demand for CCB certified forestry projects and GS certified clean stove and water filtration projects among voluntary buyers (Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013).

4.4 Conclusions

Private sector in the developed countries is the main source of demand for voluntary offsets. For-profit organisations participate in the VCM for pre-compliance and purely voluntary purposes. This study focuses on the latter as it appears to be in contrast with profit maximisation. Theoretical and empirical studies on compensating negative environmental externalities only emerge in recent years and most of these studies are in the context of individual offsetting behaviour. These studies found that individuals who are willing pay to offset their private emissions are predominantly driven by internalised norm and social approval, supported by their awareness of the offset market and belief in its effectiveness in mitigating climate change. They also found that offset's attributes such as offset certification and co-benefits can influence individuals' WTP. Determinants of WTP for voluntary offsets are summarised in Figure 4-6.

Figure 4-6: Determinants of positive WTP for voluntary offsets



Source: Author's own

Understanding individual demand for voluntary offsets is important as it reflects public expectation and demand for climate change mitigation, which can drive governments and private sectors to do more in addressing the issue of climate change. However, there is an obvious gap in understanding participation in voluntary offsetting from organisations' perspective. Existing studies claim that most organisations voluntarily offset their emissions for strategic CSR motives, such as to enhance reputation, improve brand image and engage their stakeholders, therefore purchasing offsets that also deliver co-benefits becomes relevant in the context of their motivations. However, their demand for offset co-benefits, which is the main driver behind VCM's contribution to SD, is yet to be empirical demonstrated. This study explores organisations' demand for offsets and offset co-benefits through research sub-questions 2.1 to 2.3 using survey-based SP methods, namely CE and CVM, which are described in detail in the following chapter.

5 Stated preference methods

Offset is a novel and complex environmental commodity. Despite its immateriality, it has a use value to its buyer, that is to compensate one tCO_2e of emission. Its use value is especially tangible in compliance markets where buyers purchase offsets to meet their mandatory GHG ER target. Based on the economic theory underlying carbon markets, the price of compliance offsets is expected to be determined by the intersection of buyers' internal marginal abatement cost and offset marginal production cost.

In the VCM, an offset has the same use value of compensating one tCO_2e emission. However, the voluntary nature of the market means it is subjected to free-riding and there is an emerging body of economic literature, as discussed in the previous chapter, that depicts voluntary offsetting as a form of voluntary contribution to public good to compensate for public bad. Unlike compliance offsets, how the price of voluntary offsets is derived is less clear (Conte & Kotchen, 2010). Previous studies show that individuals' positive WTP for an offset is driven by their internalised norm and social approval, as well as their awareness of the offset market and belief in its effectiveness in mitigating climate change (Blasch & Ohndorf, 2015; Lange & Ziegler, 2012; Lu & Shon, 2012; Brouwer, Brander & Van Beukering, 2008). According to Foster & Mourato (2003), the value of a public good (which is voluntary offset in this case) does not necessary equal to its production cost and non-market valuation techniques can be used to evaluate the public good in monetary terms. In this study, SP methods, including CE and CVM are used to investigate how much voluntary offsets are worth to organisations. In other words, how much organisations are willing to pay for a voluntary offset and what are the motivations underlying their positive WTP.

In addition to reducing GHG emissions, offset projects also generate SD related co-benefits as discussed in Chapter 3. These co-benefits can be considered as the positive externalities generated from one's voluntary action to compensate for his GHG emissions. Offset co-benefits have use values to their beneficiaries, for example the host country that receives technology transfer or local community that benefits from capacity building as the result of the offset project. These use values are being investigated in other studies that use real market data and benefit transfer method to quantify and monetise the co-benefits of voluntary carbon offsetting, including job creation, health benefit and ecosystem protection (ICROA, n.d.; ICROA, 2014; Net Balance, 2014). Beyond these use values, positive externalities of voluntary offsetting also have non-use values to the society at large. Existing literature finds that voluntary offsets are being differentiated based on their associated co-benefits and individuals are willing to pay more for offset with co-benefits (Blasch & Farsi, 2014; Parnphumeesup & Kerr, 2011; MacKerron et al., 2009). Using SP methods, this study investigates the

value of offset co-benefits to organisations, more specifically whether organisations are willing to pay more for an offset with co-benefits (research sub-questions 2.2).

SP methods are widely used in environmental economics to value non-marketed environmental goods and services to inform policy and decision-making (Hanley, Mourato & Wright, 2001). Both CE and CVM involve surveying a sample of the targeted population to elicit their preferences and WTP (or WTA) for the provision (or foregone) of the non-marketed good. The survey questionnaire typically consists of a hypothetical situation that describes the good in question and the payment method. In the CVM, this is followed by questions that ask respondents to express their WTP for the good, whilst in the CE, respondents are asked to choose their preferred option from a set of alternatives with different attributes and price. By collecting information on respondents' demographic and attitudinal characteristics, SP methods can also provide insight to consumer behaviour and motivations underlying WTP (Bateman et al., 2002).

SP methods are often applied to hypothetical markets but markets for voluntary offsets exist, thus one may argue that using real transaction data and revealed preference (RP) methods[41] is more appropriate for valuing voluntary offsets and offset co-benefits. For example, Conte & Kotchen (2010) examined the underlying determinants of offset price using hedonic price functions and data listed on the Carbon Catalog website[42]. However, the website is no longer available. ESMP annual reports on the VCM's state and trend only presents market average and aggregate information. In the absence of transaction level information, RP methods are not applicable for this study. Therefore, SP methods are considered appropriate. Even if information is available for RP methods, SP methods still have an advantage over RP methods, which is RP methods only capture information on existing offset users whilst SP methods enable collection of information on the vast majority of offset non-users to examine motivations for voluntary offsetting. This is particularly important for informing the market on how to promote participation from organisations that are currently not voluntary offsetting. Moreover, SP methods such as the CE enables elicitation of the marginal WTP for different offset co-benefits. Thus, it provides further insights on the specific types of offset co-benefit that the market prefers.

[41] RP methods use real information to elicit the implied value of non-marketed environmental goods, such as use of travel cost method or housing market transaction data to value environmental amenities (Earnhart, 2002; Adamowicz, Louviere & Williams, 1994).

[42] As a reminder, according to Conte & Kotchen (2010), Carbon Catalog is an online directory that provides comprehensive information on offset providers and their projects around the world. However, recent attempts to access its website: https://www.carboncatalog.org/ revealed the website is no longer working or publicly available.

Over the course of this study, two SP surveys, henceforth referred as Survey 1 and 2 respectively, were undertaken. Survey 1 took place at the beginning of 2014 and Survey 2 towards the end of 2016. Therefore, the two surveys were approximately two and a half years apart. Survey 1 was administered to offset users only but Survey 2 was extended to include both offset users and non-users. Both surveys consisted of CE and CVM questions. The CE was identical in both surveys to allow for assessment of preference stability of offset users over time. The CVM questions however differed across the two surveys as they were designed for different purposes. Detailed descriptions of the designs of CE and CVM, and the subsequent data analyses are provided in the following sections.

5.1 Choice experiment method

The CE was initially developed in transport and marketing research (Louviere & Woodworth, 1983). However, it has seen increasing application in environmental economics over the years as a technique to evaluate non-marketed environmental or public goods (Hoyos, 2010). There is also growing empirical research that applies CE to test the demand and preference for impure public goods or "green" products. These are consumer products that are being bundled with some aspects of environmental or public goods for product differentiation. Examples of CE application in consumer products include organic food (Gil, Gracia & Sanchez, 2000), eco-labelled wood product (Aguilar & Cai, 2010; Veisten, 2007) and green electricity (Borchers, Duke & Parsons, 2007). As previous studies show that voluntary offsets are being differentiated in the market based on their associated co-benefits, CE is considered appropriate to elicit the marginal value respondents place on offset co-benefits and co-benefit verification.

The CE method is based on the random utility theory (McFadden, 1974) and characteristics theory of demand (Lancaster, 1966). According to the random utility theory, the indirect utility of an individual n for choosing an alternative i can be decomposed into a deterministic part V_{ni} and a stochastic part ε_{ni} (McFadden, 1974),

$$U_{ni} = V_{ni} + \varepsilon_{ni} \qquad (1)$$

The deterministic part is observable to the researcher whilst the stochastic part includes all unobserved contributions to the utility. Following Lancaster (1966)'s theory of demand for characteristics, whereby consumers' choice is influenced by the good characteristics, the deterministic part can be written as a linear function of the good attributes X_{ni}:

$$U_{ni} = \beta_n x_{ni} + \varepsilon_{ni} \qquad (2)$$

Where β is a vector of parameters.

In a CE survey, respondents are asked to indicate their choice over a set of hypothetical alternatives that are defined by different characteristics which are known as attributes that take on different levels. When respondents make their choices, they are forced to trade-off changes in different attributes. After the choice task is repeated several times, the CE reveals the implied ranking of attributes by respondents (Bateman et al., 2002). By including cost as one of the attributes, respondents have to trade-off cost against changes in attribute levels, and the marginal utility gained from the changes in attributes can be converted into WTP. By including a status quo option, the CE is in line with welfare theory (Hanley, Mourato & Wright, 2001)

5.1.1 CE design

The first step of designing a CE is identification of the relevant attributes and their respective levels (Hoyos, 2010; Hanley, Mourato & Wright, 2001). However, according to Rose & Bliemer (2009), even before identifying attributes and levels, it is important to decide whether labelled or unlabelled approach will be used to describe the alternatives. This is because the unlabelled approach generally only requires a set of generic attributes but the labelled approach may involve both generic and alternative specific attributes[43]. For the present study, the alternatives could be presented as 'Renewable project' and 'Forestry project' (labelled approach) or 'Project A' and 'Project B' (unlabelled approach). According to Blamey et al. (2000), using labelled approach resembles actual choice situations and can capture the emotions that the respondent associate with the alternative, thus increases predictive validity as well as reduces cognitive burden. On the other hand, respondents may base their choices largely or wholly on the alternative labels and disregard changes in the attributes. In existing CE studies on voluntary offsetting, Mackerron et al (2009) used the unlabelled approach to present the alternatives and then used specific co-benefits in the attribute description, such as human development (social co-benefit), conservation and biodiversity (environmental co-benefit) and technology and market development (economic co-benefit), whilst Blasch & Ohndorf (2014) specified the offset project as reforestation/afforestation, renewable energy or energy efficiency project. Therefore, in Blasch & Ohndorf (2014), respondents are assumed to make their choices based on their perceived co-benefits associated with the project type.

For this study, both approaches were considered and I decided the unlabelled approach is more appropriate as the aim is to establish which co-benefit characteristics (rather than offset projects)

[43] Generic attributes occur across alternatives, whilst alternative specific attributes are associated to specific alternatives. For example, if the alternatives are labelled as 'Renewable project' and 'Forestry project', then the attribute 'Employment creation' may be a generic across both alternatives, whilst the attribute 'Biodiversity conservation' is likely to be only associated with Forestry project, thus it is an alternative specific attribute.

appeal to organisations the most. If the labelled approach were used, I would expect respondents' prior belief to have a strong influence on their choices. For example, if the alternative was labelled as Forestry project, respondents may instinctively associate the project with certain co-benefits and make their decision based on their prior assumptions rather than consider changes in attribute levels. In addition, respondents with pre-existing preference (or bias) towards a certain project type, for example some respondents may be fundamentally against forestry projects due to the associated permanence or leakage issue, may consistently select (or disregard) the project type without accounting for changes in attribute levels. Therefore, the unlabelled approach was used to describe the alternatives.

Through literature review (Alexeew et al., 2010; Nussbaumer, 2009; Olsen & Fenhann, 2008; Sutter & Parreño, 2007) and extensive consultation with the members of International Carbon Reduction and Offset Alliance (ICROA)[44] who are considered as industry experts, three main types of offset co-benefits were identified: social co-benefit, economic co-benefit and environmental co-benefit, the three pillars of SD.

Social co-benefits of offset projects include poverty alleviation, women empowerment and improved public health. Household appliances projects, such as clean stove, water filtration and domestic biodigester dissemination projects are typically associated with social co-benefits as these projects deliver health benefit to their beneficiaries by reducing their exposure to indoor air pollutants generated from incomplete combustion of fuelwood or charcoal. In addition, these projects also help alleviate fuel poverty and relieve women and children from the drudgery of fuelwood collection.

Economic co-benefits of offset projects include job creation, technology transfer and market development. Renewable projects are commonly associated with economic co-benefits as they create employment during the construction and operation stages. At the national level, renewable energy projects also promote transfer and diffusion of clean technology, as well as improve balance of payment.

Environmental co-benefits include local environmental quality improvement and biodiversity conservation. Renewable energy and energy efficiency projects are often being associated with conserving local air quality due to the avoidance of non-GHG emissions from combustion of fossil fuels. Waste related projects such as landfill and composting projects help reduce local water and

[44] ICROA is a not-for-profit association of carbon reduction and offset providers (http://www.icroa.org/)

land contamination due to their associated improved waste management practices. LULUCF projects on the other hand offer local ecosystem services and biodiversity protection.

Each co-benefit type as described above was included as an attribute. In addition to co-benefit types, co-benefit verification was also included as one of the attributes. In the VCM, sustainability standards such as GS and CCBS have been developed to verify offset co-benefits. Sustainability standards are used to differentiate quality offsets from the more generic offsets. Therefore, they function the same as eco-labelling or eco-certification of consumer products such as organic foods, fair-trade goods, energy efficient electric appliances or sustainable wood products by signalling the positive qualities of the product that would otherwise not be obvious to its consumers. Use of eco-labelling can influence consumers' choice as it provides assurance to the claimed green or ethical qualities of the product (see Shen & Saijo (2009) for a summary of studies on the preference for eco-labelling products). However, the use of third-party certification increases transaction cost. By including co-benefit verification as one of the attributes, this study examined if organisations are willing to recoup project developers the cost of verifying offset co-benefits.

After the co-benefit related attributes were identified, each of them was assigned with levels. According to Hanley, Mourato & Wright (2001), the levels can be presented qualitatively or quantitatively but they need to be realistic and reflect the range that the targeted population expects. In this study, a simple binary yes/no approach was used to indicate the presence/absence of the co-benefit(s) and co-benefit verification.

Finally, a monetary cost, was included to elicit WTP for offset co-benefits and co-benefit verification. Establishing the levels for offset price was challenging as historical voluntary offset prices as reported by ESMP varied considerably (as shown in Figure 2-6). At the time of designing the CE, the reported voluntary offset price ranged from less than US$1 to over US$100 per tCO_2e, with a volume-weighted average of US$5.9 per tCO_2e (Peters-Stanley et al., 2013). The reported price included large volume lower-cost transactions by offset retailers for resale purpose. As the survey was targeted at offset end users, mainly the customers of ICROA members, ICROA members were consulted to ensure the price levels used in this study were in-line with their customers' expectation. A summary of all the attributes and their levels are presented in Table 5-1.

Table 5-1: Choice scenario attributes and levels

Attributes	**Levels**
Social co-benefit	Yes, No
Economic co-benefit	Yes, No
Environmental co-benefit	Yes, No
Co-benefit verification	Yes, No
Price per tCO_2	US$7, US$12, US$18, US$25

This study recognises that other offset attributes that are not included in Table 5-1 may affect respondents' choice and WTP for a voluntary offset, for example carbon certification standard, vintage[45] and project location. Whilst it is important to include all the attributes that could influence respondents' choice, this is compensated by having too many attributes could increase complexity and result in a negative impact on choice variance (Caussade et al., 2005). As respondents have to process more information, the resulted cognitive burden and fatigue effect could lead to them making more mistakes or resorting to simplifying strategy (Arentze et al., 2003). According to Scarpa & Rose (2008), most published non-market valuation studies investigate three to six attributes, plus a monetary attribute. For the present study, after some considerations and testing with different attributes, I decided to only include co-benefit related attributes and respondents were asked to assume all other offset attributes to be equal. As the purpose of this study is to examine the effects of different co-benefits on organisations' WTP for a voluntary offset, focusing only on offset co-benefits is considered sufficient.

Caussade et al. (2005) who investigated various CE design dimensions that could impact on respondents' choice consistency found that apart from the number of attributes, another design dimension that has a considerable impact on respondents' choice consistency is the number of alternatives per choice set. More specifically, they found increasing number of alternatives per choice set has a positive impact on choice consistency up to four alternatives per choice set, then its impact on choice consistency starts to decline (an inverted U-shaped relationship). Rolfe & Bennett (2009) compared CE designs that contain choice sets with two alternatives (one of which is status quo, i.e. referendum format) and choice sets with three alternatives. They found the former results in a greater non-participation rate and respondents being indifferent to the changes in attributes. According Ferrini & Scarpa (2007), the most common set up among valuation studies in environmental economics is two alternatives with attributes and levels, plus a status quo. Informed by existing studies, I chose three alternatives per choice set, one of which is the status quo.

[45] Offset vintage refers to the year the ER is achieved.

Based on the chosen attributes and levels, a full factorial design that produces all possible combinations of attributes generates 64 (2^1 x 2^1 x 2^1 x 2^1 x 4^1) alternatives. Considering a choice set that consists of two alternatives and a status quo, this results in 128 possible choice sets. Many studies rely on fractional factorial designs to reduce the number of choice situations for practical reasons. A fractional factorial design is therefore a subset of the full factorial design. Generation of experimental design is an important and complex component of CE studies (Rose & Bliemer, 2009). There are two main design approaches: orthogonal and efficient designs with the former aims to maximise the differences (or minimise the correlations) between the attribute levels in alternatives, whilst the latter aims to minimise the standard errors of the attribute coefficients obtained from data collection (Scarpa & Rose, 2008). Whilst orthogonal designs have been the mainstream for experimental design, such approach has received criticisms in the recent years and efficient designs are gaining popularity[46]. The most notable advantage of efficient designs over orthogonal designs is its ability to generate more reliable parameter estimates based on a small sample size, thus it is especially valuable for studies that have limited budget or time (Rose & Bliemer, 2009).

In this study, a d-efficient design was used to generate the choice sets. D-efficient design is an efficient design that is optimised based on the D-error measure. It is the most preferred and widely used design efficiency measure among existing literature (Rose et al., 2008). The measure is computed by taking the determinant of the asymptotic variance-covariance (AVC) and scaled to account for the number of parameters (*ibid*). Lower D-error value corresponds to more efficient design.

Despite the advantages that efficient designs have over orthogonal designs, there are some issues associated with the former approach. Firstly, the design is specific to the econometric model to be used to analyse the CE data (Bliemer & Rose, 2010). In this study, at the time of designing the CE, the econometric model to be used to analyse the data was yet to be decided. As the result, the efficient design was optimised based on multinomial logit (MNL) model for two reasons. First, efficient designs that are based on Random Parameter Logit (RPL) model require greater level of computation time and complexity as compared to ones that are based on MNL model (Bliemer & Rose, 2010). Second, efficient designs that are based on MNL model are found to perform relatively well for estimating panel RPL model[47], despite some loss of efficiency (Bliemer & Rose, 2010; Rose &

[46] For a summary of issues associated with orthogonal designs, please refer to Rose & Bliemer (2009).
[47] Panel RPL model recognises some correlations over certain choice observations as respondents were presented with multiple choice situations, whilst cross-sectional RPL model treats all choice observations independently.

Bliemer, 2009). Therefore, my decision to base the efficient design on MNL model was a trade-off between practicality and design efficiency.

The second issue associated with efficient designs is the explicit requirement of *priori* information about the parameter estimates. In the ideal situation, a pilot study would be carried out beforehand to generate the priors. However, such an opportunity was not available for this study. Even if a pilot study can be carried out, it remains a question what is the sufficient sample size to obtain the priors (Bliemer & Rose, 2010). According to Rose & Bliemer (2009), when priors are unknown to the researcher, then an orthogonal design is preferred over efficient designs with zero priors. However, orthogonal designs quickly loose efficiency as the parameter estimates move away from zero. This means even with very little information about the priors can improve the design efficiency considerably. Indeed, proponents of efficient designs argue that in non-market valuation studies, researchers can at least predict the sign of the coefficient of price or cost parameter (Rose & Bliemer, 2009; Scarpa & Rose, 2008). In this study, based on literature review, it was reasonable to assume that organisations in general prefer offset with verified co-benefits but at a minimum cost. Thus, I expected the signs for all co-benefit related coefficients to be positive and negative for the coefficient of offset price. In the efficient design, non-zero positive priors were arbitrarily assigned to all the attributes, except for offset price which prior was negative. This is justifiable as Rose & Bliemer (2009) and Ferrini & Scarpa (2007) found efficient designs that are based on MNL model are robust to misspecification of priors.

In terms of the optimal number of choice sets to be presented to each respondent, it remains a controversial issue as it involves a trade-off between learning and fatigue effects. Review of existing studies by Caussade et al. (2005) shows mixed results with some studies claim the number of choice sets has limited effect on respondents' choice consistency and others find increasing number of choice sets increases the error variance due to fatigue effect. Caussade et al. (2005)'s own study shows the relationship between number of choice sets and choice consistency is an inverted U-shaped with an optimum of around nine to ten choice sets. They also found the impact of number of choice sets on choice consistency to be relatively marginal as compared to other design dimensions. In this study, to reduce the risk of respondents terminating the survey due to having to answer too many choice sets, I decided to present each respondent with five choice sets. Therefore, the efficient design was specified to generate ten choice sets in total and split them into two blocks.

The efficient design was carried out in Ngene, an experimental design software developed by ChoiceMetrics, using swap (column-based) algorithm[48] set to run until no improvement is achieved

[48] For a summary of different algorithms for design optimisation, please refer to Scarpa & Rose (2008)

after 50,000 iterations have elapsed. Restriction on choice sets that contain a dominant alternative was also applied. An example of the choice sets generated is shown in Figure 5-1.

Figure 5-1: An example choice set

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit			N/A
Economic co-benefit	√		
Environmental co-benefit	√	√	
Co-benefit verification	None	Verified	
Price per tCO_2	US$25	US$7	0

Please select your preferred option:

- Project A
- Project B
- Neither

Prior to presenting the choice sets to respondents, a hypothetical scenario was constructed based on the respondent is seeking offsets to abate his organisation's emissions. He was asked to choose, in the following series of choice sets, the project that he would prefer to purchase offsets from. Descriptions of offset project's co-benefits and the different types of co-benefits were provided, as well as an explanation of co-benefit verification using third-party standards. Finally, examples of different co-benefit types and co-benefit verification were also provided. The aim was to ensure respondents understand the goods to be valued. As mentioned, respondents were asked to assume all other attributes of the two offset projects to be equal. The respondent could choose to offset using one of the projects presented in the choice set and pay the price of offsets or the respondent could choose the opt-out non-offsetting alternative. The payment vehicle was voluntary. Finally, a brief cheap talk script was also included to remind respondents of the budget they need to allocate for offsetting programme. Existing research has found mixed results about the effect of cheap talk in mitigating hypothetical bias but most of these studies are applied to CVM (Özdemir, Johnson & Hauber, 2009; Aadland & Caplan, 2003). Carlsson, Frykbloom & Lagerkvist (2005) and List, Sinha & Taylor (2006) examined the impact of cheap talk on the marginal WTP elicited from CE and found the strategy has some success in mitigating hypothetical bias. In the present study, the following short cheap talk script was presented prior to presenting the choice sets to respondents:

'The projects and carbon prices presented in the choice scenarios are only illustrative, however please answer as truthfully as possible, bearing in mind the budget you might have for purchasing carbon offsets.'

Finally, it is important to ensure the choice sets are simple yet realistic to reduce cognitive burden that is widely associated with CE (Hanley, Mourato & Wright, 2001). CE design that is too complex or involve too many choice sets can result in respondents ignoring attributes or producing inconsistent choices (Caussade et al., 2005; Hensher, Rose & Greene, 2005). In this study, after the CE design was finalised, ICROA members were consulted regarding the choice sets and their presentation. The CE was also pre-tested by ICROA members with a small number of their clients. No major comments concerning the CE design were received.

5.1.2 Preference estimation model

When an individual is being asked to choose an alternative in a choice set, he will choose the alternative that yields the greatest utility. However, given that there is an error component in the utility function that researchers cannot observe, the analysis becomes one of probabilistic choice. Therefore, the probability of selecting an alternative increases as the utility associated with that alternative increases. The choice probability that an individual n chooses alternative i over other alternatives j can be presented as:

$$P_{ni} = \Pr\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\,; \forall j \neq i\right) \qquad (3)$$

The equation shows that the individual will choose alternative i over alternative j, if the differences in the deterministic parts of the utility exceeds the differences in the error parts.

In this study, conditional logit (CL), random parameter logit (RPL) and latent class logit (LCL) models were used to analyse the CE data. Developed by McFadden (1974), the CL model has been the workhorse for analysing CE data. However, it is also known for its many restrictions, in particularly its failure to account for preference heterogeneity among respondents, its reliance on the Independence of Irrelevant Alternatives (IIA) property[49] and its disregard for correlation within respondents who complete a number of choice sets (Train, 1998). According to Malhotra (1984), reliance on IIA property is unrealistic when examining consumer behaviour, therefore is considered unsuitable for marketing research.

Train (1998) developed the RPL or mixed logit model to overcome the limitations of CL model. In RPL model, the parameters of preference are specified as continuous, therefore it accounts for preference heterogeneity across respondents. In addition, the error term is correlated across alternatives for each respondent, thus avoiding reliance on the IIA property as well as accommodating for correlation within a respondent (i.e. panel RPL model). Despite the advantages

[49] IIA property implies that the relative probability of any two options being selected is unaffected by the introduction or removal of other alternatives from the choice set (Foster & Mourato, 2003).

of RPL model, finding the right distribution for each parameter is challenging and misspecification of distributions can have a substantial impact on the estimation results (Carlsson,2003). In addition, RPL model is not suitable for explaining the sources of heterogeneity (Boxall & Adamowicz, 2002). A number of recent CE studies have applied LCL model as an alternative to RPL model for examining preference heterogeneity (Sagebiel, 2017; Birol, Karousakis & Koundouri, 2006). In LCL model, the parameters of preferences are specified as discrete rather than continuous, therefore it is sometimes referred as nonparametric or finite mixed logit model (Boxall & Adamowicz, 2002). There are no straightforward ways or rules for identifying which model is better-suited for a study (Sagebiel, 2017). Therefore, both RPL and LCL models were used in this study for comparison. The econometric specifications for the models are described below:

Conditional logit (CL) model

In the basic CL model, the error components are assumed to be independent across alternatives and are identically distributed extreme value. Therefore, the probability that respondent n chooses alternative i would be:

$$P_{ni} = \frac{\exp(\mu\beta X_{ni})}{\sum_{j=1}^{J}\exp(\mu\beta X_{nj})} \qquad (4)$$

Where μ is a scale parameter that is typically normalised to 1. In this study, the CL model was estimated using *clogit* command in STATA 14 that is based on maximum likelihood procedure.

Random parameter logit (RPL) model

The RPL model assumes the coefficients, β to vary in the population with density denoted by $\int(\beta \mid \theta)$, where θ are the parameters of the distribution. Therefore, the probability of respondent n choosing alternative i is the integral of equation (4) over the full probability distribution of β:

$$P_{ni}(\theta^*) = \int \frac{\exp(\beta X_{ni})}{\sum_{j=1}^{J}\exp(\beta X_{nj})} f(\beta \mid \theta) d\beta \qquad (5)$$

The probability is approximated using simulation techniques where values of β are taken from a large number of draws following an ex-ante defined distribution θ. The values of β that enter the utility function as random with a mean and standard deviation can capture preference heterogeneity for each attribute in the CE. If the standard deviation parameter for an attribute is statistically significant, then the RPL model suggests that there exists preference heterogeneity for that attribute within the sampled population.

In this study, all the attributes were specified as random and normally distributed except for price, which was specified random but lognormally distributed following Revelt & Train (1998) and Kim,

Blattberg & Rossi (1995) to constrain the price coefficient to negative. The decision to specify the cost attribute as random was informed by recent studies that criticise specification of cost as fixed for the convenience of marginal WTP calculation (Sagebiel, 2017; Meijer & Rouwendal, 2006). When the cost efficient is fixed, the WTP for an attribute has the same distribution as the attribute's coefficient and can be estimated straightforwardly as the ratio of two coefficients (Revelt & Train, 1998). Although convenient, there is no theoretical basis that supports specification of cost coefficient as non-random (Sagebiel, 2017). Using the CE data generated from a survey of Dutch rail passengers, Meijer & Rouwendal (2006) compared the results derived from RPL models with different distribution specifications for the coefficients and strongly rejected the hypothesis that cost coefficient is non-random. This implies a trade-off between realistic and convenience in the modelling approach (Hole & Kolstad, 2012). In a study of Indian household preferences for electricity supply quality using a CE method, Sagebiel (2017) found that specifying cost coefficient as random increases the model fit for his data significantly.

The RPL model estimation was performed using the *mixlogit* command in STATA 14 that is based on maximum likelihood estimator procedure (Hole, 2007) with 1,000 Halton draws.

Latent class logit (LCL) model

In the LCL model, the coefficients β are specified as discrete and respondents are being assigned to different segments or classes. Preferences are assumed to be relatively homogenous within classes but vary across classes. For an individual n that belongs to class k (k = 1…K), equation (4) can be rewritten as follow:

$$P_{ni} = \frac{\exp(\mu_k \beta_k X_i)}{\sum_{j=1}^{J} \exp(\mu_k \beta_k X_j)} \qquad (6)$$

Where β_k and μ_k are class specific parameters and scale parameters. For an individual n to belong to a specific class is also probabilistic and depends on his socioeconomic and attitudinal characteristics, which can be estimated using MNL model that analyses choice probabilities based on individual characteristics rather than attributes of choices:

$$k = \frac{\exp(\propto \lambda_k Z_n)}{\sum_{k=1}^{K} \exp(\alpha \lambda_k Z_n)} \qquad (7)$$

Where Z_n is the respondent's characteristics, λ_k is a vector of parameters for the class k and α is the scale factor. As the result, the LCL model incorporates both alternative attributes and individual characteristics in its estimation (Boxall & Adamowicz, 2002):

$$P_{ni} = \sum_{k=1}^{k} \left[\frac{\exp(\propto \lambda_k Z_n)}{\sum_{k=1}^{K} \exp(\alpha \lambda_k Z_n)}\right] \left[\frac{\exp(\mu_k \beta_k X_i)}{\sum_{j=1}^{J} \exp(\mu_k \beta_k X_j)}\right] \qquad (8)$$

In this study, the LCL model was first estimated using *lclogit* command in STATA 14 that is based on Expectation-Maximisation algorithm (Pacifico & Yoo, 2013). Then post-estimation command, lclogitml, which is a wrapper for gllamm (a general class of multilevel models) was used to obtain the standard errors. The lclogitml command passes lclogit estimates to gllamm to fit generalised linear latent class and mixed models that are maximised using Newton-Rhapson (NR) algorithm (Pacifico & Yoo, 2013). I specified further 20 NR iterations when using lclogitml to ensure convergence was achieved. The data setup for lclogit was identical to clogit and mixlogit.

5.1.3 Marginal WTP estimations

The implicit price or marginal WTP measure for each attribute is commonly calculated as the ratio of the attribute coefficient and price coefficient:

$$Implicit\ WTP\ for\ attribute\ h = \frac{\beta_h}{\beta_{price}} \qquad (9)$$

Where price coefficient β_{price} is specified as fixed, the estimated marginal WTP measure for an attribute takes after the distribution of the attribute coefficient. Therefore, where the non-monetary attribute parameter is assumed to be normally distribution with a mean parameter of β_h and standard deviation of parameter σ_h, WTP for the attribute is also distributed normally with mean β_h/β_{price} and standard deviation σ_h/β_{price}. In this study, where the coefficient of price was specified as fixed, mainly in CL and LCL models, the confidence intervals of WTP measures were estimated using Delta method in STATA 14.

For RPL model where price is specified as random, estimations of marginal WTP for the attributes become less straightforward. As the coefficient of price is specified as lognormally distributed rather than fixed, using the conventional WTP estimation approach would imply that the marginal WTP for an attribute is the ratio of two randomly distributed terms. This results in a highly skewed WTP distribution and produces an unrealistically large WTP estimate (Hole & Kolstad, 2012; Scarpa, Thiene & Train, 2008).

To overcome the issue of deriving marginal WTP from a model that specifies price as random, Train and Weeks (2005) proposed RPL estimation in WTP space method that involves reformulating the model to estimate the distribution of WTP directly. Unlike the conventional estimation in preference space whereby the derived coefficients represent the preference and scale parameters, the coefficients derived from estimation in WTP space directly represent the marginal WTP values for the attributes. In this approach, the researcher makes priori assumptions about the distributions of WTP rather than the preference parameters. Empirical studies found that estimation in WTP space

produces more realistic WTP measures than estimation in preference space (Hole & Kolstad, 2012; Scarpa, Thiene & Train, 2008; Train & Weeks, 2005).

In this application, the utility buyer n derives from choosing alternative i can be specified as a function of the offset price and other non-monetary attributes of the offset:

$$U_{ni} = -\delta_n p_{ni} + \beta'_n x_{ni} + \varepsilon_{ni} \qquad (10)$$

Where δ_n and β_n are individual-specific coefficients for the price and other attributes of the offset, and ε_{ni} is the error term. ε_{ni} is assumed to be distributed extreme value with a variance of $\mu_n^2(\pi^2/6)$, where μ_n is the scale parameter for a specific decision-maker (Hole & Kolstad, 2012). Therefore, the variance of the error term is different across decision-makers. As shown by Train & Weeks (2005), dividing utility by the scale parameter does not affect behaviour and generate a new error term that is iid type-one extreme value with constant variance of $\pi^2/6$ across all decision makers:

$$U_{ni} = -\frac{\delta_n}{\mu_n} p_{ni} + \frac{\beta'_n}{\mu_n} x_{ni} + \varepsilon_{ni} \qquad (11)$$

By defining (δ_n/μ_n) as τ_n and (β_n/μ_n) as c_n, Equation 11 becomes:

$$U_{ni} = -\tau_n p_{ni} + c'_n x_{ni} + \varepsilon_{ni} \qquad (12)$$

Equation 12 is referred as the model in preference space. Given that the WTP for an attribute is the ratio of attribute coefficient to price coefficient, $\Upsilon_n = c_n/\tau_n$, Equation 12 can be rewritten as:

$$U_{ni} = \tau_n(-p_{ni} + \gamma'_n x_{ni}) + \varepsilon_{ni} \qquad (13)$$

In this study, RPL estimation in WTP space was conducted using *mixlogitwtp* command in STATA 14, which is a modification of mixlogit command by Hole (2007) using maximum simulated likelihood with 1,000 Halton draws.

5.1.4 Tests for preference and WTP stability

To address research sub-question 2.3 on temporal stability of demand for offset co-benefits among offset users, the same CE was administered in Survey 1 and 2. SP studies only provide information about preferences at a particular point of time and such preferences may change over time. Thus, repeating the CE can provide some insights to offset users' preference dynamic over time and helps inform the market on the changes in their preferences and marginal WTP measures. Temporal stability of offset users' preferences and WTP measures for offset co-benefits and co-benefit verification can provide confidence to project developers to continue to invest in projects that deliver a range of offset co-benefits, as well as in third-party verification of co-benefits.

There is a small but growing body of environmental economic literature on test-retest reliability of CE. Liebe, Meyerhoff & Hartje (2012) who claimed to be the first to undertake test-retest study on CE in environmental valuation, administered the same CE to the same sample population around a year apart to evaluate preference stability for onshore wind farm in Germany. They found the underlying preference parameters have changed significant over a year time but the marginal WTP estimates for the attributes have not changed significantly except for one attribute. Bliem, Getzner & Rodiga-Laßnig (2012) assessed temporal stability of preferences for river restoration in Austria using web-based CE survey administered to two independently drawn samples that were one year apart. They did not find significant differences in WTP estimates between the two surveys but they did not formally test equality of preference and scale parameters. Schaafsma et al. (2014) conducted a web-based CE survey on the same sample population twice, over a year apart to evaluate preference stability for land use changes in Belgium. They found the estimated parameters of RPL model have changed significantly but could not attribute the difference to preference or scale factors. Nevertheless, they found WTP estimates to be stable over the one year period. Brouwer, Logar & Sheremet (2017) applied a SP survey that comprised of both CE and open-ended CVM to the same sample population three times to assess the stability of Swiss public preference and WTP for improving local water quality. The first and second retest were conducted 6 and 24 months after the original survey (test). They found the underlying preference parameters to be stable over time but the mean WTP values have changed significantly with obvious decline over the two-year period. More recently, Neher et al. (2017) published a study that assesses the temporal stability of recreational values of the Colorado River in the US with a 30-year interval between test and retest. They found that after adjusting WTP estimates from the previous study (carried out in 1985) to the 2015 levels using consumer price index, the mean WTP estimates have not changed significantly over the 30 years. However, they did not formally test equality of the underlying preference structures.

Other test-retest studies on CE are mainly conducted in the field of health economics which are summarised in Liebe, Meyerhoff & Hartje (2012). According to Liebe, Meyerhoff & Hartje (2012), these studies generally found promising results on the reliability of CE valuation but they have very short time lag between test and retest (from immediately to four months apart), therefore are prone to carry-over or memory effects. In addition, these studies are based on two-alternative choice sets rather than three (three alternatives are more common in environmental valuation), thus increases the probability of reliability.

The most ideal condition for testing temporal stability is applying the CE to the same sample population for both test and retest (Brouwer, 2012; McConnell, Strand & Valdés, 1998). In practice

however, relying on the same sample population is often challenging and there are SP studies that use different sample population for test and retest (Neher et al., 2017; Bliem, Getzner & Rodiga-Laßnig, 2012). In this study, the same CE was administered to two independently drawn sample population around two and a half years apart. Therefore, it is not strictly a test-retest. As the aim here is to establish if market demand for offset co-benefits and co-benefit verification are stable over time, using different sample population within the VCM is considered to be sufficient.

Most existing studies evaluate test-retest reliability of CE based on three criteria: (1) choice consistency, (2) stability of preference and scale parameters, and (3) equality of WTP measures for each attribute (Brouwer, Logar & Sheremet, 2017; Schaafsma et al., 2014; Liebe, Meyerhoff & Hartje, 2012). Choice consistency involves assessing the extent of identical choices between test and retest at the choice task and respondent level. Assessment of choice consistency is not possible for this study as the sample populations for Survey 1 and 2 are different. Besides, Liebe, Meyerhoff & Hartje (2012) pointed out that assessing choice consistency is too restrictive and ignores the stochastic nature of the choice process. In addition, changes of choices at the individual level might aggregate to non-significant difference in the parametric estimates. Therefore, instead of assessing choice consistency, I followed Kountouris, Nakic & Sauer (2015) and carried out a comparison of choice patterns between Survey 1 and Survey 2.

To address sub-research question 3.2 that investigates if demand and WTP measures of offset users for offset co-benefits are stable through time, the following two hypotheses are tested:

H_1: The preference (β) and scale (μ) parameters estimated from Survey 1 and Survey 2 are not significantly different.

H_2: The marginal WTP estimates for all attributes do not change significantly between Survey 1 and Survey 2.

The first hypothesis examines stability of preference and scale parameters (the second test criterion) between Survey 1 and Survey 1. Following the two latest studies of test-retest on CE (Brouwer, Logar & Sheremet, 2017; Schaafsma et al., 2014), I first analysed the CE data for Survey 1 and Survey 2 independently then jointly using RPL estimation model. Then, Swait & Louviere (1993)'s procedure was carried out to compare the two CE datasets. According to Swait & Louviere (1993), the scale and preference parameters are jointly estimated in random utility models, therefore are confounded. Thus, two CE datasets cannot be meaningfully compared without being able to distinguish if the differences in the estimated parameters are due to the differences in underlying preference or scale factors. To overcome this issue, Swait & Louviere (1993) proposed two-stage

hypothesis testing. The first hypothesis (H_{1a}) tests for equality of preference parameters while allowing the scale parameters to differ between datasets. If H_{1a} is rejected, that means there are significant differences in model estimated parameters between the two datasets, although it is not possible to ascribe the differences to either differences in preference or scale parameters, or both. If H_{1a} cannot be rejected, then the second test hypothesis, H_{1b} can be carried out to test if the scale parameters for the two datasets are not significantly different. Only when both H_{1a} and H_{1b} cannot be rejected that H_1, i.e. equality of preference and scale parameters from the Survey 1 and Survey 2 is true.

H_{1a}: $\beta_{Survey1} = \beta_{Survey2}$

H_{1b}: $\mu_{Survey1} = \mu_{Survey2}$

Following Swait & Louviere (1993), the likelihood ratio test statistic $-2[L_\mu - (L_1 - L_2)]$ was used to test H_{1a}, where L_μ is the log-likelihood of the pooled dataset rescaled to μ_2 that produce the optimal log-likelihood of the pooled dataset, L_1 and L_2 are the log-likelihood values of the individual Survey 1 and Survey 2 CE dataset, X_1 and X_2 respectively. The test statistic is Chi-squared distributed with (K+1) degrees of freedom where K is the number of common parameters in both datasets. The additional degree of freedom is because μ_2 is allowed to vary under H_1. H_{1b} was tested using $-2[L_p - L_\mu]$ where L_p is the log-likelihood value for the pooled model without rescaling and L_μ as above. This test statistic is also Chi-squared distributed with one degree of freedom.

With regards to the second hypothesis, equality of WTP estimates (the third test criterion) was tested using the complete combinatorial method as proposed by Poe, Giraud & Loomis (2005). According to Poe, Severance-Lossin & Welsh (1994), the non-overlapping confidence interval criterion as proposed by Park, Loomis & Creel (1991) is not appropriate for determining whether the difference between two welfare measures is statistically significant. Poe, Giraud & Loomis (2005) proposed that to test if two WTP distributions are the same, the difference between the two WTP estimates need to be calculated and then tested if the difference is statistically significant. To achieve this, random draws are taken from the two WTP distributions. For each pair of draws, the difference between the two variables is calculated. This generates a vector of differences. Then depending on how the alternative hypothesis is defined, a one-sided approximate significance level can be calculated. This is referred to as Poe test hereafter.

In this study, to test if $WTP_{Survey1} = WTP_{Survey2}$, the alternative hypothesis was defined as $WTP_A > WTP_B$ where WTP_A could either be $WTP_{Survey1}$ or $WTP_{Survey2}$ whichever was greater. A one sided-approximate significance level was calculated based on the proportion of cases whereby WTP_A –

WTP_B was negative, in other words, where WTP_B was greater than WTP_A. If the proportion of cases was less than 0.05 (5%), then the two WTP was deemed to be significantly different at the 5% level with WTP_A being greater than WTP_B. If the proportion of cases was greater than 0.10 (10%), then the difference between the two WTP values was considered to be insignificant. The Poe test was undertaken in R using *mded* package developed by Aizaki (2015), based on 1,000 random draws. The test procedures can also be performed to compare if the preferences and WTP measures of two sample populations are significantly different. For example, Kountouris, Nakic & Sauer (2015) used the Swait & Louviere procedure and Poe test to assess the impact of political instability on public preference and WTP for water quality respectively. They administered the same CE survey to two different sample populations pre- and post-anti-government protests in Croatia. They found that after the protests, scale factor increases while WTP decreases significantly. However, their findings are conditional to model specification that includes ASC. In this study, the test procedures are used to compare the preferences and WTP measures for co-benefits and co-benefit verification between offset users and non-users. The hypotheses tested are as follows:

H_3: The preference (β) and scale (μ) parameters estimated from offset users and non-users are not significantly different.

H_4: The marginal WTP estimates for all attributes do not differ significantly between offset users and non-users.

5.2 Contingent valuation method

The CVM is based on the same theoretical foundation of the random utility model as the CE, that the indirect utility of an individual comprises of a deterministic and a stochastic part. CVM was first developed by resource economists to value non-marketed public goods (Veisten, 2007). Since its inception in the 1940s in the US, CVM has undergone extensive methodological development and has been applied in a range of studies, including health, transport, environmental quality and biodiversity conservation (Haab et al., 2013; Carson, 2000). Within the CVM, different elicitation formats have been developed, including open-ended (OE), dichotomous choice (DC) and payment card (PC). Each format has its pros and cons, for example, the OE format is more cognitive challenging which often results in a greater number of protest bids whilst the DC format is subjected to yes-saying and starting bias (Hanley, Mourato & Wright, 2001). Despite its disadvantages, DC format is the recommended elicitation method by the National Oceanic and Atmospheric Administration (NOAA) Panel on contingent valuation (Arrow et al., 1993).

In this study, CVM questions were included in both surveys. In Survey 1 which respondents only consisted of offset users, the CVM question was presented after the CE section with the intention to

elicit the value of the 'whole' good, which is offset with verified social, economic and environmental co-benefits. In Survey 2 that was extended to offset non-users, two CVM questions were posed to assess the underlying motivations for positive WTP for offset and offset with co-benefits.

5.2.1 CVM question in Survey 1

One distinct feature that differentiates the CVM and the CE is that the former yields the value of the good in its entirety whilst the latter elicits the value of each attribute that make up the good (Mogas, Riera & Brey, 2009). Whether CE can be used to estimate the total economic value of the bundled good based on the assumption that the marginal WTP for the whole good is equal to the sum of marginal WTP for each of its attribute remains questionable, especially the total value of the whole good is likely to be affected by attributes that have not been accounted in the CE (Hanley, Wright & Adamowicz, 1998). There exist a few environmental economic studies that compare the value of the overall bundle of attributes in the CE with the same bundle as obtained directly from the CVM. Some studies found the difference in the WTP measures elicited from CE and DC CVM to be insignificant (e.g. Adamowic et al. (1998) on the valuation of passive use values of enhancing the threatened species of caribou in Alberta, Hanley et al. (1998) on the economic value of conserving Environmentally Sensitive Areas in Scotland and Jin, Wang & Ran (2006) on the valuation of improved solid waste management programme in Macao). However, these studies have used estimation models that do not account for preference heterogeneity to analyse CE data. Foster & Mourato (2003) applied both SP methods in the charitable sector. They used the RPL model to analyse their CE data and found that CE estimates are significantly larger than CVM estimates at the aggregate level. They also compared WTP estimates at the attribute level and found CE estimates are significantly smaller than CVM estimates, implying that CVM is subjected to adding-up or embedding problem, therefore the elicited WTP values are insentive to scope. Scarpa & Willis (2006) who applied both methods on the valuation of speed reduction schemes in three English rural towns found that welfare estimates of CE and CVM become significantly different when preference heterogeneity is accounted for. Thus, they called for previous studies that have not accounted for preference heterogeneity and concluded that CE and CVM WTP estimates are not significantly different to be re-examined using RPL or LCL model. Christie & Azevedo (2009) used CE and repeated CVM to elicit preferences and WTP for different levels of water quality improvement at Clear Lake in Iowa, US. They found that while the attribute parameters derived from CE and repeated CVM are relatively consistent, the estimated WTP measures differ significantly across the two models.

According to Christie & Azevedo (2009), the discrepancies in the estimated WTP measures could be attributed to sub-additivity effect[50].

Informed by previous studies, rather than assuming that respondents' WTP for offset with verified co-benefits is the sum of his marginal WTP for each attribute as elicited from the CE, this study uses a separate OE CVM question to elicit the value of the bundle of good. Thus in Survey 1, the following CV question was posed to survey respondents:

"What is the maximum amount your organisation would be willing to pay per tCO_2 from a project with verified social, economic and environmental co-benefits?"

Prior to the CVM question, respondents were asked to disclose the volume of offsets they contracted in the previous year and the average price they paid per offset. These questions were intended to remind respondents of their budget as well as to provide an anchoring point for the OE CVM question.

5.2.2 CVM question in Survey 2

In Survey 2 that included both offset users and non-users, the aim of the CVM questions was to elicit organisations' WTP for offset alone and for offset with verified co-benefits, as well as to examine the underlying determinants of WTP amount. Detailed description of the survey questionnaire design is presented in Chapter 7, but it is worth noting here that prior to the CVM section, respondents were presented with detailed explanation about the VCM and offset co-benefits, followed by a series of questions that gauged their attitude and perception towards voluntary offsetting and offset co-benefits. By having these debriefing questions at the beginning of the survey, the aim was to provide respondents some knowledge about the goods in question, as well as to ease them into the following CVM and CE sections.

The CVM section started with a description of the hypothetical scenario whereby respondents were asked to imagine they have calculated the GHG emissions from their organisation and implemented a set of measures to abate some of the emissions. Respondents can choose to abate residual emissions through voluntary offsetting. A cheap talk script was included to remind respondents of the budget they have to allocate for voluntary offsetting. Then, each respondent was presented with the following CVM questions:

[50] Sub-additivity effect is where "*the WTP for a composite change in a group of public goods may be less than the sum of the WTP for the individual changes separately*" (Hanemann, 1994, p. 34). This effect can be explained in terms of substitution and diminishing rates of substitution (Hanemann, 1994; Madden, 1991).

"What is the maximum price you would be willing to pay in US$ for one carbon offset without co-benefits?"

"What is the maximum price you would be willing to pay in US$ for one carbon offset that also creates employment, improves public health and reduces water pollution?"

For the second question, the sample population was split into two groups so that approximately half of the respondents received an additional information:

"*Each offset generates around US$2 of local income, saves local households around US$5 of medical bills and avoids US$3 of water pollution clean-up cost*".

The aim was to assess if quantifying and monetising offset co-benefits can influence organisations' WTP for a voluntary offset.

Following each CVM question, respondents were presented with a series of monetary values ranging from US$0 to US$20 per offset in a US$2 increment. The range of payment levels offered in the survey was informed by literature review and consultation with ICROA members. If respondents indicated their WTP is greater than US$20, they were asked to state in an OE question the maximum amount they would be willing to pay.

PC elicitation format was chosen in this study not only for its simplicity but also to reflect the wide range of offset prices in the VCM. According to Blaine et al. (2005), the disadvantage of PC is that by presenting and letting respondents to choose from all possible payment levels, it is expected that respondent will choose a relatively low amount. Therefore, PC elicitation format is likely to yield a lower WTP than DC format. However, this is considered as an advantage for this study in view of the considerable range of voluntary offset prices in the market, some of which are transacted at less than US$1. In addition, PC format avoids the starting point bias that is being widely associated with DC format (Cameron & Huppert, 1989).

5.2.3 Data analysis

With the OE elicitation method in Survey 1, the WTP was given directly by the respondents. In Survey 2 however, the chosen elicitation method, PC with follow-up OE framework produced point and interval data. Therefore, the point and interval data model as set out by Mahieu, Riera and Giergiczny (2012) was used to analyse the CVM data. The model incorporates both point and interval data form rather than conventional interval data model that removes point responses or treats them as censored responses (Mahieu, Riera & Giergiczny, 2012). Therefore, the point and interval data model takes full advantage of all the information collected.

Following Cameron & Huppert (1989), a log-transformation of the WTP was applied to avoid negative values. Therefore, the WTP valuation function can be expressed as follow:

$$\log WTP_i = \beta x_i + \varepsilon_i \qquad (14)$$

Where WTP_i is the true WTP for respondent i and x_i is a vector of explanatory variables and ε_i is the random error following a normal distribution with a mean of zero and standard deviation σ.

In the point and interval data model, when a respondent selects a price interval, his true WTP is assumed to lie somewhere in between the lower (t_l) and upper (t_u) bound of the selected price interval. Hence, log WTP for individual i is between log t_l and log t_u, which corresponds to interval censoring:

$$P(\log t_{li} < \log WTP_i < \log t_{ui}) = P\left(\frac{\log t_{li} - \beta x_i}{\sigma} < z_i < \frac{\log t_{ui} - \beta x_i}{\sigma}\right) = \Phi(z_{ui}) - \Phi(z_{li}) \qquad (15)$$

Where z_i is the standard normal random variable and Φ is the cumulative standard normal density function.

When a respondent chooses the highest value in the range, which is >US$20 in this study and provides an amount in the follow-up open-ended question, it is a point uncensored observation. However, if the respondent has not provided an amount in the OE question, the observation is treated as right censored observation with US$20.01 as the lower bound (t_l) and log WTP is greater than log (20.01):

$$P(\log WTP_i > \log t_{li}) = P\left(z_i > \frac{\log 20.01 - \beta x_i}{\sigma}\right) = 1 - \Phi(z_{li}) \qquad (16)$$

If a respondent chooses zero and it is a genuine zero response, then following Mahieu, Riera & Giergiczny (2012), it will be treated as a left censored observation with US$0.01 as the upper bound t_u and log WTP is lower than log (0.01):

$$P(\log WTP_i < \log t_{ui}) = P\left(z_i < \frac{\log 0.01 - \beta x_i}{\sigma}\right) = \Phi(z_{ui}) \qquad (17)$$

An illustration of how data was treated and coded in this study is shown in Table 5-2.

Table 5-2: Data treatment and codification for CVM point and interval data model

Type of data	Example	Dependent variable 1 (t_{li})	Dependent variable 2 (t_{ui})
Point data	US$30	Log (30)	Log (30)
Interval data	US$2.01-4	Log (2.01)	Log (4)
Left-censored data	US$0	-	Log (0.01)
Right censored data	>US$20	Log (20.01)	-

In the point and interval data model that incorporates both point uncensored and censored data, the corresponding log-likelihood function is as follow:

$$Log\ L = \sum_{i=1}^{N}\left(I_i^a log\left(\Phi\left(\frac{\log t_{ui}-\beta x_i}{\sigma}\right)-\Phi\left(\frac{\log t_{li}-\beta x_i}{\sigma}\right)\right)+I_i^b \log\left(1-\Phi\left(\frac{\log t_{li}-\beta x_i}{\sigma}\right)\right)+ I_i^c \log\left(\Phi\left(\frac{\log t_{ui}-\beta x_i}{\sigma}\right)\right)+\ I_i^d\left(-\log\sigma_i+\log\varphi\left(\frac{\log WTP_i-\beta x_i}{\sigma}\right)\right)\right) \quad (18)$$

Where I_i^a, I_i^b, I_i^c and I_i^d are indicator variables that take on value 1 (and 0 otherwise) when the observation is interval censored, right censored, left censored and uncensored respectively.

The point and interval data model was performed through *intreg* command in STATA 14 that is based on maximum likelihood estimator procedures. The marginal effect of a significant coefficient and its 95% confidence level was also estimated in STATA using postestimation command, *margins* that is based on Delta method.

6 Survey 1: An assessment of demand for offset co-benefits among offset users

This chapter presents the first survey undertaken in this study, including a description of the survey questionnaire design and administration, descriptive statistics of survey respondents, analyses of CE data using CL, RPL and LCL models, and presentation of CVM results. The objective of this chapter is to explore demand for voluntary offset co-benefits among offset users (research sub-question 2.2). CE results suggest that respondents are willing to pay substantially more for co-benefit verification, social co-benefit and economic co-benefit, but not for environmental co-benefit. However, considerable unobserved preference heterogeneity also exists among respondents. Results from CVM show respondents are willing to pay significantly more for offset with verified co-benefits as compared to the price level they are currently paying for offset. Overall, results from this chapter indicate significant WTP for offset co-benefits, especially for co-benefit verification. Therefore, it is worthwhile for the market to invest in projects that deliver co-benefits, as well as getting the co-benefits independently verified.

6.1 Questionnaire design and administration

6.1.1 Questionnaire design

A survey questionnaire was developed in consultation with ICROA members. The questionnaire started with an introductory section that explains the purpose of the survey and provides the estimated time to complete the survey. The section also specifically asked respondents to answer the questionnaire from the perspective of their organisations. Respondents were given assurance that their individual responses are confidential and the option for anonymity was also provided.

At the beginning of the survey, respondents were given the option to disclose their organisation name and the position they hold within the organisation. Then, they were encountered with a set of questions that collect their organisation demographic information, including organisation type, location and operating sector. Then, respondents were asked if their organisations purchase offsets to abate emissions. At this point, the survey branched into two separate sections, one for offset users and another for non-users. Based on respondents' answer to the previous question, they were directed to the appropriate section.

For offset users, the survey continued to the following sections:

- Motivations: Respondents were asked to indicate their motivations for voluntary offsetting from a series of statements. They were also asked if voluntary offsetting deliver tangible benefits to their organisations.

- Preferences: Respondents were asked to choose their preferred project types and locations from a series of choices. They were also asked to rank a set of criteria that they consider important when contracting offsets. Finally, they were also asked their preference for greater quantification of offset's co-benefits in monetary terms.
- CE: The CE section started with a description of the hypothetical scenario whereby respondents were asked to imagine they have measured and reduced their emissions. They were then asked to consider purchasing offsets from projects that have different co-benefit attributes to abate their residual emissions. The different offset co-benefit types and co-benefit verification were explained to them. Examples of different co-benefit types and co-benefit verification were also provided. Then, each respondent was presented with five choice sets. In each choice set, respondents were asked to choose between two offset projects that have different co-benefit attributes and offset price, or an opt-out alternative. Respondents were asked to assume all other attributes of the offset projects to be the same.
- CV: Prior to presenting the CVM question, respondents were asked to state the volume of offsets they contracted in the previous year, 2013 and how much they paid per offset. Then they were asked in an OE CVM question the maximum amount they would be willing to pay per tCO_2 with verified social, economic and environmental co-benefits. Finally, respondents were also asked if they are likely to increase their purchase of offsets in the future and how the market can improve to promote further participation.

For offset non-users, the survey asked them to provide reasons for not participating in the VCM and the factors that could encourage their future participation.

The survey questionnaire was constructed online using Qualtrics, a survey platform hosted by Imperial College of London. The survey web link was circulated around ICROA members for pre-testing with their clients in the last week of January 2014. The aim was to assess clarity of the survey questions, difficulty of the choice tasks and identify any glitches with the online survey software. Detailed and constructive comments were received and incorporated to refine the survey questionnaire. A copy of the final survey questionnaire is presented in Appendix 6-1. Although the survey questionnaire covers a range of topics that are related to the VCM, this chapter mainly focuses on the CE and CVM results which are the most relevant to the aims of this study.

6.1.2 Survey administration

To collect the relevant data, the survey web link was distributed among ICROA members who conducted the survey with their existing and potential clients through telephone interview. Potential respondents were identified and contacted to set up an interview time at the respondent's

convenience. A PDF version of the survey questionnaire was sent to the respondent beforehand so that the respondent had the survey questionnaire in front of him during the telephone interview. The PDF version of the survey questionnaire was identical to the online version except for the CE section where both blocks of choice sets were also presented (as shown in Appendix 6-1). In the online survey, the order in which the block was presented was randomised. Depending on which CE block was generated on the interviewer's computer, the respondent was directed to the appropriate section. The interviewer went through the survey questionnaire with the respondent on the phone and recorded the answers directly on the web survey. Responses were submitted online as soon as the phone interview was completed. At the time of survey, ICROA had 15 members and each member was requested to approach 10 organisations for the survey. Therefore, the expected number of organisations contacted were 150. Data collection lasted approximately eight weeks, from the 31st of January to the 8th of March 2014.

As respondents were chosen from ICROA members' contacts, it was a non-random sampling technique, or more specifically convenience sampling (Ferber, 1977). Unlike the CDM market where compliance buyer information can be found in the PDD (Parnphumeesup & Kerr, 2011), the unregulated and fragmented nature of the VCM means there is no publicly available database of organisations that participate in voluntary offsetting. One potential source of such information is through CDP where organisations that participate in voluntary carbon disclosure indicate voluntary offsetting as part of their carbon management strategy. Efforts were made to reach out to these organisations but locating the appropriate person within an organisation for the survey was challenging. ICROA members' contacts were potential respondents who were accessible for the survey. However, the use of non-random sampling approach means generalisation of findings from this study needs to be treated with caution. Furthermore, selection bias is expected as ICROA members were likely to approach clients who they have a good relationship with or those who have keen interests or supports for the market as survey respondents.

The decision to use telephone interview as the survey mode was to ensure high response rate and better data quality, whilst save cost as compared to face-to-face interview (Arrow et al., 1993). However, respondents may be subjected to interviewer effects and social desirability bias (*ibid*). Interviewer effects refer to the impacts interviewers may have on interviewees' responses (Bateman & Mawby, 2004), whilst social desirability bias refers to the phenomenon which an interviewee provides an answer that he believes to be socially desirable and puts him in a favourable light, rather than an answer that reflects his true feeling (Maguire, 2009). Therefore, one of the interviewer effects in SP survey is social desirability bias (Arrow et al., 1993). Through a comparison of face-to-face interview, telephone interview and internet survey, Maguire (2009) found evidence of social

desirability bias in the telephone survey mode. In the present study, interviewer effects and social desirability bias are expected to be limited for two reasons. Firstly, respondents of the CE and CVM questions are existing voluntary offset users. Therefore, they are expected to have certain level of knowledge and experience about the market. Some respondents may even have prior-formulated values for offset co-benefits and co-benefit verification. Thus, their responses were less likely to be influenced by their interviewers. Secondly, the respondents are the customers of the interviewers. Therefore, the respondents were likely to be honest with their demand and budget for purchasing voluntary offsets, rather than felt the need to please or impress their interviewers.

6.2 Survey respondents

6.2.1 Respondents' profile

The survey generated 75 responses. The 50% response rate is comparable to another SP survey of organisations conducted in the compliance market by Parnhumeesup & Kerr (2015), which has a response rate of 40%. 14 of the respondents are offset non-users and further three are carbon retailers. They are excluded from the analyses as they are not offset end-users and the aim of this chapter is to examine the demand of offset end-users for offset co-benefits. Furthermore, in this round of survey, offset non-users were not required to complete the CE and CVM sections. After excluding offset non-users and carbon retailers, the number of respondents is reduced to 58. Among the remaining respondents, three did not complete all choice sets. Thus, the number of usable responses is 55.

The descriptive statistics of survey respondents are presented in Table 6-1. The unit measurement here is organisation rather than individual. Majority of the respondents are based or headquartered in Annex I countries (91%), in particularly Europe (69%). Most of the respondents are private for-profit organisations (91%). Only one governmental and one not-for-profit organisation participated in the survey. Others include one sporting federation and one knowledge institution. Most of the respondents operate in the financial/ insurance sector (22%), follows by professional/ administrative services (16%) and transportation/ tourism sector (16%).

Table 6-1: Survey 1 respondents' profile

	Number	**Percentage[a]**
Type		
Private for-profit	50	91%
Government	1	2%
Not-for-profit & others	3	5%
Undisclosed	1	2%
Location		
Annex I European country	38	69%

	Number	Percentage[a]
Annex I non-European country	12	22%
Non-Annex I country	1	2%
Multinational	3	5%
Undisclosed	1	2%
Sector		
Financial and insurance	12	22%
Professional and administrative services	9	16%
Transportation and tourism	9	16%
Information and communication	6	11%
Electricity and energy	3	5%
Construction	3	5%
Manufacturing	3	5%
Paper and printing	2	4%
Textile and leather	1	2%
Wholesale and retail	1	2%
Arts, entertainment and recreation	1	2%
Education	1	2%
Other	4	7%
Sample size	55	100%

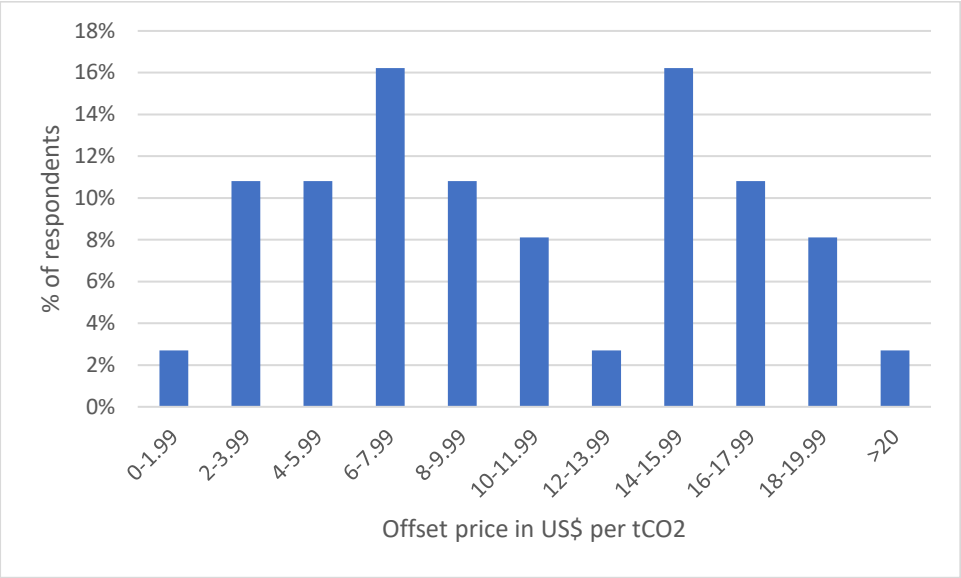
[a] Percentages may not add up to 100% due to rounding of numbers

6.2.2 Offsetting activities

Majority of the respondents offset the whole organisation's operation (51%), follows by specific activities of the organisation, such as Scope 1, 2 or 3 emissions (35%). The remaining respondents offset a specific product (13%) or event (2%). 87% of the respondents disclosed the volume of offsets they contracted in the previous year. Collectively, they purchased approximately 1.56 million tCO_2 in 2013. In comparison, the total volume of voluntary offsets transacted in 2013 was 76 million tCO_2 (Peters-Stanley et al., 2014). However, around 44% of the total transacted volume was by offset retailers (*ibid*). Excluding offset retailers as they are not representative of offset end-users, the volume purchased by offset end-users in 2013 were around 43 tCO_2. Based on the transacted volume, the sample represents around 4% of offset end-users in 2013.

67% of the respondents provided information on the price they paid per offset in 2013. The reported price ranges from US$1.26 to US$20.02, with an average of US$10.60. Figure 6-1 depicts the distribution of offset price paid by respondents in 2013. The distribution has twin peaks at around US$6-7.99 and US$14-15.99, indicating presence of two different types of buyers in the sample population.

Figure 6-1: Distribution of offset price respondents paid in 2013



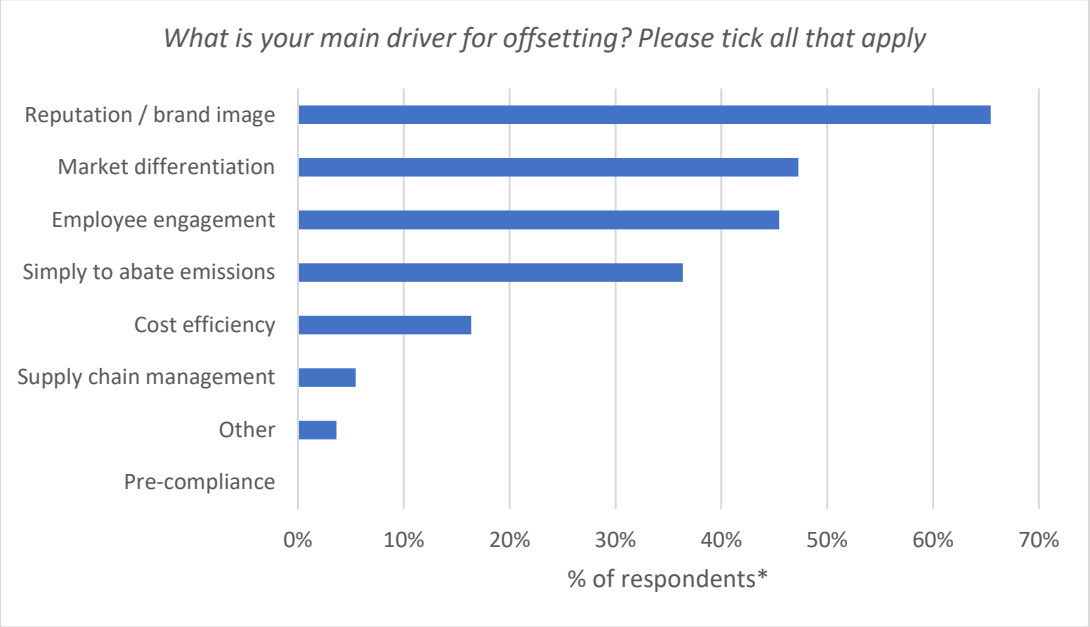
65% of the respondents provided both pieces of information, contracted offset volume and offset price. Based on their information, the volume-weighted average price was calculated to be US$7.04. In comparison, the volume-weighted average price transacted in the VCM in 2013 was US$4.9 per tCO_2 (Peters-Stanley et al., 2013). However, the market wide volume-weighted average includes offsets purchased by offset retailers and other intermediaries for resale purpose, which are likely to be low-cost large-volume transactions. Multiplying the volume-weighted average price with the total volume respondents contracted indicates that respondents collectively invested around US$10 million in the VCM in 2013.

The survey also asked respondents to state their motivations for participating in voluntary offsetting by selecting from a series of statements. The results are summarised in Figure 6-2. It shows that most respondents (65%) consider reputation/ brand image as their motivation for voluntary offsetting, follows by employee engagement (48%) and market differentiation (47%). The top three motivations show that majority of the respondents voluntary offset for strategic reasons and they expect some forms of return on their investment in voluntary offsetting programmes.

When respondents were asked if they observe tangible benefits from their participation in voluntary offsetting, 67% of them indicated yes, 31% indicated no and 2% did not answer the question. Common benefits of voluntary offsetting observed by respondents who indicated yes include positive feedbacks from their employees, helping them answer tender questions and reduction of energy consumption. However, according to the respondents, attempts to quantify these benefits are limited. Some respondents who indicated no explained that the benefits of voluntary offsetting are intangible, therefore are impossible to quantify or they are not aware of the techniques for

quantifying these benefits. This shows that despite most respondents voluntary offset for strategic motives, quantification of return on their investment is limited.

Figure 6-2: Motivations for participating in voluntary offsetting



*The percentages do not add up to 100% as respondents can choose multiple answers.

6.3 Choice experiment results

6.3.1 CL and RPL estimation results

Table 6-2 reports CL and RPL estimation results. They show all the selected attributes except for environmental co-benefit are significant determinants of offset choice. The coefficient estimates also display the expected signs. A comparison of coefficient estimates in column 2 and column 3 of Table 6-2 shows results from CL and RPL models are consistent in terms of coefficients that are significant and the implied ranking of offset attributes. Estimations results from RPL model indicate presence of unobserved preference heterogeneity among respondents, as the standard deviations for some of the coefficients are significant. Pseudo R^2 values [51] also show RPL model is superior to CL model for the dataset. Therefore, the following discussion is based on the results of RPL model.

[51] Pseudo R^2, also known as Mcfadden's R^2 reports on the percentage improvement from the null model to the fitted model. It is calculated as $1 – (LL_{model} – LL_{null})$, where LL_{model} and LL_{null} are the log-likelihood values for the estimated model and for model without coefficients respectively. According to Louviere, Hensher & Swait (2000, p.54) a pseudo R^2 value of 0.2-0.4 is considered good fit for MNL. It can also be used for model comparison (Sagebiel, 2017). Pseudo R^2 can be adjusted by the number of parameters estimated to penalise model for overparameterisation. Adjusted pseudo R^2 is calculated as $1 – [(LL_{model} – P)/LL_{null})]$, where P is the number of parameters estimated.

Table 6-2: CL and RPL estimation results

	CL	RPL	RPL with interactions
Attributes	**Mean**	**Mean**	**Mean**
Offset (ASC)	1.027 (0.258) ***	1.486 (0.367) ***	2.648 (1.308) **
Social co-benefit	1.041 (0.235) ***	1.240 (0.407) ***	0.009 (1.547)
Economic co-benefit	0.653 (0.231) ***	0.760 (0.314) **	0.800 (1.227)
Environmental co-benefit	0.306 (0.202)	0.206 (0.260)	-0.720 (1.163)
Co-benefit verification	1.304 (0.182) ***	1.812 (0.323) ***	3.135 (1.110) ***
Price	-0.120 (0.018) ***	-1.884 (0.169) ***	-1.712 (0.168) ***
	Standard deviation	**Standard deviation**	**Standard deviation**
Offset (ASC)		-0.876 (0.515) *	0.877 (0.567)
Social co-benefit		1.807 (0.501) ***	1.835 (0.549) ***
Economic co-benefit		-0.695 (0.615)	-0.004 (0.649)
Environment co-benefit		0.009 (0.505)	0.042 (0.690)
Co-benefit verification		0.942 (0.379) **	0.917 (0.443) **
Price		0.269 (0.171)	0.202 (0.147)
Interaction terms			
ANNEXI_EU * Environmental co-benefit			1.401 (0.773) *
INFORMATION * Economic co-benefit			-3.519 (1.251) ***
Model fit			
No. of observations	825	825	750 [a]
Log likelihood (null)	-302.118	-302.118	-274.653
Log likelihood (model)	-245.200	-231.743	-187.653
Pseudo R^2	0.188	0.233	0.317
Adjusted pseudo R^2	0.169	0.193	0.164

() standard error, ***, **, * = significance at 1%, 5%, 10% level. [a] 75 observations were excluded as two respondents did not disclose full demographic information and three respondents indicated they are multinational organisations but did not specify where they are headquartered.

The coefficient of offset, which is also the alternative specific constant (ASC), is significant at 1% level and the positive sign indicates that respondents are more likely to choose an offsetting alternative than the non-offsetting status quo. As expected, price enters respondents' utility negatively and is

highly significant at 1% level, suggesting respondents are more likely to choose the cheaper alternative. In terms of offset co-benefit related attributes, they are all significant (at 1% and 5% level) and positively valued except for environmental co-benefit. Based on the coefficient values, respondents value co-benefit verification the most, followed by social co-benefit and economic co-benefit.

The standard deviations of the coefficients for offset, social co-benefit and co-benefit verification are significant, indicating preference heterogeneity for these attributes. The standard deviation of the coefficient for social co-benefit is especially considerable in relative to its mean and is highly significant at 1% level, follows by co-benefit verification that is significant at 5% level. The standard deviation of the coefficient of offset is only significant at 10% level. It is worth noting that the standard deviation of the coefficient of price is insignificant, which means there is no heterogeneity in the treatment of price among respondents.

One way to examine the sources of preference heterogeneity is to interact respondents' characteristics with the ASC and attributes (Revelt & Train, 1998). In the absence of previous studies to inform this study on the potential sources of preference heterogeneity among offset users for offset co-benefits, an extensive testing of various interactions of attributes with respondents' variables was undertaken. Through testing, I found the model became unstable as more interaction terms were added. Therefore, in the final model specification, I limited the respondent variables to those that have reasonable sample size (greater than five respondents). Table 6-3 describes respondents' variables that are included in the final RPL model with interactions. The full estimation results are presented in Appendix 6-2. Only interaction terms that are significant are presented in the last column of Table 6-2. The interaction term which coefficient is highly significant is INFORMATION*Economic co-benefit. Its negative coefficient indicates that organisations that operate in information and communication sector are less likely to choose offset with economic co-benefit. Organisations that are located or headquartered in Annex I EU countries are more likely to choose offset with environmental co-benefit, however the coefficient of the interaction term is only significant at 10% level. It is also worth noting that after including the interaction terms, the coefficients of social, economic and environmental co-benefits become insignificant.

Table 6-3: Respondents' variables specified in RPL model with interactions

Variable	Description	Mean (standard deviation) [a]
PROFIT	1 if the respondent is a private for-profit organisation, 0 otherwise	0.920 (0.274)

Variable	Description	Mean (standard deviation) [a]
ANNEXI_EU	1 if the respondent is located or headquartered in an Annex I and European country, 0 otherwise	0.740 (0.443)
FINANCE	1 if the respondent operates in financial and insurance sector, 0 otherwise	0.220 (0.418)
PROFESSIONAL	1 if the respondent operates in professional and administrative services, 0 otherwise	0.140 (0.351)
TRANSPORT	1 if the respondent operates in transport and tourism sector, 0 otherwise	0.180 (0.388)
INFORMATION	1 if the respondent operates in information and communication sector, 0 otherwise	0.100 (0.303)

[a] Calculated based on 50 respondents who have disclosed all demographic information

6.3.2 LCL estimation results

LCL model is also used to analyse the CE data. In LCL analysis, respondents' characteristics are used to predict assignment of class membership. Initially, I specified all the respondents' variables as described in Table 6-3 in a two-class LCL model. However, the model failed to converge. Therefore, I systematically tested respondents' variables by excluding one variable at a time. Through a series of tests, I found the coefficient of INFORMATION has a large standard error, which could be attributed to its small sample size. As the result, I decided to exclude INFORMATION from the LCL model.

To determine the optimal number of classes for the LCL model, the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC)[52] are commonly used, with lower value preferable (Boxall & Adamowicz, 2002). Table 6-4 reports the log likelihood, number of estimated parameters, AIC and BIC statistics for LCL model with one to three classes. When more than three classes is specified, the model fails to converge. The log likelihood and AIC values reduce from one to three classes, indicating the model improves with increasing number of classes. However, the BIC that accounts for sample size increases as more classes are added. This means AIC and BIC disagrees with each other in terms of the optimal number of classes for the LCL model. According to Nylund, Asparouhov, Muthén (2007), most studies found BIC is the preferable information criterion for determining the number of classes. For the present study, BIC indicates that one-class LCL model, which is equivalent to the CL model that assumes no preference heterogeneity, is best fit for the dataset. However, RPL

[52] AIC and BIC are log likelihood based tests. AIC is calculated as $-2LL_{model} + 2P$ and BIC is calculated as $-2LL_{model} + [(P * \ln(N)]$, where LL_{model} is the log likelihood values for the estimated model, P is the number of parameters estimated and N is the number of observations.

estimation results clearly show presence of unobserved preference heterogeneity among respondents. Furthermore, distribution of offset price respondents paid in 2013 as depicted in Figure 6-1 has twin peaks, indicating possibility of two different types of offset buyers among respondents. Therefore, two-class LCL model is presented here for discussion.

Table 6-4: AIC and BIC statistics for different number of LCL classes

Model specification	**Log likelihood**	**Parameters**	**AIC**	**BIC**
CL or LCL with one class	-218.757	6	449.514	477.235
LCL with two classes	-199.184	18	434.369	517.530
LCL with three classes	-183.280	30	426.559	565.161
LCL with four classes	Convergence not achieved			

Table 6-5 reports the estimation results of two-class LCL model. The first part of the table shows the coefficient estimates of attributes for each class and the second part of the table reports class membership coefficients. The membership coefficients for Class 2 are normalised to zero, therefore the coefficients for Class 1 are interpreted in relative to Class 2.

Table 6-5: Two-class LCL estimation results

	Class 1	**Class 2**
Attributes	**Mean**	**Mean**
Offset (ASC)	1.831 (0.393) ***	-0.675 (1.254)
Social co-benefit	1.525 (0.361) ***	0.673 (0.753)
Economic co-benefit	0.803 (0.319) ***	1.684 (0.899) *
Environmental co-benefit	0.565 (0.286) **	-0.474 (0.939)
Co-benefit verification	0.879 (0.294) ***	3.033 (0.695) ***
Price	-0.195 (0.032) ***	-0.054 (0.051)
Class share	0.672	0.328
Respondents' variables		
PROFIT	-1.061 (1.637)	
ANNEXI_EU	1.838 (1.001) *	
FINANCE	2.269 (1.489)	
PROFESSIONAL	-0.880 (1.334)	
TRANSPORT	0.515 (1.143)	
_constant	0.093 (1.478)	

Model fit		
No. of observations	750	
Log likelihood (null)	-274.653	
Log likelihood	-199.184	
Pseudo R^2	0.275	
Adjusted pseudo R^2	0.209	

() standard error, ***, **, * = significance at 1%, 5%, 10% level.

Table 6-5 shows that for Class 1 buyers, the coefficient estimates for all offset attributes are significant and have the expected signs. The coefficient of offset is positive and highly significant at 1% level, indicating respondents in Class 1 are more likely to choose the offsetting alternative than the non-offsetting status quo. The coefficients of co-benefit related attributes are all significant and positive, meaning respondents in Class 1 prefer the alternative with co-benefits. The implied ranking of co-benefit attributes is social co-benefit, co-benefit verification, economic co-benefit and environmental co-benefit. The coefficient of price is negative and highly significant at 1% as expected, meaning respondents in Class 1 are sensitive to price and are more likely to choose the cheaper alternative.

Moving to Class 2, all the coefficient estimates are insignificant except for co-benefit verification that is positive and highly significant at 1% level and economic co-benefit that is positive but only significant at 10% level. The coefficient of price is insignificant, indicating respondents in this class are insensitive to offset price.

In the LCL model, the probabilities of each respondent belonging to Class 1 and Class 2 are calculated and respondents are assigned to the class which they have the greater probability (Birol, Karousakis & Koundouri, 2006). LCL results in Table 6-5 show that 67% of the survey respondents belong to Class 1 and the remaining 33% belong to Class 2. In terms of membership coefficients, only the coefficient of ANNEXI_EU is significant at 10% level. The positive sign of the coefficient indicates organisations that are located or headquartered in Annex I European countries are more likely to belong to Class 1. This shows that organisations that are based in Annex I European countries differentiate offsets based on their co-benefit types (as the coefficients of all co-benefit types in Class 1 are significant). On the other hand, organisations that are based outside of Annex I European countries appear to have less experience in differentiating offsets by types of co-benefits they deliver. Furthermore, they are less sensitive to offset price, which reiterates that they are less experienced in selecting offsets as compared to organisations that are based in Annex I European countries.

To investigate which model better explains the CE data and the underlying sources of preference heterogeneity, Table 6-6 compares the measures of fit of RPL model with interactions and two-class LCL model. The adjusted pseudo R^2, AIC and BIC values indicate dominance of two-class LCL model. Only pseudo R^2 values show preference for RPL model with interactions but this could be attributed to the greater number of parameters included in RPL with interactions.

Table 6-6: Measures of fit for Survey 1 RPL model with interactions and LCL model

Model	**Sample size**	**No. of parameters**	**Log likelihood**	**Pseudo R^2**	**Adjusted pseudo R^2**	**AIC**	**BIC**
RPL with interactions	750	42	-187.653	0.317	0.164	459.305	653.348
2-class LCL	750	18	-199.184	0.275	0.209	434.369	517.530

6.3.3 Marginal WTP estimations

The marginal WTP for offset and offset co-benefit attributes as derived from different estimation models are presented in Table 6-7. Only attributes that are significant are reported. The coefficient of price is insignificant for Class 2 of LCL model, which means respondents in this class are willing to pay any amount for co-benefit verification. Therefore, their WTP measures are not reported here.

Table 6-7: Marginal WTP measures for offset attributes in US$ per offset

	CL	**RPL**	**LCL**		
			Class 1	**Class 2**	**Weighted**
Offset (ASC)	US$8.56 (4.71-12.42)	US$9.19 (5.20-13.18)	US$9.39 (5.77-13.01)	-	US$6.31 (3.88-8.74)
Social co-benefit	US$8.68 (5.49-11.88)	US$7.96 (3.33-12.59)	US$7.82 (5.03-10.61)	-	US$5.25 (3.38-7.13)
Economic co-benefit	US$5.44 (2.15-8.75)	US$4.92 (1.23-8.60)	US$4.12 (1.22-7.01)	-	US$2.77 (0.82-4.71)
Environmental co-benefit	-	-	US$2.90 (0.17-5.62)	-	US$1.95 (0.11-3.78)
Co-benefit verification	US$10.88 (7.67-14.09)	US$11.91 (8.14-15.69)	US$4.51 (1.75-7.26)	-	US$3.03 (1.18-4.88)

() 95% confidence level

Focusing on CL and RPL models, the average marginal WTP measures for offset and co-benefit attributes are relatively similar. This shows that despite the presence of unobserved preference heterogeneity among respondents, the marginal WTP measures are stable across CL and RPL models. However, results from LCL model tell quite a different story. Comparing Class 1 of LCL model with CL and RPL models, the WTP estimates for offset, social co-benefits and economic co-benefits are relatively similar, however differ considerably for environmental co-benefit and co-benefit verification. After being weighted by class shares, WTP estimates for the attributes reduce as expected and they become considerably smaller than CL and RPL estimates, except for environmental co-benefit.

Comparisons of LCL with CL and RPL results show discrepancies that could lead to very different conclusions. Firstly, LCL results show for some respondents, environmental co-benefit is a significant determinant of offset choice, which is not captured in both CL and RPL models. Secondly, LCL results show some respondents are insensitive to offset price but RPL model has not detected heterogeneity in respondents' sensitivity to offset price. Finally, the ranking of attributes in LCL model also differs from CL and RPL models. These findings illustrate the importance of choosing the best-fit LCL model for the dataset as BIC statistics indicate single-class LCL model is preferred over the two-class LCL model for the CE dataset generated in this study. BIC's preference for single-class LCL model could be attributed to the small sample size obtained in this study. The sample size is further reduced for the LCL model after excluding respondents with incomplete demographic information. Thus, despite the potential of LCL model in investigating the underlying sources of preference heterogeneity among respondents, its use in the present study appears to be limited by a small sample size.

6.4 Contingent valuation results

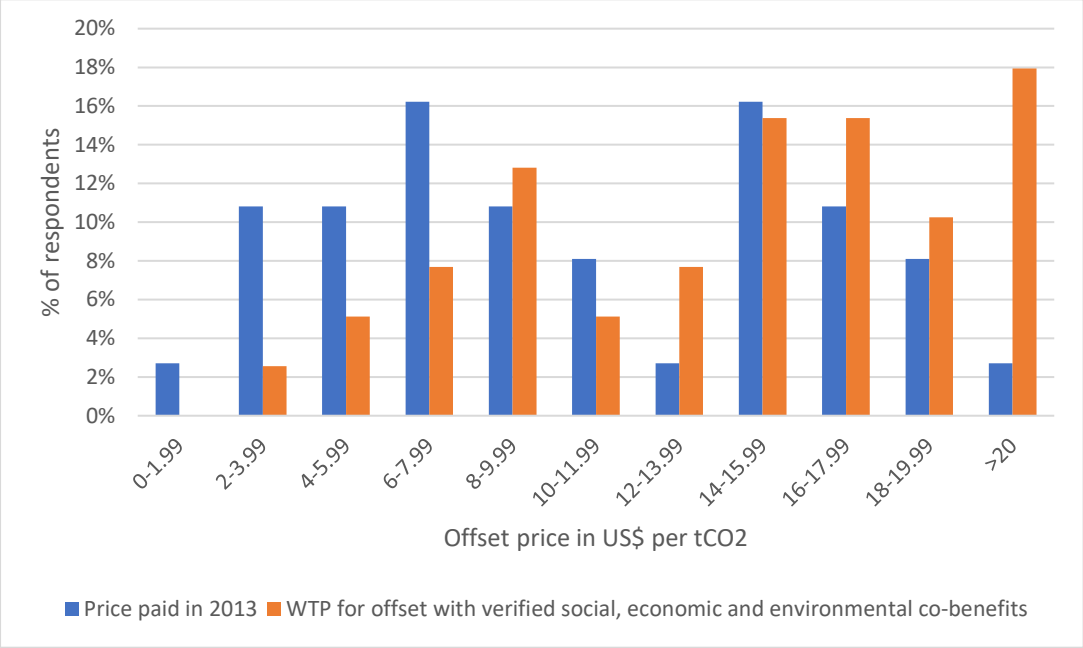
6.4.1 WTP for offset with verified co-benefits

In the survey questionnaire, following the CE section, respondents were asked to disclose the volume and offset price they contracted in the previous year. Then, respondents were asked to state in an OE CVM question the maximum amount they would be willing to pay per offset with verified social, economic and environmental co-benefits. 71% of the respondents answered the CVM question. Their reported maximum WTP values range from US$2.09 to US$27.80, with an average of US$15.64.

Figure 6-3 depicts the WTP distribution, alongside with the price respondents paid in 2013 for comparison. Both distributions have twin peaks but the WTP distribution appears to have a thicker right tail with a greater proportion of respondents willing to pay more than US$20 for an offset with

verified social, economic and environmental co-benefits. Based on 30 respondents who have provided both pieces of information, the price they paid per offset in 2013 and their maximum WTP for offset with verified co-benefits, pairwise t-test shows that their maximum WTP for offset with verified co-benefits is significantly greater than the average price they paid in 2013 (χ^2 = -4.99, p = 0.00)[53]. This indicates that respondents are willing to pay significantly more than the price level that they are currently paying for offset with verified social, economic and environmental co-benefits.

Figure 6-3: A comparison of WTP and actual price paid per offset



6.4.2 Assessing the effect of offset volume on WTP

The analysis so far has been focusing on respondents' WTP per offset. Each offset compensates one tCO_2e emission. As the GHG emissions of the underlying consumption activity grow, the volume of offsets that is required to compensate the emissions also grows and so does the overall cost of offsetting. Therefore, the total cost of voluntary offsetting incurred to buyers is determined by both the offset price and the offset volume. Harris (2007) found that organisations that are willing to pay premium prices for offsets with co-benefits are usually associated with smaller volumes. Hamrick & Gallant (2017) and Hamrick & Goldstein (2016) also reported that offset volume is a strong determinant of offset price with lower prices are generally associated with higher volume transactions.

[53] The pairwise t-test is presented in Appendix 6-3.

In this study, a simple regression analysis is used to investigate the relationship between offset price and volume. During the survey, respondents were asked to disclose the volume and price of offsets they contracted in the previous year. Not all respondents provided the information. The response rates are summarised in Table 6-8.

Table 6-8: Response rates for contracted offset volume, price and CVM

	Number	Response rate
Total respondents	55	100%
Respondents who provided volume contracted in 2013	48	87%
Respondents who provided average contracted price per offset in 2013	37	67%
Respondents who provided contracted volume and price per offset in 2013	36	65%
Respondents who provided maximum WTP per offset with verified social, economic and environmental co-benefits	39	71%
Respondents who provided contracted volume in 2013 and maximum WTP per offset with verified social, economic and environmental co-benefits	35	64%

Table 6-9 reports the regression results. Under Model 1, the coefficient of volume is negative and significant at 5% level, meaning greater contracted volume corresponds to lower contracted price. Model 2 shows the regression result of contracted offset price on log transformation of contracted volume. The coefficient of log(volume) is also negative and significant at 5% level. However, F-test shows Model 2 is more significant than Model 1, which implies the relationship between offset price and volume is a non-linear one. The regression analysis is repeated using the elicited WTP for offset with social, economic and environmental co-benefit (Model 3). The result shows the WTP is also negatively correlated with log(volume) and highly significant at 1% level. These results confirm contracted offset volume has a significant effect on the offset price respondents are willing to pay.

Table 6-9: The effect of contracted offset volume on average price paid and WTP per offset

	Model 1	Model 2	Model 3
Dependent variable	Price paid per offset	Price paid per offset	WTP per offset
Independent variable	Volume	Log(volume)	Log(volume)
Coefficient	-0.00004 (0.00002) **	-1.379 (0.375) ***	-1.506 (0.403) ***
_constant	11.712 (1.035) ***	22.419 (3.300) ***	27.853 (3.635) ***

	Model 1	Model 2	Model 3
Model fit			
No. of observations	36	36	35
F (d.f)	4.49 (1,34) **	13.49 (1,34) ***	13.98 (1,33) ***

() standard error, ***, **, * = significance at 1%, 5%, 10% level

6.4.3 A comparison of WTP estimates

Table 6-10 provides a summary of actual price respondents paid per offset and their WTP measures for offset and offset co-benefits as elicited from CE and CVM. Although these values are not fully comparable for reasons to be discussed below, preliminary comparison of these values can provide some valuable insights.

Table 6-10: A comparison of WTP estimates with actual price paid per offset

Actual price paid	**Mean WTP per offset (95% confidence interval)**		
Price paid per offset in 2013	US$10.60 (8.70-12.49)		
CVM results			
Offset with verified social, economic and environmental co-benefits	US$15.64 (13.55-17.73)		
CE results	**CL**	**RPL**	**LCL weighted**
Offset (ASC)	US$8.56 (4.71-12.42)	US$9.19 (5.20-13.18)	US$6.31 (3.88-8.74)
Social co-benefit	US$8.68 (5.49-11.88)	US$7.96 (3.33-12.59)	US$5.25 (3.38-7.13)
Economic co-benefit	US$5.44 (2.15-8.75)	US$4.92 (1.23-8.60)	US$2.77 (0.82-4.71)
Environmental co-benefit	-	-	US$1.95 (0.11-3.78)
Co-benefit verification	US$10.88 (7.67-14.09)	US$11.91 (8.14-15.69)	US$3.03 (1.18-4.88)

() 95% confidence level

The first notable observation from Table 6-10 is the differences in WTP measures as elicited from CE and CVM. Although the survey is not specifically designed to enable full comparability of welfare measures from CE and CVM, the differences in the welfare estimates from CE and CVM are notable and require further discussion. The WTP measure elicited from CVM is considerably smaller than the

aggregate WTP measure elicited from CE (based on the assumption that the WTP for the whole good is the sum of WTP for offset and its attributes that are significant). This finding is in-line with existing studies, including Foster & Mourato (2003), Scarpa & Willis (2006) and Christie & Azevedo (2009). The discrepancy between the aggregate WTP measures as elicited from CVM and CE could be attributed to sub-additivity effects that are expected in CVM (Christie & Azevedo, 2009; Christie, 2001; Hanemann, 1994). Sub-additivity occurs as the result of substitution effect (Hanemann, 1994; Madden, 1991). According to Brown & Duffield (1995), when the valued public goods fall within the same budget constraint, imperfect substitution could occur which leads to the total value of the bundle of goods exceeding the value of individual good when assessed separately, but at the same time being less than the sum of values of individual goods that are assessed separately. This appears to be the case for this study as CVM WTP for the bundle of goods (offset with verified co-benefits) is greater than the CE WTP for individual good (i.e. offset, individual co-benefit type and co-benefit verification) but is less than the sum of CE WTPs. This shows that respondents treat the different co-benefits as imperfect substitutes of one another, especially when the co-benefits are considered under the same budget of voluntary offsetting. In addition, prior to the CVM question, respondents were asked the average price they paid per offset and the volume of offsets they contracted in the previous year. These questions may serve better at reminding respondents of their budget than the brief cheap talk presented at the beginning of the CE section. By asking respondents to state the average offset price they paid in the previous year also provided respondents an anchoring point and prompted them to provide a more realistic WTP for the CVM question.

Despite the mean WTP measures elicited from the CVM is lower than the CE at the aggregate level, it is greater than the mean WTP measures elicited from the CE for offset alone, which is expected and thus provides some confidence to the WTP measures estimated from this study. The WTP estimates can be summarised as follow: WTP_{CE} (offset alone) < WTP_{CVM} (offset with verified co-benefits) < WTP_{CE} (offset with verified co-benefits).

The second notable observation in Table 6-10 is the WTP measures estimated from CE and CVM are considerably greater than the actual price buyers paid per offset. Again, these values are not fully comparable as the co-benefit attributes of offsets respondents purchased is unknown to this study. In addition, some buyers may contract offsets from a portfolio of different offset projects and the reported offset price only reflects the average price they paid combining both generic and quality voluntary offsets. There is a possibility that some buyers are paying more than their reported offset price for offsets with verified co-benefits that make up their portfolio of offset projects.

Nevertheless, the presence of hypothetical bias cannot be ruled out in this study. Hypothetical bias is widely associated with SP methods and is especially notable when the payment vehicle is in the form of voluntary contribution as free-riding is more prevalent (Hanley, Mourato & Wright, 2001). Purchase of offsets that also deliver co-benefits at a premium price is entirely voluntary. However, voluntary buyers want to promote their efforts for supporting offset projects that also deliver a range of co-benefits to their stakeholders as a way to enhance their public image. Therefore, they derive private benefits from purchasing offsets with verified co-benefits. From this perspective, the extent of free-riding may be limited.

Ultimately, the offset price is also determined by the supply-demand balance. At the moment, the VCM is a buyers' market that is heavily oversupplied. Therefore, buyers are able to negotiate a competitive price. If respondents can source offsets with verified co-benefits at a lower price, there is no reason for them to pay the maximum amount they indicated in this SP study. Therefore, the WTP estimates generated from this study may reflect the potential price level that offset with verified co-benefits will be able to fetch. In comparison to the internal carbon prices used by companies that range from US$0.01 tCO_2e to US$909/tCO_2e (Zechter et al., 2017), the WTP for offset elicited from this study is not unreasonable.

6.5 Conclusions

This chapter sets out to explore the demand for voluntary offset co-benefits among organisations that are purchasing offsets to abate their emissions. A SP survey of organisations that are offset users were undertaken and 55 usable responses were obtained. These respondents collectively invested around US$10 million in voluntary offsetting in 2013. Majority of them participate in voluntary offsetting for strategic motivations, mainly to enhance reputation or brand image, engage their employees and achieve market differentiation. However, demonstration of return on their investment in voluntary offsetting programmes remains limited.

CE results as generated from CL and RPL models show substantial WTP exist among respondents for offset co-benefits, in the order of co-benefit verification, social co-benefit and economic co-benefit. However, rather surprisingly, respondents in general are indifferent to environmental co-benefit. Considerable unobserved preference heterogeneity is also detected among respondents for, in the order of significance, social co-benefit, co-benefit verification and offset. Interactions of offset (the ASC) and offset co-benefit attributes with respondents' demographic variables reveal very limited information that explain the sources of preference heterogeneity. On the other hand, results from LCL model reveal some valuable insights. In particularly, offset buyers from Annex I European countries appear to be more experienced in differentiating offsets by their co-benefits. However,

this study also illustrates the limitation of LCL model for analysing CE data with small sample size as BIC statistics indicate one-class LCL or CL model is best fit for the dataset. Choosing the two-class LCL model has generated results that are considerably different from CL and RPL models which lead to very different conclusions. Thus, this study demonstrates the importance of choosing the best-fit LCL model to analyse the dataset.

There are a few limitations associated with this SP study. Firstly, due to the non-random sampling strategy and the small sample size, generalisation of results to the whole market needs to be treated with care. In addition, selection bias is expected to present in this study as survey respondents are likely to be those who have good relationship with ICROA members or have interest in the VCM. Secondly, each respondent in the survey represents an organisation. However, the survey was completed by individuals within the organisations. Therefore, there is a risk that the respondents' views may not be representative of their organisations or some of their personal preferences have been captured in the survey responses. To a certain extent, these potential issues are mitigated by targeting the right person within the organisation for the survey. 75% of the respondents disclosed their positions in their organisations. 83% of them hold a managerial, directorial or higher position, such as President or Head. Therefore, their views are likely to influence their organisations' decision-making and can be considered as representative of their organisations.

Despite these limitations, this survey provides some valuable insights to corporate buyers' preferences for offset co-benefits and expectations from the market. In particularly, two key messages can be derived from the survey results to inform the market. Firstly, there are substantial demand and WTP for offset co-benefits among corporate buyers. This confirms previous presumptions that as organisations participate in voluntary offsetting to demonstrate CSR, they are likely to seek offsets that also deliver a range of co-benefits. Therefore, promotion and communication of offset co-benefits can command a higher offset price or at least encourage uptake. Secondly, co-benefit verification is highly valued among corporate buyers, therefore the VCM is encouraged to invest in verification of offset co-benefits. Interestingly, studies that compared SD contributions of GS labelled CDM projects with unlabelled CDM projects found that GS labelled CDM projects do not outperform the unlabelled ones substantially, especially when comparing projects of similar types (Drupp, 2011; Nussbaumer, 2009). This means GS labelled offset projects do not necessarily deliver greater SD co-benefits. Nevertheless, in a market that is unregulated and plagued with information asymmetry, sustainability labels such as GS and CCBS provide assurance to offset buyers that the claimed co-benefits are real. This presents the VCM with the challenge of balancing between promoting credibility and keeping the transaction cost low so more carbon finance can go to benefiting local communities rather than the administrative process of

demonstrating the co-benefits on the paper. This may require some innovations in the market to develop simple yet effective procedures for monitoring and verifying offset co-benefits.

7 Survey 2: An assessment of organisations' participation in voluntary offsetting

The objective of this chapter is to assess organisations' participation in voluntary offsetting (research sub-question 2.1) using empirical data generated from the second survey undertook in this study. First, this chapter provides detailed descriptions of Survey 2 questionnaire design and administration. Then, organisations' participation in voluntary offsetting is assessed on two levels: (1) organisations' propensity to purchase voluntary offset and (2) their WTP amount per offset. Comparisons of the views and attitudes of offset users and non-users towards climate change and voluntary offsetting show they are not significantly different. However, parametric analysis shows organisations' demographic characteristics are strong determinants of their participation in voluntary offsetting. Organisations' WTP amount for an offset on the other hand is driven by internalised norm to abate GHG emissions. Presence of offset co-benefits can also increase organisations' WTP for offset significantly.

7.1 Questionnaire design and administration

7.1.1 Questionnaire design

To assess organisations' demand and motivations for voluntary offsetting, a survey questionnaire was designed to collect information on organisation's characteristics, their current offsetting activities (if any) and their WTP for voluntary offsets. The survey questionnaire started with a cover letter that explained the purpose of the survey and the estimated time for undertaking the survey. Respondents were specifically asked to answer the survey questionnaire from the perspective of their organisation. They were also informed that the survey was completely anonymised to promote participation and to encourage truthful responses.

The first section of the survey questionnaire was designed to measure the attitudes and knowledge of organisations on climate change and the VCM. The section started with a description of the climate impact of organisation's day-to-day operation, followed by information about the VCM. Then respondents were confronted with a series of attitudinal questions and their answers were measured in five-point Likert Scale. Having these debriefing questions at the beginning of the survey was intended to help ease respondents into the following CVM and CE sections.

The second section was the CVM section. Respondents were asked to imagine a hypothetical scenario whereby they have measured their organisation's energy consumption and undertaken a series of measures to reduce its carbon footprint. The organisation could abate its residual emissions through voluntary offsetting. Then, respondents were asked to indicate from a range of monetary

values, the maximum price they would be willing to pay for (1) an offset alone and (2) an offset with co-benefits to abate one tCO_2e emission[54]. The sample population was split into two groups with approximately half receiving an additional information on the monetary values of the co-benefits.

Following the CVM section, respondents were presented with the CE. The CE design was the same as Survey 1 and as described in Section 5.1.1. The analysis and discussion of CE data are presented in the following chapter, Chapter 8 on the comparison of demand for offset co-benefits between offset users and non-users.

The final section of the questionnaire collected demographic information such as organisation type, location and sector. Respondents were also asked if they have a carbon management plan in place and if they are currently voluntary offsetting.

The survey questionnaire was constructed using an online survey platform, Qualtrics and then sent to industry experts, including ICROA members and the UNFCCC for comments. The questionnaire was refined following comments from the experts. A pre-testing of the questionnaire was carried out between 30th of August and 5th of September 2016 with seven employees of ICROA members and UNFCCC who were not involved in the questionnaire design. Pre-test participants were asked to provide feedbacks on their impression of the overall survey questionnaire such as the presentation style and length of the survey, ease of understanding and answering the questions, as well as if they have experienced any technical issue with the online survey software. Detailed and constructive feedbacks were received from the pre-test participants and incorporated to further refine the questionnaire. A copy of the final survey questionnaire is provided in Appendix 7.1. The questionnaire covers a wide range of topics related to the VCM but only those that are relevant to this study are analysed and discussed.

7.1.2 Questionnaire administration

Following discussions with ICROA and UNFCCC, online survey was the chosen mode of survey administration for this round of survey. Online survey is gaining popularity in recent years over face-to-face and telephone interview due to the many advantages it offers, including time and cost saving, quicker survey distribution and response submission, better survey experience by making some questions conditional to previous answers (thus respondents do not have to go through questions that are not applicable to them), the ability to directly download survey results from the online survey software thus avoiding manual data entry mistakes (Olsen, 2009). Self-administered

[54] The CVM questions are described in Section 5.2.2.

survey is also less likely to suffer from social desirability or interviewer bias as compared to face-to-face or telephone interviews (Maguire, 2009).

Once the online survey questionnaire was finalised, the survey web link was sent to ICROA members for distribution among their clients and newsletter subscribers, as well as to UNFCCC for distribution among organisations that participate in the UN's Caring for Climate Initiative. The approach thus represents non-random, convenient sampling for ease of access to potential respondents at the minimum cost. As the result, generalisation of findings from this survey needs to be treated with care. Self-selection bias is also expected as respondents to the survey are likely to be those who have keen interest or strong opinion about voluntary offsetting.

The web link was live from the 12th of September to the 1st of November 2016 (around 7 weeks). According to ICROA members and UNFCCC, they collectively reached out to around 40,000 organisations worldwide to participate in the survey. However, over 90% of these organisations were reached through company newsletter circulation, which based on conversation with one of ICROA members was unlikely to yield a high response rate in comparison to personalised contact with follow-up email to encourage participation.

7.2 Survey respondents

7.2.1 Respondents' profile

At the end of data collection, a total of 103 responses were received. The low response rate, 0.3% could be attributed to the large number of organisations reached through newsletters circulation which was unlikely to yield a high number of responses as the survey was not incentivised. The low response rate is also an indication of the challenges of getting organisations to participate in a survey on a voluntary basis. According to Parnphumeesup & Kerr (2011), previous surveys of organisations that participate in the compliance Kyoto market generated between 19 and 82 usable responses. Their own survey yielded 117 usable responses but their survey was incentivised by sharing of research results and a free prize draw. Although the present study is targeted at a different population, the number of responses achieved is comparable.

Of the 103 respondents, six are carbon retailers which are excluded from this study as they purchase offsets for resale purpose and therefore do not represent the fundamental demand of the market. As the result, the total number of responses is reduced to 97. Table 7-1 reports the profile of survey respondents. Similar to Survey 1, each respondent represents an organisation instead of an individual. Majority of the respondents are from private for-profit sector (81%), follows by public sector (12%) and not-for-profit and others (6%). Others include a think tank, a social enterprise and a partnership. 62% of the respondents are based in Annex I European countries, distantly follows by

Annex I non-European countries (19%) and non-Annex I countries (16%). The remaining 3% did not disclose their organisation's location. The survey also attracted participants from a wide range of sectors. Most of them operate in electricity and energy (14%), transportation and tourism (12%), professional and administrative services (10%), financial and insurance (9%), and information and communication (9%) sector. 80% of the respondents have carbon management strategy in place and 48% of the respondents purchase voluntary offsets.

Table 7-1: Survey 2 respondents' profile

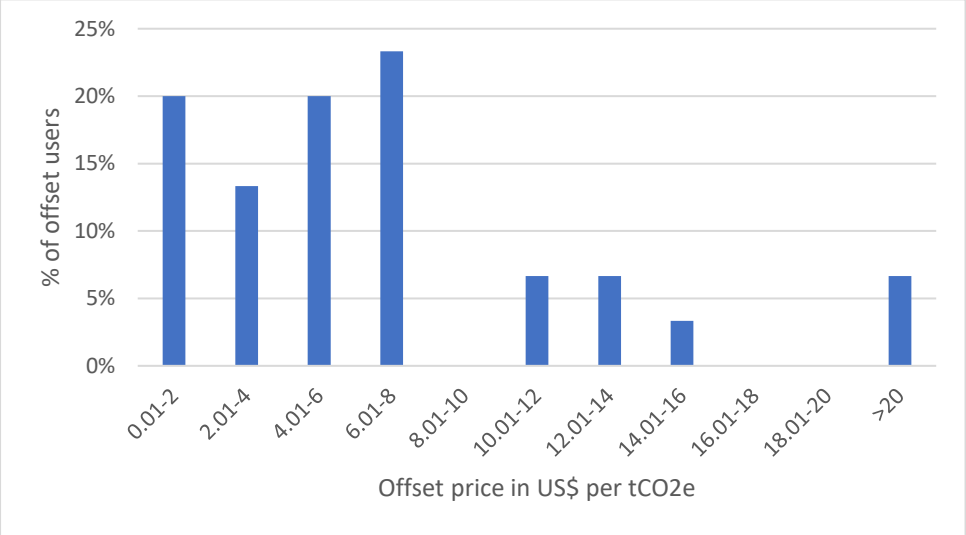
	Number	Percentage [a]
Organisation type		
Private for-profit	79	81%
Government	12	12%
Not-for-profit & other	6	6%
Location		
Annex I European country	60	62%
Annex I non-European country	18	19%
Non-Annex I country	16	16%
Undisclosed	3	3%
Sector		
Electricity and energy	14	14%
Transportation and tourism	12	12%
Professional and administrative services	10	10%
Financial and insurance	9	9%
Information and communication	9	9%
Manufacturing	7	7%
Waste, water and transport infrastructure	5	5%
Agriculture and forestry	4	4%
Food and drink	4	4%
Arts, entertainment and recreation	2	2%
Mining and quarrying	2	2%
Textile and leather	2	2%
Wholesale and retail	2	2%
Paper and printing	2	2%
Construction	1	1%
Education	1	1%
Other	11	11%
Carbon management strategy		
Yes	78	80%
No	19	20%
Offset user		
Yes	47	48%
No	50	52%
Sample size	97	100%

[a] Percentages may not sum up to 100% due to rounding of numbers

7.2.2 Offset users

Of the offset users among survey respondents, 72% of them provided information on the volume of offsets they contracted in 2015, which amounted to around 4.7 million tCO_2e reductions. 64% of them reported the price they paid per offset in 2015. The reported offset price ranges from less than US$1.00 to US$38, with an average of US$7.56. The distribution of offset price respondents paid in 2015 is depicted in Figure 7-1. It shows that majority of the respondents were paying less than US$8 per offset in 2015. The weighted average offset price was calculated as US$3.46. Multiplying the weighted average price with the total volume contracted, collectively the respondents invested around US$16 million in the VCM in 2015.

Figure 7-1: Distribution of offset price respondents paid in 2015

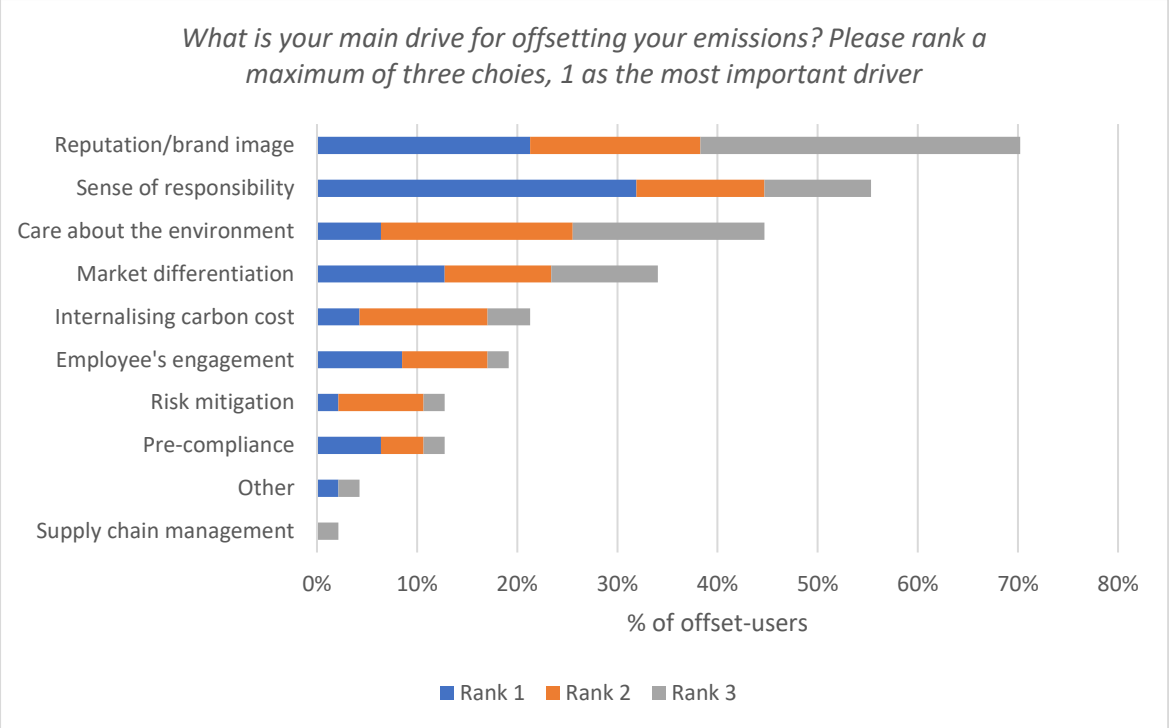


According to Hamrick & Goldstein (2016), the total volume of offsets transacted in the VCM in 2015 was 84 million tCO_2, at a price of between US$0.1 to US$44.8 per offset. The volume weighted average price was US$3.3 per offset and the total market value was US$278 million. At the first glance, offset users participated in this study represents around 6% of VCM market share, based on both the transacted volume and value. However, the reported volume and value by Hamrick & Goldstein (2016) include transactions by brokers and retailers that are not offset end-users. Therefore, in terms of offset end-users, respondents of this survey represent more than 6% of the VCM market share.

Majority of the offset users are offsetting their Scope 1 & 2 emissions (53%), closely follows by Scope 3 emissions (51%). Some offset users are also offsetting for an event/conference (19%), a specific product (15%) and other activities (6%)[55].

To assess their motivations for voluntary offsetting, respondents were asked to rank their top three motivations from a list of statements. The results are summarised in Figure 7-2. It shows that most respondents voluntary offset for reputational or brand image purpose. However, more interestingly, sense of responsibility and care about the environment are the second and third most common motivations for voluntary offsetting among respondents. Furthermore, for most respondents, sense of responsibility is the main motivation for purchasing offsets. These findings show that in contrast to Survey 1 (see Figure 6-2) and existing literature that focus on private and economic benefits as the primary motivations for engaging in CSR, altruism is also a strong motivator for voluntary offsetting among Survey 2 respondents.

Figure 7-2: Motivations for voluntary offsetting



The survey questionnaire also asked offset users if they have experienced tangible benefits from voluntary offsetting. 49% of offset users answered 'Yes', whilst 9% answered 'No' and 38% were unsure. Two respondents did not answer the question (4%). Main benefits of voluntary offsetting

[55] The percentages do not add up to 100% as respondents can choose multiple answers. For example, a number of respondents offset their Scope 1&2, as well as Scope 3 emissions.

that were mentioned in the follow-up OE question are reputation and market differentiation, as well as employees' and stakeholders' engagement. However, only one offset user indicated that the benefits are being measured. The lack of tangible benefits and efforts to monitor these benefits by organisations that participate in voluntary offsetting indicate that they may be purchasing offsets for altruistic motives and are not expecting return on their investment in voluntary offsetting.

7.2.3 Offset non-users

52% of the survey respondents are offset non-users. However, 14% of them have purchased offsets in the past whilst 52% are investing directly into climate mitigation and adaptation projects without going through the VCM. Figure 7-3 reports the reasons these organisations are not participating in the VCM. '*It is currently not on our list of priorities'* is the most common reason (50%), distantly follows by entry barrier (20%) and market lack credibility and transparency (18%). Other reasons include focusing on internal abatements and development of own ER projects.

Figure 7-3: Reasons for not participating in the VCM

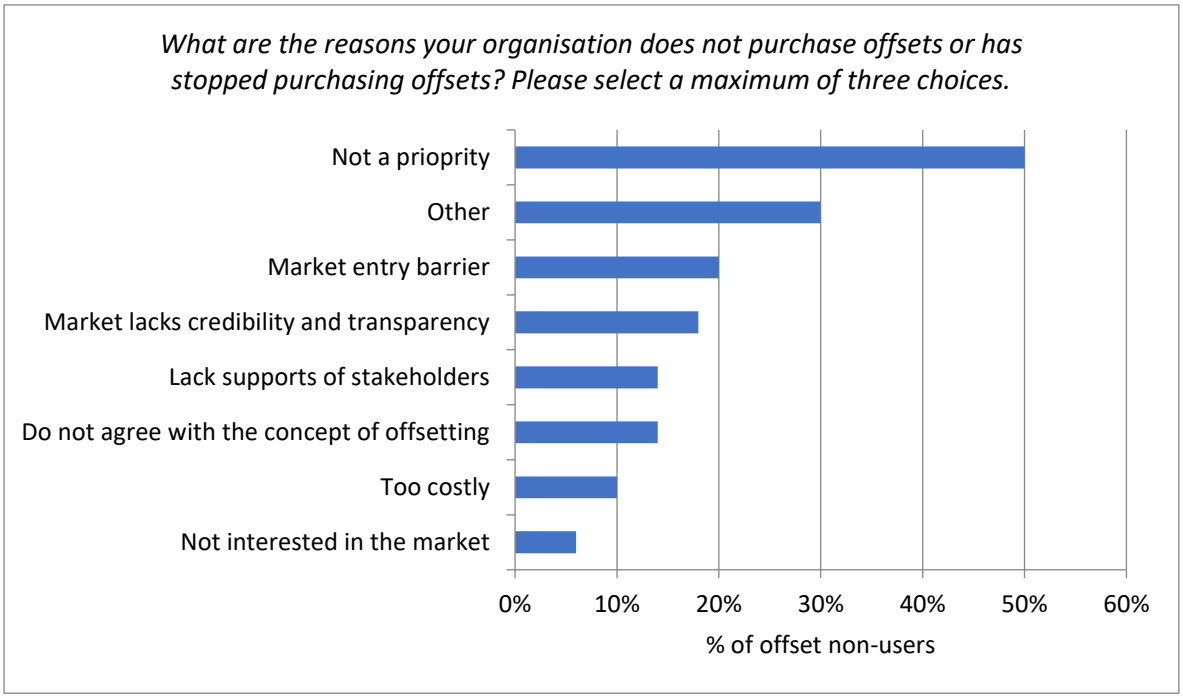
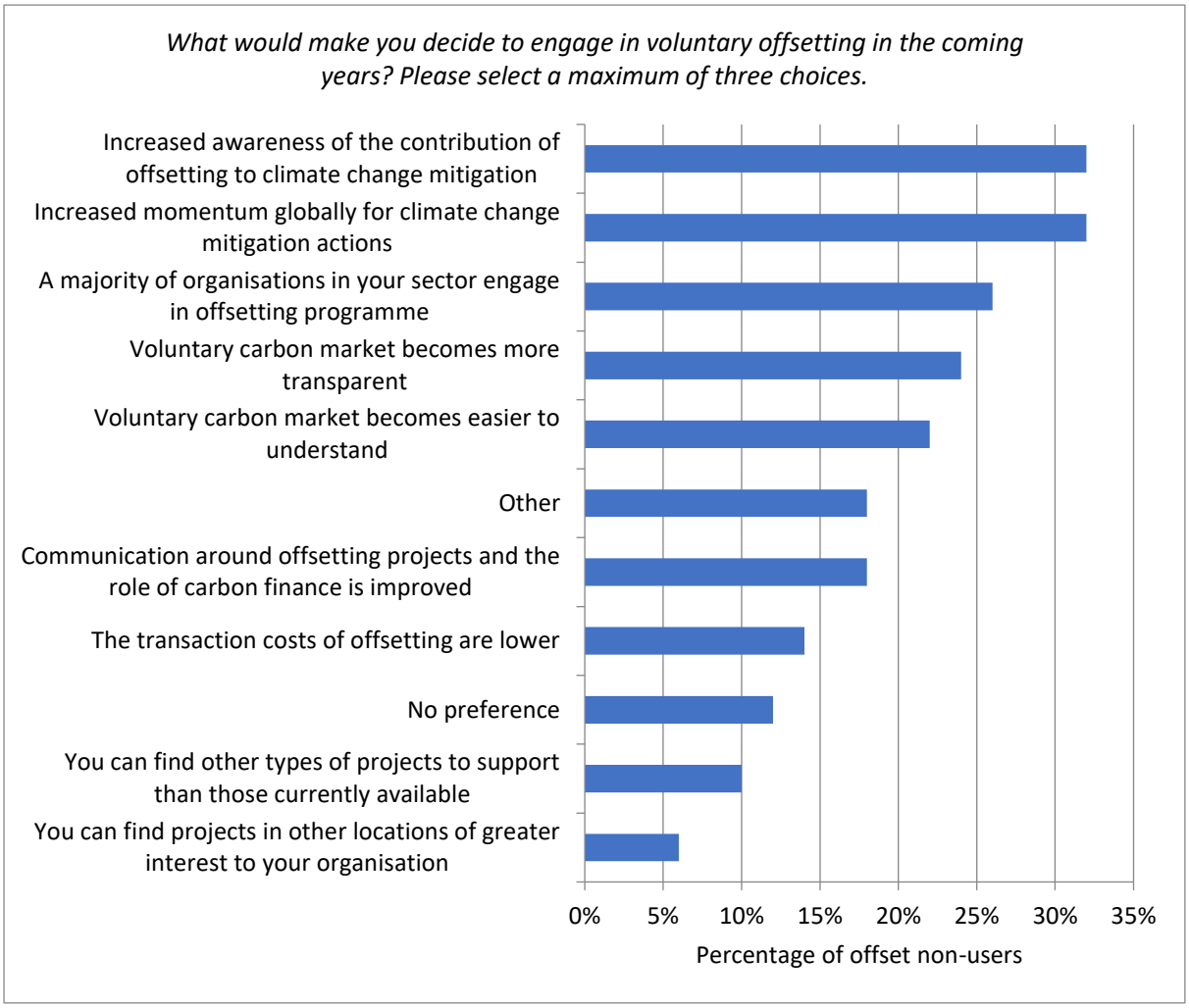


Figure 7-4 provides a list of factors that could promote offset users' participation in the VCM. The top three factors can be considered as external drivers. Most offset non-users would like to see greater recognition that offsetting contribute to climate change mitigation, which shows they may still be sceptical towards the concept of offsetting as a viable strategy to curb climate change. The second and third factors, greater efforts at the international level as well as within their operating sector in abating climate change, indicate the potential of collective participation effect in promoting voluntary offsetting. This is expected due to the nature of climate change that is subjected to free-

riding. The fourth and fifth factors indicate the VCM lacks transparency and is difficult to understand. These issues are related the market itself, which market actors need to address in order to attract further participations.

Figure 7-4: Factors that could promote offset non-users' participation in the VCM



7.3 Attitudes towards climate change and voluntary offsetting

This section examines the attitudes and perceptions of organisations towards climate change and voluntary carbon offsetting. More specifically, this section assesses organisations' attitudes towards climate change issue, knowledge about the VCM and belief in its effectiveness to abate GHG emissions, and perceptions of institutional conditions. In addition, their views on the importance of offset co-benefits are also being investigated.

To compare if the differences in the attitudes and perceptions of offset users and non-users are statistically significant, Mann-Whitney U-test (MWU test) was performed. MWU test is a non-parametric test that examines significant differences in ordinal data. The test does not assume

distribution for the data and compares the median of two sample populations. The null hypothesis is as follow:

H_0: There is no significant difference in the attitude/perception of offset users and non-users.

95% confidence level is used in this study and the corresponding critical value (c) is 1.96. If the absolute value of the calculated z statistic is greater than 1.96, then H_0 can be rejected or otherwise. Calculations of the MWU tests performed in this section are presented in Appendix 7-2.

7.3.1 Attitudes towards climate change issues

Through an analysis of organisations that voluntarily disclose their GHG emissions to the CDP in 2015 and 2016, Goldstein (2016; 2015) found that organisations that use voluntary offsets have deeper cut of their Scope 1 & 2 emissions than organisations that do not. This seems to suggest that organisations that voluntarily offset have greater self-ascribed responsibility and commitment to abate their GHG emissions than those that do not. As discussed in Section 4.2, internalised norm is also a strong driver underlying individuals' offsetting behaviour. In this study, respondents' level of self-ascribed responsibility to abate GHG emissions are being measured using five-point Likert Scale and the results are depicted in Figure 7-5.

Figure 7-5: Respondents' level of self-ascribed responsibility to abate GHG emissions

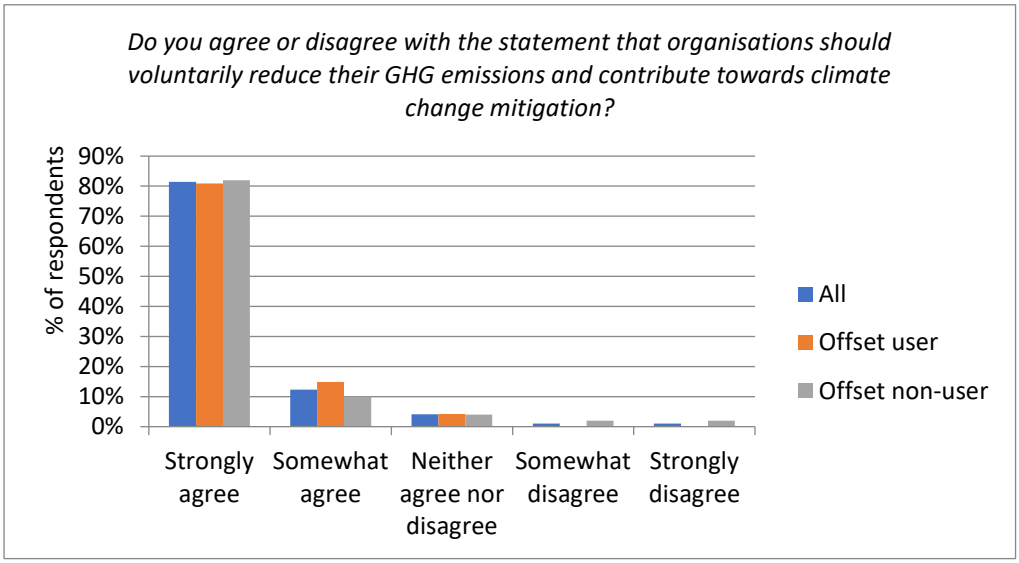
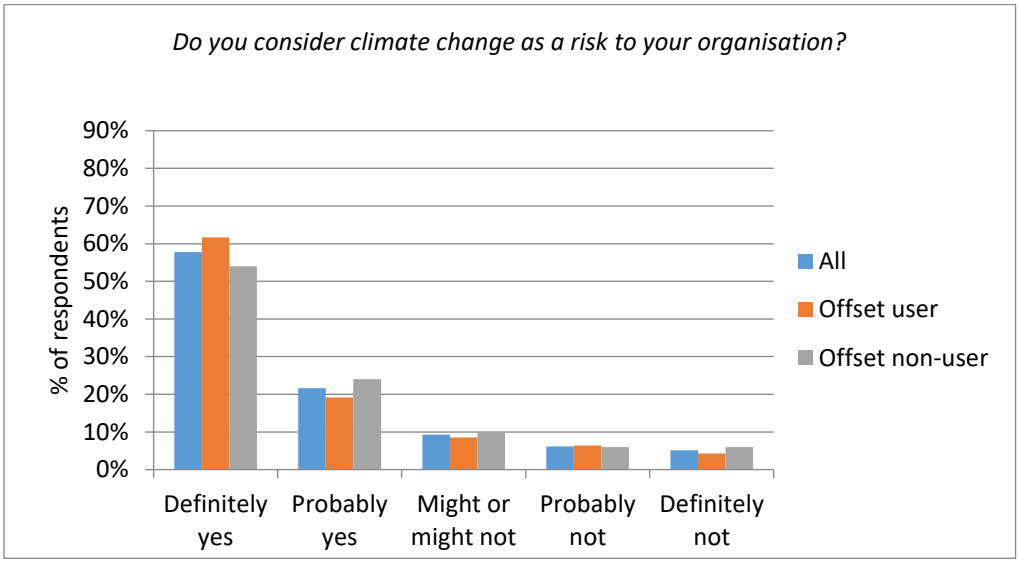


Figure 7-5 shows an overwhelming 94% (including strongly agree and somewhat agree) of the respondents feel that organisations should voluntarily abate their GHG emissions. This shows majority of the respondents have heightened awareness and sense of accountability towards their climate impacts. This is not surprising considering the population targeted for the survey, which are ICROA members' contacts and members of UN's Care for Climate Initiative. Both offset users and non-users have a median score of 1 and MWU test shows that the null hypothesis cannot be

rejected (z statistic = 0.02). This means there is no significant difference between offset users and non-users in their attitudes towards voluntary contribution to climate mitigation.

Goldstein (2016; 2015) also found that organisations that purchase voluntary offsets perceive greater climate change related risks, including reputation, extreme weather events and change in consumer behaviour. This shows that organisations' perceptions of climate change related risks can affect their decision to purchase voluntary offsets. In the survey, respondents were asked if they consider climate change as a risk to their organisation. Their responses are shown in Figure 7-6. Majority of the respondents consider climate change as a risk to their continual operation (79% including definitely and probably yes). In the follow-up question, most respondents identify extreme weather event as a climate change risk (57%), follows by supply chain related risk (29%), potential future regulation (38%), reputational risk (37%) and change in consumer behaviour (24%). Both offset users and non-users have a median score of 1 and MWU test shows that the null hypothesis cannot be rejected (z statistics = 0.63). Therefore, there is no significant difference between offset users and non-users in their perception of climate change risk.

Figure 7-6: Respondents' perception of climate change risk



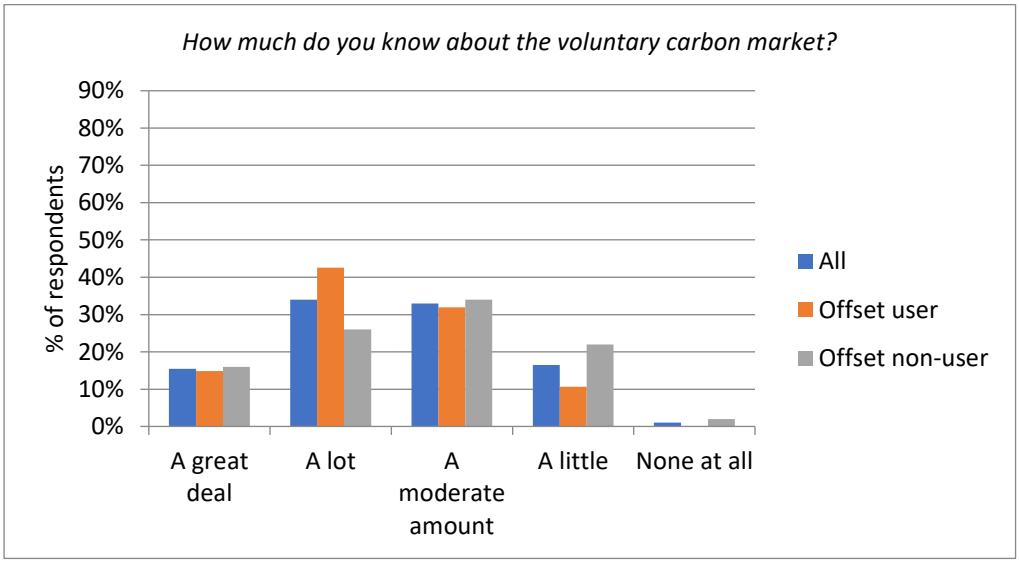
Another way of assessing respondents' attitudes towards climate change issue is whether they have carbon management strategy in place. Overall, 80% of them do. More specifically, 89% of offset users have carbon management strategy, whilst only 72% of offset non-users do. Chi-square test was used to examine if there is a relationship between having carbon management plan in place and becoming an offset user. Under the null hypothesis, having a carbon management strategy in place and being an offset user are independent of each other. Chi-square test result shows that the null

hypothesis can be rejected at 5% level ($\chi^2 = 4.636$, $p = 0.031$)[56] and there is a significant positive relationship between having a carbon management strategy in place and being an offset user. This is expected as having a carbon management plan to calculate and reduce emissions is often a prior step to purchasing voluntary offsets.

7.3.2 Knowledge of the VCM and belief in carbon offsetting

Awareness and knowledge about a product are expected to affect uptake of the product. Gracia & de Magistris (2008) found that greater knowledge about organic food increases the likelihood of purchasing organic products, whilst in the context of voluntary offsetting, Lu & Shon (2012) found the more air travellers know about the offsetting scheme, the more they are willing to pay to offset their flights. Following Gracia & de Magistris (2008) and Wheeler (2008)'s approach of using self-reported knowledge as a proxy of real knowledge, respondents were asked how much do they know about the VCM. Their responses are depicted in Figure 7-7. It shows most respondents have a lot to moderate amount of knowledge about the market. Based on the distributions and median scores (2 for offset users and 3 for non-users), offset users appear to have greater knowledge about the market than non-users. However, results from MWU test shows that the null hypothesis, i.e. the levels of knowledge of offset user and non-users are not significantly different, cannot be rejected (z statistic = 1.42).

Figure 7-7: Respondents' level of knowledge about the VCM

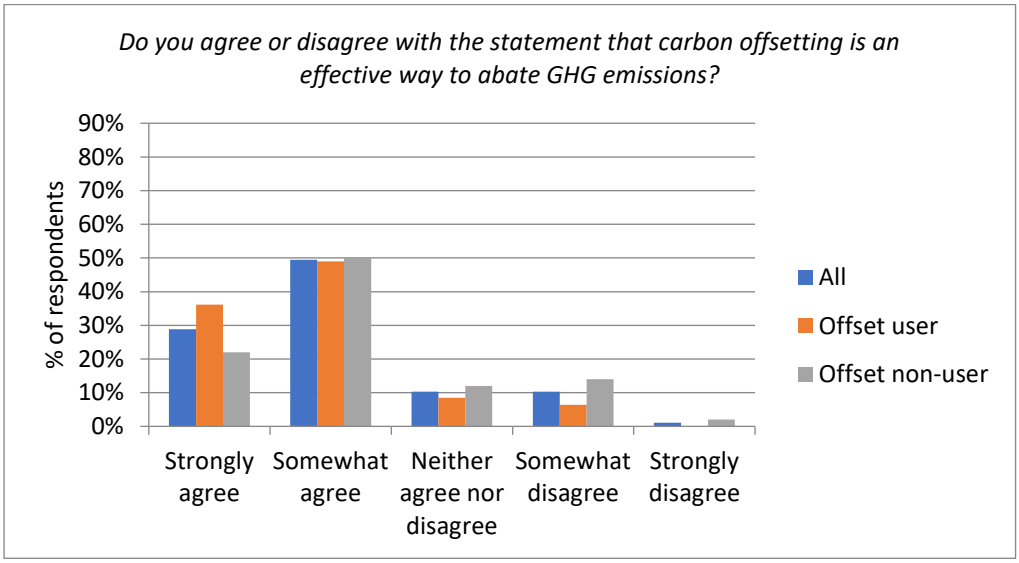


In addition to being aware of a product, belief in its benefits is also an important factor that drives purchase of the product. For example, belief in the health and environmental benefits of organic farming promotes positive WTP for organic products (Gil, Gracia & Sanchez, 2000). Similarly, belief in

[56] Calculations of all the Chi-square tests presented in this section are shown in Appendix 7-3.

the effectiveness of the offsetting scheme to abate emissions is a significant determinant for positive WTP for offsets (Lu & Shon, 2012; Akter et al., 2009; Brouwer, Brander & Van Beukering, 2008). In this survey, respondents' views on the effectiveness of carbon offsetting to abate GHG emissions were explored. Figure 7-8 presents the results and it shows that majority of the respondents somewhat agree that voluntary offsetting is an effective way to abate emissions. As expected, greater number of offset users than non-users strongly agree that offsetting is an effective way to abate GHG emissions. However, both offset users and non-users have a median score of 2 and MWU test shows that offset users and non-users are not significantly different in their belief in the effectiveness of carbon offsetting to abate GHG emissions (z statistic = 1.79).

Figure 7-8: Respondents' view on the effectiveness of offsetting in abating GHG emissions



According to Wheeler (2008), greater product knowledge can improve consumers' belief in the benefits of the product. In this study, Chi-square test was used to investigate if there is a correlation between respondent's knowledge of the VCM and belief in its effectiveness to abate GHG emissions. Under the null hypothesis, there is no correlation between knowledge of the VCM and belief in its effectiveness to abate GHG emissions. Chi-square test result shows that the null hypothesis can be rejected at 5% level ($\chi^2 = 10.62$, $p = 0.031$), meaning there is a correlation between the two. However, determining cause and effect would be difficult as according to Costa-Font & Mossialos (2006), knowledge could influence a consumer's attitude towards a product, however pre-exiting belief in a product could also leads to knowledge acquirement about the product.

7.3.3 Perceptions of institutional conditions

Institutional conditions such as the level of pressure or scrutiny from the government, NGOs, media or other independent regulatory bodies can drive organisations to behave in socially responsible way

(Campbell, 2007). Government's strong commitment to curb climate change can send a clear signal to the industry and drive them to act upon their climate impacts on a voluntary basis, whether to avoid or to prepare for future more stringent regulation. In this study, the perceived impacts of the landmark Paris Agreement are explored, including its impacts on organisations' expectations of others' participation and its own participation in voluntary offsetting. The results are presented in Figure 7-9 and Figure 7-10 respectively.

Figure 7-9: Respondents' expectation of others' participation in voluntary offsetting following the Paris Agreement

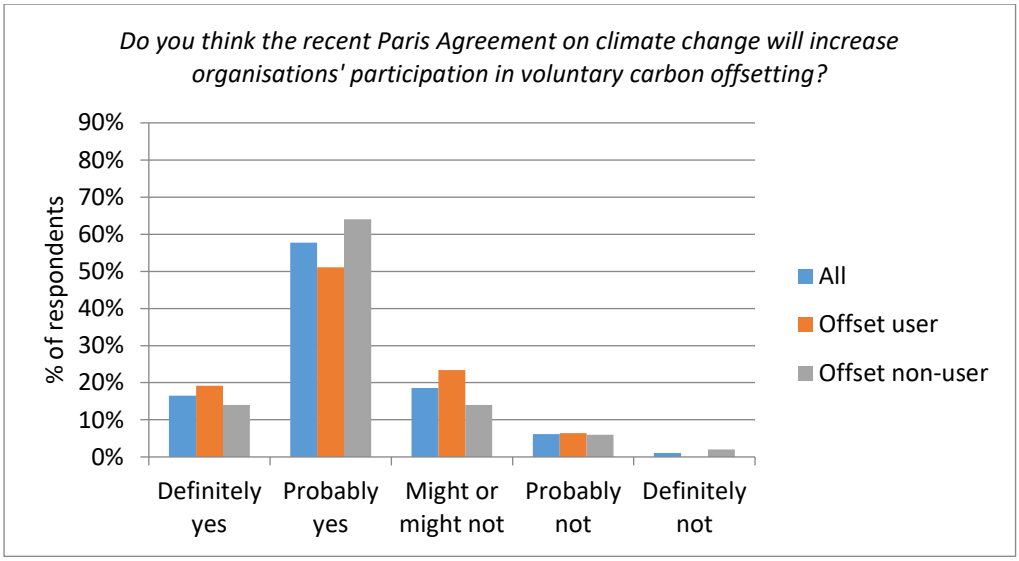


Figure 7-10: Respondents' expectations of own's participation in voluntary offsetting following the Paris Agreement

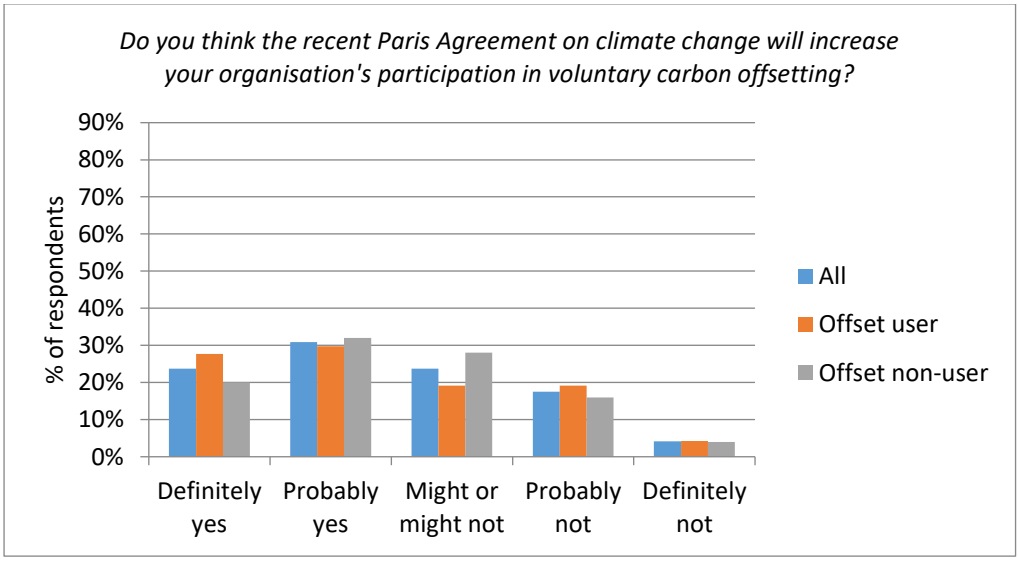


Figure 7-9 shows that 74% (including definitely and probably yes) of the respondents feel Paris Agreement is likely to increase organisations' participation in voluntary offsetting, however Figure

7-10 shows only 55% (including definitely and probably yes) feel it will increase their own participation. Both offset users and non-users have a median score of 2 for both questions, and MWU test shows that there are no significant differences between offset users and non-users regarding their perceived participation effects, others as well as own, as the result of the Paris Agreement (z statistics = 0.13 and 0.48 respectively). Chi-square test result shows there is a correlation between expectation of other organisations' participation and expectation of own participation in voluntary offsetting (χ^2 = 12.116, p = 0.017), with greater expectation of others' participation corresponds to greater expectation of own participation.

7.3.4 Views on the importance of offset co-benefits

The aim of offset consumers is to use offsets to compensate an equivalent amount of their own GHG emissions. Thus, offset has a use value to its consumers. However, offset co-benefits such as poverty alleviation and biodiversity conservation could also have non-use or passive use values to offset consumers. As previously discussed, for organisations that engage in voluntary offsetting for strategic CSR reasons, offset co-benefits become relevant in the context of their motivations. In this sense, offset co-benefits also have a use value to these organisations as they use offset co-benefits to engage their stakeholders and maximise their CSR impact. In this study, the importance of offset co-benefits and co-benefit verification to organisations are being investigated and the results are presented in Figure 7-11 and Figure 7-12 respectively.

Figure 7-11: Respondents' view on the importance of offset co-benefits

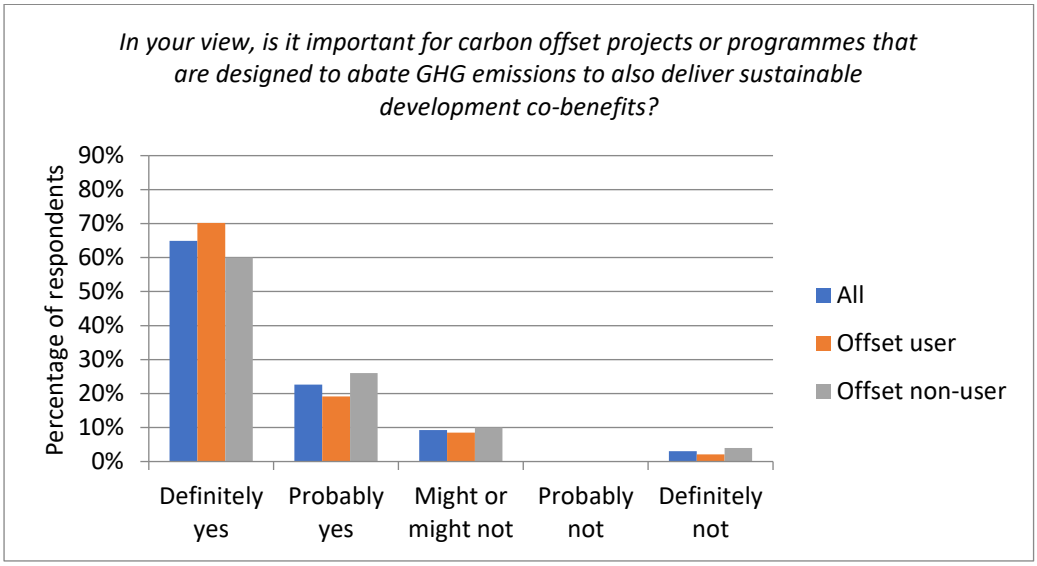


Figure 7-11 shows that 88% (including definitely yes and probably yes) of the respondents feel that offset co-benefits are important. Their preference for offset co-benefits that are linked to SDGs are also being explored. The top five most preferred co-benefits are conservation of local natural

ecosystems and biodiversity (SDG 15), improved local health and well-being (SDG 3), poverty alleviation (SDG 1), improved energy security (SDG 7) and improved access to clean drinking water and sanitation (SDG 6). The full list of co-benefits that respondents prefer in an offset project is presented in Appendix 7-4.

Figure 7-12: Respondents' view on the importance of offset co-benefit verification

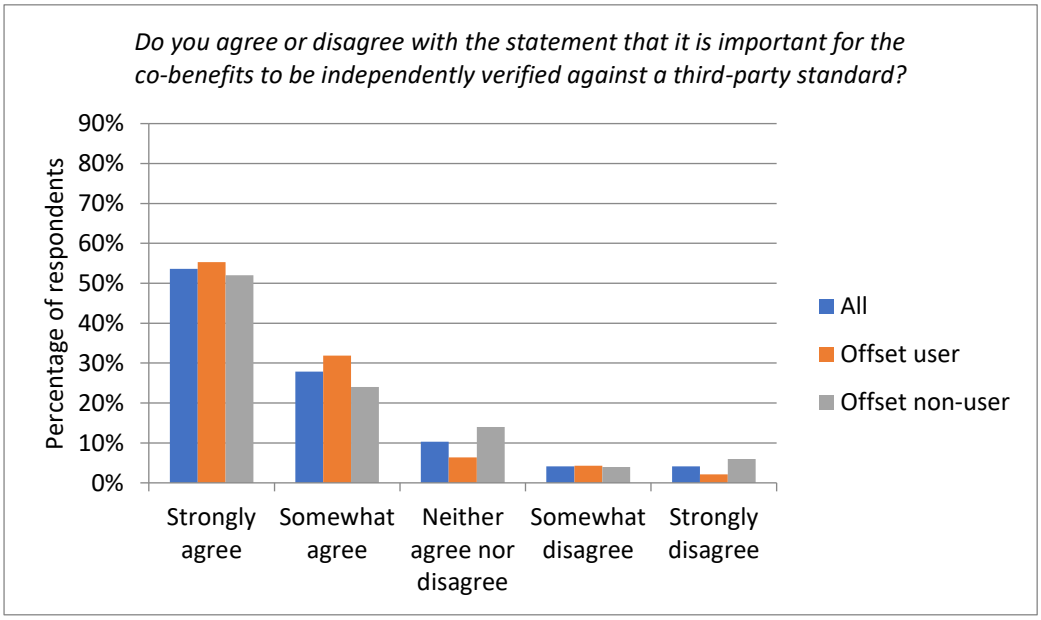


Figure 7-12 shows that majority of the respondents (81% including strongly agree and somewhat agree) also feel it is important for the co-benefits to be independently verified. Third-party verification of co-benefits provides confidence to offset buyers that the co-benefits are being realised on the ground. Both offset users and non-users have a median score of 1 and MWU test shows that offset users and non-users are not significantly different in their views on the importance of offset co-benefits and co-benefit verification (z statistics = 0.87, 0.66 respectively).

7.4 Propensity to purchase voluntary offset

7.4.1 The econometric model

To gain further understanding in what drives organisations to participate in voluntary offsetting, an econometric analysis is used. In the model, the likelihood of respondents being an offset user (dependent variable) is determined by a set of organisations' attitudinal and demographic characteristics (independent variable). The analysis enables determination of the marginal effect of each independent variable on the dependent variable. As the dependent variable is binary, 1 if the respondent is an offset user and 0 if otherwise, a logit equation such as follows is estimated:

$$ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon_i \qquad (14)$$

In the equation, P_i is the probability of being an offset user, $(1 - P_i)$ is the probability of being an offset non-user, $ln\left(\frac{P_i}{1-P_i}\right)$ is the natural logarithm of the odd ratio, β_n is the estimated coefficient, X_n is the independent variable and ε_i is the error term that includes all unobserved contributors.

Informed by existing studies on individual offsetting behaviour and the limited grey literature on organisations' participation in voluntary offsetting, I hypothesised in this study that factors that could influence an organisation's decision to purchase offsets are their self-ascribed responsibility to abate GHG emissions (RESPONSIBILITY), perceived climate change risk (RISK), knowledge about the VCM (KNOWLEDGE), belief in the effectiveness of offsetting (EFFECTIVENESS), the Paris Agreement (INSTITUTION) and the perceived participation effect of the Paris Agreement (OTHER).

In terms of organisation demographic variables that could be significant determinants, ESMP annual reports on the VCM indicate that the main source of demand for voluntary offsets is private organisations that are based in Annex I countries, mainly Europe and North America. In addition, majority of voluntary buyers are from energy, financial and transport sectors. Therefore, in this study, organisations' variables such as organisation type, location and operating sector are controlled for. Due to the large number of sectors that participated in the survey, only sectors with reasonable sample size, i.e. more than five respondents, are included in the model (except for manufacturing as all respondents from the sector are non-users). This includes the three sectors that are prominent sources of demand for voluntary offsets, energy, financial and transport.

In addition, the analysis also investigates if organisations that have a carbon management plan are more likely to purchase voluntary offset than those that do not (MANAGEMENT). Thus, the final specification of the binary logistic regression is as follows and the variables are described in Table 7-2.

$$USER = \beta_0 + \beta_1 RESPONSIBILITY + \beta_2 RISK + \beta_3 KNOWLEDGE + \beta_4 EFFECTIVENESS + \beta_5 INSTITUTION + \beta_6 OTHER + \beta_7 PROFIT + \beta_8 PUBLIC + \beta_9 ANNEXI\_EU + \beta_{10} ANNEXI\_NONEU + \beta_{11} ENERGY + \beta_{12} FINANCIAL + \beta_{13} TRANSPORT + \beta_{14} PROFFESSIONAL + \beta_{15} INFORMATION + \beta_{16} MANAGEMENT + \varepsilon \quad (15)$$

Table 7-2: Descriptions of dependent and independent variables specified in logistic regression

Variable name	Variable definition	Mean (standard deviation) [a]	Expected sign
Dependent variable			
USER	1 if the respondent is an offset user, 0 if otherwise	0.489 (0.503)	
Independent variable			
Attitudinal variables			
RESPONSIBILITY	Organisations should voluntarily reduce their GHG emissions. 1 – strongly agree and somewhat agree, 0 – neither agree or disagree, somewhat disagree and strongly disagree.	0.936 (0.246)	+
RISK	Consider climate change as a risk to the organisation. 1 – definitely yes and probably yes, 0 – might or might not, probably not and definitely not.	0.787 (0.411)	+
KNOWLEDGE	Respondent's self-reported knowledge about the VCM. 1 – a great deal and a lot, 0 – a moderate amount, a little and none at all.	0.489 (0.503)	+
EFFECTIVENESS	Carbon offsetting is an effective way to abate GHG emissions. 1 – strongly agree and somewhat agree, 0 – neither agree or disagree, somewhat disagree and strongly disagree.	0.777 (0.419)	+
INSTITUTION	The Paris Agreement on climate change will increase your organisation's participation in voluntary carbon offsetting. 1 – definitely yes and probably yes, 0 – might or might not, probably not and definitely not.	0.543 (0.501)	+
OTHER	The Paris Agreement on climate change will increase other organisations' participation in voluntary carbon offsetting. 1 – definitely yes and probably yes, 0 – might or might not, probably not and definitely not.	0.745 (0.438)	+

Variable name	Variable definition	Mean (standard deviation) [a]	Expected sign
Organisation type			
The base case is not-for-profit and other types of organisations such as think tank and social enterprise			
PROFIT	1 if the respondent is private for-profit organisation, 0 if other organisation types	0.809 (0.396)	+
PUBLIC	1 if the respondent is a governmental or public organisation, 0 if other organisation types	0.128 (0.335)	Not sure
Organisation location			
The base case is organisation that is located or headquartered in a non-Annex I country			
ANNEXI_EU	1 if the respondent is located or headquartered in an Annex I and European country, 0 if elsewhere	0.638 (0.483)	+
ANNEXI_NONEU	1 if the respondent is located or headquartered in an Annex I and non-European country, 0 if elsewhere	0.191 (0.378)	+
Organisation sector			
The base case is all sectors excluding the following five sectors			
ENERGY	1 if the respondent operates in electricity and energy sector, 0 if others	0.149 (0.358)	+
FINANCIAL	1 if the respondent operates in financial and insurance sector, 0 if others	0.096 (0.296)	+
TRANSPORT	1 if the respondent operates in transport and tourism sector, 0 if others	0.128 (0.335)	+
PROFESSIONAL	1 if the respondent operates in professional and administrative services, 0 if others	0.106 (0.310)	Not sure
INFORMATION	1 if the respondent operates in information and communication sector, 0 if others	0.085 (0.281)	Not sure
Carbon management			
MANAGEMENT	1 if the respondent has carbon management strategy in place, 0 if otherwise.	0.798 (0.404)	+

[a] Mean and standard deviation are calculated based on 94 respondents. 3 respondents are excluded from the analysis as they did not disclose their location.

7.4.2 Logistic regression results

The coefficients of the independent variables, as well as their standard errors and significance levels are estimated in STATA 14 using the *logit* command that is based on maximum likelihood procedure.

Table *7-3* reports the regression results. The marginal effects and their confidence intervals are also estimated in STATA 14 using postestimation command, *margins* that is based on Delta method. The command estimates the effect of a unit increase of the independent variable, from 0 to 1, on the probability of becoming an offset user while holding all other independent variables at their means. Only the marginal effects of independent variables that are significant are reported.

Table 7-3: Logistic regression results

Independent variables	**Coefficient (Standard error)**	**Marginal effect (95% confidence interval)**
Attitudinal variables		
RESPONSIBILITY	0.167 (1.135)	
RISK	0.201 (0.690)	
KNOWLEDGE	0.146 (0.549)	
EFFECTIVENESS	1.127 (0.727)	
INSTITUTION	0.127 (0.558)	
OTHER	-1.172 (0.652) *	-0.21 (-0.42-0.01)
Organisation variables		
PROFIT	2.506 (1.538)	
PUBLIC	3.804 (1.740) **	0.67 (0.12-1.22)
ANNEXI_EU	1.603 (0.786) **	0.28 (0.03-0.53)
ANNEXI_NONEU	1.473 (0.887) *	0.26 (-0.03-0.55)
ENERGY	1.698 (0.803) **	0.30 (0.05-0.55)
FINANCIAL	2.220 (0.974) **	0.39 (0.09-0.70)
TRANSPORT	1.464 (0.854) *	0.26 (-0.02-0.54)
PROFESSIONAL	1.753 (0.950) *	0.31 (0.00-0.62)
INFORMATION	1.637 (1.086)	
MANAGEMENT	1.046 (0.761)	
_constant	-6.212 (2.137) ***	
Model fit		
Number of observations	94[a]	
Log likelihood (null)	-65.135	

Independent variables	Coefficient (Standard error)	Marginal effect (95% confidence interval)
Log likelihood (model)	-49.658	
Likelihood ratio, χ^2 (d.f)	30.95 (16) **	
Pseudo R^2	0.238	

***, **, * = significance at 1%, 5%, 10% level. [a] Three observations were dropped as respondents did not disclose their locations.

The likelihood ratio chi-square value shows that overall, the model is significant. Only one attitudinal variable, OTHER is significant in explaining the likelihood of respondents being an offset user but its coefficient is only significant at 10% level. The negative sign of its coefficient is rather unexpected. It implies that the perceived participation effect of the Paris Agreement has a negative impact on organisations' likelihood to purchase voluntary offsets. Previous studies on individuals' offsetting behaviour have found that expectation of others' participation has a positive impact on an individual's WTP for offset. Some individuals purchase offsets to adhere to social norm, whilst others feel obliged to contribute their fair shares when others do the same (collective participation effect). However, result here shows that organisations behave more like pure altruists. They contribute when their expectation of others' contribution is low. This suggests they only derive utility from the overall level of public goods. Interestingly, offset non-users participated in the survey have indicated greater engagement in voluntary offsetting within their sector as the third most important factor that could promote their future participation. These findings collectively indicate that majority of existing offset users voluntarily offset their emissions for altruistic reasons, however greater collective participation is required to promote future participation of offset non-users.

In terms of demographic variables, most of the coefficients are significant. Based on the coefficient sign and marginal effect, public sector is 67% (12-122%) more likely to purchase offsets than for-profit and not-for-profit sectors. This finding contrasts with ESMP reports which found private for-profit sector to be the main offset consumer. Organisation's location is also a significant factor that influence the likelihood of organisation being an offset user. Organisations that are based in Annex I European countries are most likely to purchase offsets, follows by organisations in Annex I non-European countries and then organisations in non-Annex I countries (base case). This is in-line with ESMP's finding that most offset users are from Annex I countries. The coefficients of ENERGY, FINANCE and TRANSPORT, the three most prominent buyers of the VCM are all positive and significant, although the coefficient of TRANSPORT is only significant at 10% level. The coefficient of PROFESSIONAL is also positive and significant but only at 10% level. Despite Chi-square test shows there is a significant positive relationship between having a carbon management strategy in place

and being an offset user, the coefficient of MANAGEMENT is insignificant in the parametric analysis. Overall, the estimation results show that organisations' demographic variables are stronger determinants than attitudinal variables in influencing the likelihood of an organisation being an offset user. This is not surprising as attitudinal variables are likely to capture some views and preferences of the individuals who undertook the survey.

7.5 Contingent valuation results

7.5.1 Protest bidders

Survey results show ten respondents did not answer both CVM questions, five respondents stated a zero WTP for offset alone and one respondent stated a zero WTP for offset with co-benefits. Furthermore, two respondents provided non-monetary responses, one stated '*I have no idea*', whilst another stated *'[willing to pay the] true social cost of carbon*'. One respondent stated a WTP for offset alone but not for offset with co-benefits, quoting that '*the co-benefits were not clear so it was not possible to make decision on purchasing offsets*'.

Before analysing the CVM data, the zero responses need to be examined to determine if they are protest bids so that appropriate treatments can be applied. Protest bidding is a common issue in the CVM that is yet to be resolved. According to Halstead, Luloff & Stevens (1992), there are three types of protest bidders: (1) those who simply not respond, (2) those who state a zero WTP eventhough they have a positive value for the goods in question (protest zeros), and (3) those who state a WTP that is greater than their true WTP (outliers). Reasons underlying protest bids include protesting against additional taxes, believing someone else should pay, ethical issue or insufficient information to make their decisions (Lindsey, 1994). There are a number of ways of treating protest bids, (1) exclude them from the analysis, (2) treat them as legitimate responses and include them in the analysis, or (3) assign them the mean WTP value adjusted by their sociodemographic characteristics (Halstead, Luloff & Stevens, 1992). Identification and treatment of protest bids are often done on an ad-hoc basis but the most common way is identifying and differentiating protest zeros from genuine zeros using a follow-up question that enquires reasons for providing a zero bid, and remove protest bids from the analysis (Jorgensen et al., 1999).

In the present study, the payment vehicle is voluntary contribution rather than mandatory tax, therefore protest against payment vehicle is unlikely. Of the five respondents indicated a zero WTP for offset alone, three are offset non-users, therefore their zero WTP can be considered as legitimate answer. The remaining two are offset users. One possible explanation for their zero WTP for offset alone could be they do not intend to purchase offsets that do not generate co-benefits as both of them display a positive WTP for offset with co-benefits in the second CVM question. As the results,

all zero responses in this study are considered as genuine zeros and are included in the analysis. This also represents a more conservative approach as excluding zero responses without concrete justification may lead to biased WTP estimation (Bliem, Getzner & Rodiga-Laßnig, 2012).

For non-responses, including responses that are not in monetary value, one potential way of treating them is by assigning them the mean WTP derived from the remaining sample population, adjusted by their demographic characteristics. This approach may be useful if the aim of the study is to derive an aggregate WTP estimate for the non-marketed good. As the objective of this study is to examine the underlying determinants of WTP amount, assigning non-responses with the adjusted mean WTP would not have been useful. Thus, non-responses are excluded from analyses in this study.

The issue of outliners is also relevant in this study. Positive WTP expressed by offset non-users can be considered as outliers as they are not paying for voluntary offsets in real life. Inclusion of offset non-users' positive WTP may be inappropriate if the aim is to derive an aggregate WTP estimate for climate change mitigation such as the case in Brouwer, Brander & Van Beukering (2008). However, for this study, the aim is to identify the underlying determinants of positive WTP for offset, thus the responses of offset non-users are considered particularly valuable to inform the market on how to promote their participation. Therefore, they are included in the analysis.

After excluding the missing and non-monetary responses, the final number of usable responses are 85 for the first CVM question and 84 for the second CVM question. A summary of response rates for the CVM questions is presented in Table 7-4.

Table 7-4: CVM response rates

	All	**Offset users**	**Non-users**
CVM question 1	85	43	42
CVM question 2	84	43	41

7.5.2 WTP for offset

Figure 7-13 depicts the WTP distribution for voluntary offset. 94% of the respondents are willing to pay at least the minimal positive amount on the payment card. The distribution is skewed to the left with a right tail and a peak at US$2.01-4 per offset.

Figure 7-13: WTP distribution for offset

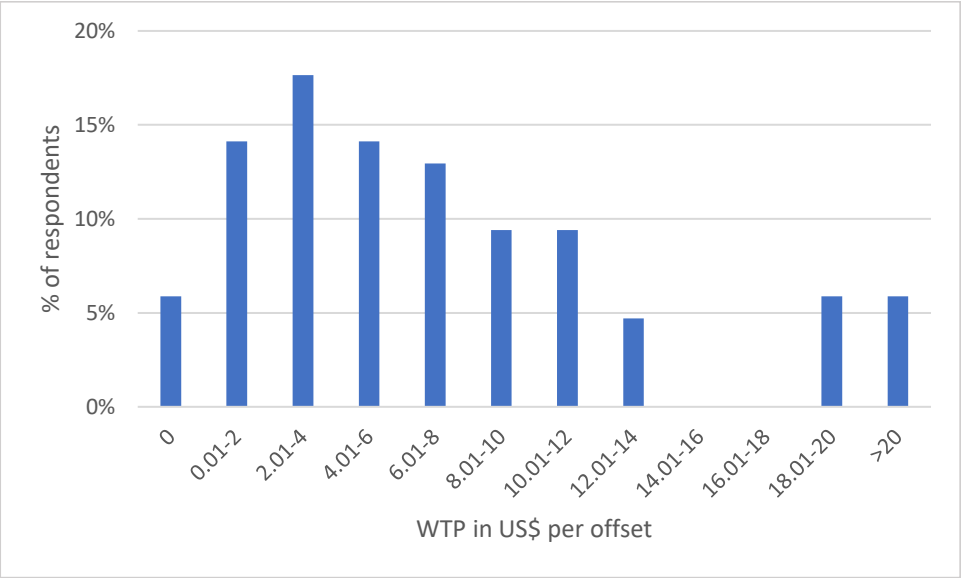
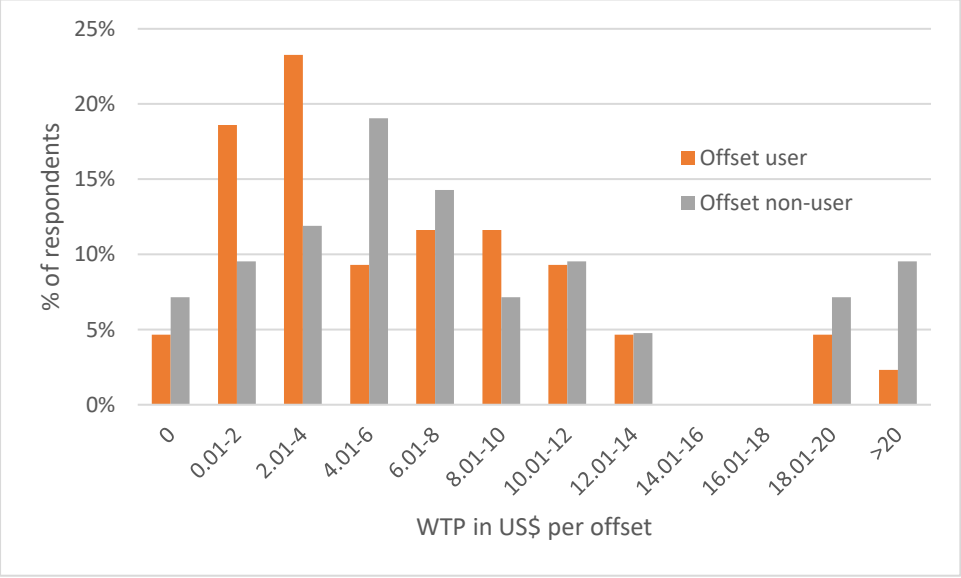


Figure 7-14 compares the WTP distributions between offset users and non-users. Based on the distributions, offset non-users appear to have greater WTP than offset users as the former's WTP distribution appears to be more skewed towards the right. The median WTP for offset users is US$4.01-6 per offset whilst the median WTP for non-users is US$6.01-8. However, MWU test shows there is no significant difference in the WTP of offset users and non-users (z statistic = 1.25)[57].

Figure 7-14: A comparison of offset users and non-users' WTP for offset



A regression analysis is used to gain insights on the determinants underlying organisations' WTP for voluntary offset. Variables that are being examined are as described in Table 7-2. In addition, a

[57] The MWU test is presented in Appendix 5-7.

dummy variable, USER (1 if respondent if an offset user and 0 if otherwise) is also included as one of the independent variables. Thus, the final valuation function is as follows:

$$LogWTP = \beta_0 + \beta_1 RESPONSIBILITY + \beta_2 RISK + \beta_3 KNOWLEDGE + \beta_4 EFFETIVENESS + \beta_5 INSTITUTION + \beta_6 OTHER + \beta_7 ANNEXI\_EU + \beta_8 ANNEXI\_NONEU + \beta_9 PROFIT + \beta_{10} PUBLIC + \beta_{11} ENERGY + \beta_{12} FINANCIAL + \beta_{13} TRANSPORT + \beta_{14} PROFFESIONAL + \beta_{15} INFORMATION + \beta_{16} MANAGEMENT + \beta_{17} USER + \varepsilon \quad (16)$$

Where β_n is the estimated coefficient and ε is the error term that is not observed in the model. The regression results are reported in Table 7-5, including the estimated coefficients and their standard errors. Only the marginal effects of coefficients that are significant are reported.

Table 7-5: Regression results for WTP for offset

Independent variable	Coefficient (standard error)	Marginal effect (95% confidence level)
Attitudinal variables		
RESPONSIBILITY	0.945 (0.383) **	US$8.81 (1.56-49.55)
RISK	-0.114 (0.225)	
KNOWLEDGE	0.230 (0.198)	
EFFECTIVENESS	-0.012 (0.248)	
INSTITUTION	0.151 (0.191)	
OTHER	-0.105 (0.220)	
Organisation variables		
PROFIT	0.277 (0.416)	
PUBLIC	-0.331 (0.479)	
ANNEXI_EU	-0.141 (0.276)	
ANNEXI_NONEU	0.250 (0.307)	
ENERGY	-0.151 (0.289)	
FINANCIAL	-0.304 (0.315)	
TRANSPORT	-0.314 (0.325)	
PROFESSIONAL	0.621 (0.320) *	US$4.18 (0.99-17.74)
INFORMATION	0.441 (0.350)	
MANAGEMENT	-0.095 (0.252)	
USER	-0.151 (0.202)	
_constant	-0.359 (0.634)	

Independent variable	Coefficient (standard error)	Marginal effect (95% confidence level)
Model fit		
Number of observations	83[a]	
Log likelihood (null)	-228.397	
Log likelihood (model)	-215.392	
LR χ^2 (d.f)	26.01 (17) *	

***, **, * = significance at 1%, 5%, 10% level. [a] Two observations are dropped in the regression analysis due to their incomplete demographic information.

Table 7-5 shows that the coefficient of RESPONSIBILITY is positive and significant at 5% level. The positive sign of the coefficient is as expected as it indicates that greater respondent's self-ascribed responsibility to abate GHG emissions corresponds to greater WTP for voluntary offset. The marginal effect shows that respondents who agree organisations should abate their GHG emissions and contribute to climate change mitigation on a voluntary basis are willing to pay US$8.81 (1.56-49.55) more per offset than those who do not.

In terms of demographic variables, only the coefficient of PROFESSIONAL is significant. Its positive sign and the marginal effect indicate that organisations that operate in professional and administrative services are willing to pay US$4.18 (0.99-17.74) more per offset than other sectors.

It is also worth mentioning that the coefficient of USER is insignificant, which confirms MWU test result that the WTP of offset users and non-users are not significantly different.

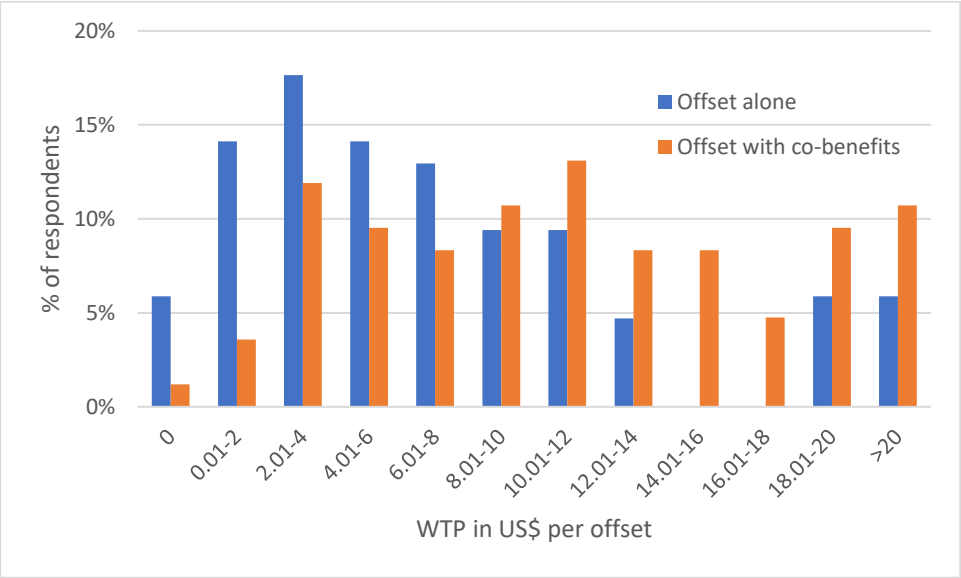
The overall mean marginal WTP for offset, with all independent variables set at their mean values, is estimated to be US$3.37 (2.28-4.97).

7.5.3 WTP for offset with co-benefits

The WTP distribution for offset that also delivers co-benefits is depicted in Figure 7-15, along with the WTP distribution for offset alone for comparison. It shows that the presence of offset co-benefits appears to shift the WTP distribution to the right, with a greater percentage of respondents willing to pay more than US$12 per offset. The median WTP for offset alone is US$4.01-6, whilst the median WTP for offset with co-benefits is US$10.01-12. MWU test (based on 84 respondents who provided WTP for both offset alone and offset with co-benefits) shows that the median WTP for offset alone and offset co-benefits are significantly different (z statistic = 4.09)[58].

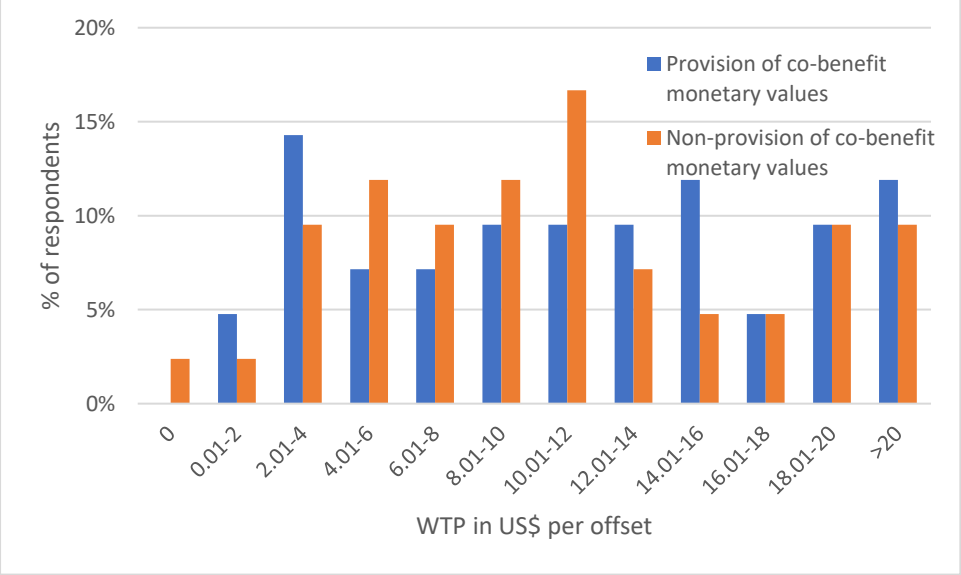
[58] The MWU test is presented in Appendix 7-6.

Figure 7-15: A comparison of WTP for offset alone and offset with co-benefits



For the second CVM question, half of the respondents received an additional information about the monetary values of offset co-benefits. Figure 7-16 compares the WTP distributions for the two sub-samples. Based on the distributions, it is not obvious if provision of the monetary values of the co-benefits can yield greater WTP. The median WTP for both sub-samples are US$10.01-12 and MWU test confirms that the WTP of the two sub-samples are not significantly different (z statistic = 0.51)[59].

Figure 7-16: A comparison of WTP of respondents who received information on the monetary values of offset co-benefits and those who did not

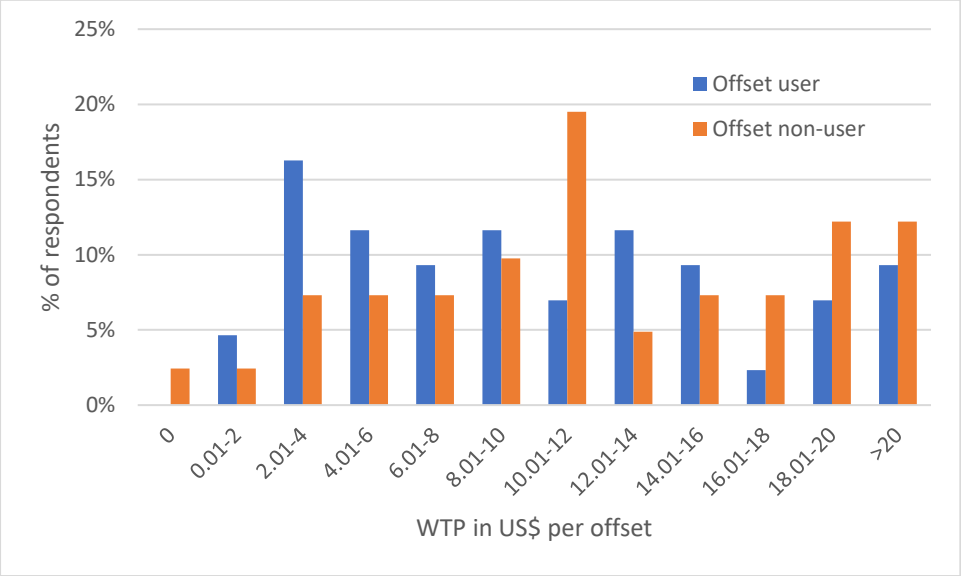


Finally, the WTP for offset with co-benefits of offset users and non-users are being compared as shown in Figure 7-17. Based on the distributions, offset non-users seem to have greater WTP for

[59] The MWU test is presented in Appendix 7-7.

offset with co-benefits than offset users as the former's WTP distribution appears to be more skewed towards the right. The median WTP of offset users and non-users for offset with co-benefits are US$8.01-10 and US$10.01-12 respectively, however MWU test shows the two medians are not significantly different (z statistic = 1.36)[60].

Figure 7-17: A comparison of WTP of offset users and non-users for offset with co-benefits



Again, a regression analysis is used to identify characteristics of respondents who are willing to pay more (or less) for offset with co-benefits. In addition to the attitudinal and demographic variables that are used in examining respondents' WTP for offset alone, respondents' attitudes towards offset co-benefits (COBENEFIT) is also included in the present model. The variable is defined by the respondent's view on the importance of offset co-benefits (1 – definitely yes and probably yes, it is important for offset projects to also deliver co-benefits and 0 – might or might not, probably not and definitely not important). A dummy variable, QUANTIFCATION is also included to control for respondents who are informed of the monetary values of the co-benefits and those who are not (1 if the respondent received the additional information, 0 if otherwise). The final specification of the model is as follows:

$$LogWTP = \beta_0 + \beta_1 RESPONSIBILITY + \beta_2 RISK + \beta_3 KNOWLEDGE + \beta_4 EFFETIVENESS + \beta_5 INSTITUTION + \beta_6 OTHER + \beta_7 COBENEFIT + \beta_8 ANNEXI\_EU + \beta_9 ANNEXI\_NONEU + \beta_{10} PROFIT + \beta_{11} PUBLIC + + \beta_{12} ENERGY + \beta_{13} FINANCIAL + \beta_{14} TRANSPORT + \beta_{15} PROFFESIONAL + \beta_{16} INFORMATION + \beta_{17} MANAGEMENT + \beta_{18} USER + \beta_{19} COBENQUAN + \varepsilon \quad (17)$$

[60] The MWU test is presented in Appendix 7-8.

Where β_n is the estimated coefficient and ε is the error term that is not observed in the model. The regression results are reported in Table 7-6.

Table 7-6: Regression results for WTP for offset with co-benefits

Independent variable	Coefficient (standard error)	Marginal effect (95% confidence interval)
Attitudinal variables		
RESPONSIBILITY	0.611 (0.208) ***	US$4.08 (1.60-10.45)
RISK	0.041 (0.124)	
KNOWLEDGE	-0.063 (0.107)	
EFFECTIVENESS	0.021 (0.141)	
INSTITUTION	0.044 (0.103)	
OTHER	-0.048 (0.115)	
COBENEFIT	0.398 (0.183) **	US$2.50 (1.10-5.71)
Organisation variables		
PROFIT	-0.058 (0.224)	
PUBLIC	-0.213 (0.266)	
ANNEXI_EU	0.082 (0.149)	
ANNEXI_NONEU	0.206 (0.163)	
ENERGY	-0.007 (0.156)	
FINANCIAL	-0.055 (0.173)	
TRANSPORT	-0.086 (0.174)	
PROFESSIONAL	0.275 (0.169)	
INFORMATION	0.070 (0.193)	
MANAGEMENT	-0.030 (0.134)	
USER	-0.036 (0.110)	
QUANTIFICATION	0.025 (0.106)	
_constant	0.016 (0.354)	
Model fit		
Number of observations	82[a]	
Log likelihood (null)	-212.135	
Log likelihood (model)	-209.463	
LR χ^2 (d.f)	28.03 (19) *	

***, **, * = significance at 1%, 5%, 10% level. [a]Two observations are dropped in the regression analysis due to their incomplete demographic information.

Regression results show that RESPONSIBILITY and COBENEFIT are significant factors that influence respondents' WTP for offset with co-benefits. The coefficient of RESPONSIBILITY is positive and highly significant at 1% level. Its marginal effect shows that respondents who feel organisations should abate their GHG emissions on a voluntary basis are willing to pay US$4.08 (1.60-10.45) more than those that do not. One potential explanation of this observation is that respondents with greater self-ascribed responsibility to abate their climate change impacts are likely to also associate with other socially and environmental responsible behaviours.

The coefficient of COBENEFIT is also positive as expected and significant at 5% level. The marginal effect shows that respondents who view offset co-benefits as important are willing to pay US$2.50 (1.10-5.71) more for offset with co-benefits than those who do not.

In terms of demographic variables, none are found to be significant. The coefficient of QUANTIFICATION is also insignificant which confirms the MWU test result that provision of the monetary values of offset co-benefits does not have significant impact on respondents' WTP for offset with co-benefits. The coefficient of USER is also insignificant, meaning the WTP of offset users and non-users are not significantly different. This is also in-line with the result of MWU test.

Setting all the independent variables at their mean values, the marginal mean WTP for offset with co-benefits is estimated to be US$8.93 (7.26-10.96).

7.5.4 An assessment of hypothetical bias

Hypothetical bias is a long-standing issue in the history of SP studies (Hanley, Mourato & Wright, 2001; Arrow et al., 1993). In this CVM study, hypothetical bias can occur in two forms. The first one is where offset non-users have expressed a positive WTP for voluntary offset. Of the respondents who display a positive WTP for offset alone, almost 50% of them are offset non-users. This shows around half of the respondents who have indicated their positive WTP for voluntary offsets in a hypothetical situation do not purchase voluntary offsets in real life situation. Reasons provided by respondents for not participating in the VCM are discussed in Section 7.3.2. Majority of them (50%) quoted that offsetting is not their priority. This is not surprising as according to Hanley, Mourato & Wright (2001), hypothetical bias is especially notable when the payment vehicle is voluntary contribution as respondents tend to overbid in the hypothetical situation but free-ride in real life.

Other reasons respondents are not purchasing voluntary offsets include market related issues such as entry barrier (25%) and market lacks credibility and transparency (20%). 14% of offset non-users do not agree with the concept of offsetting but a number of them still display a positive WTP for offset. One of the respondents explained that although his organisation fundamentally does not

agree with the concept of offsetting, it would purchase offsets if there is a demand from its clients. This shows that even for organisations that are against voluntary offsetting, their positive WTP for voluntary offset could be initiated externally.

The second form of hypothetical bias is where offset users have stated a WTP that is greater than the offset price they pay in real life situation. One way to investigate this is to compare the offset price respondents paid in 2015[61] with their indicated WTP for offset and offset co-benefits. Although it is not a like-to-like comparison as information regarding the attributes of the offsets respondents purchased in the previous year are unknown to this study. However, based on the assumption that respondents will contract from a range of projects to balance between price and co-benefits, we can expect that the average price they paid per offset is between their WTP for offset alone and WTP for offset with co-benefits.

Figure 7-18: A comparison of price paid and CVM WTP estimates per offset

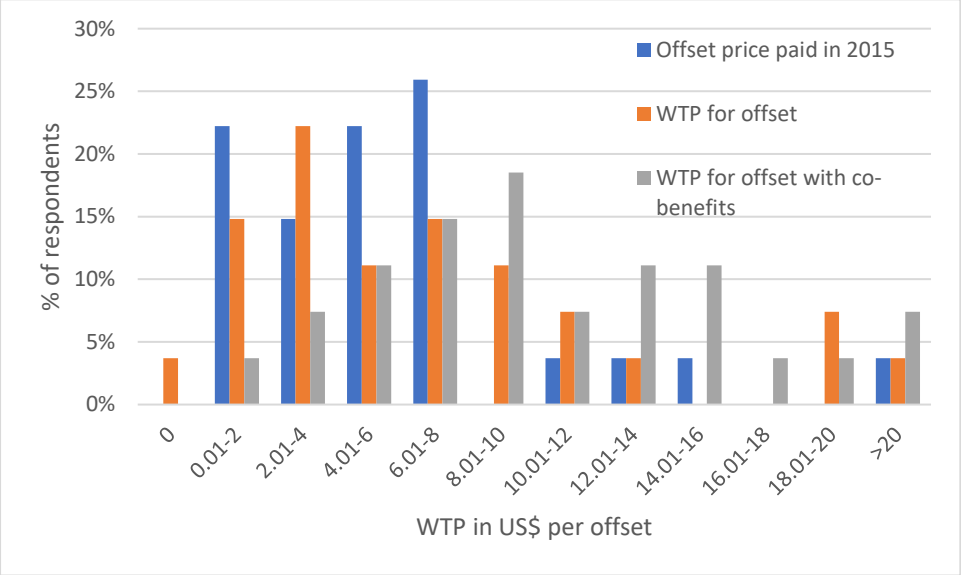


Figure 7-18 provides a comparison of the actual price paid and WTP distributions, based on 27 respondents who disclosed the price they paid in 2015 as well as completed both CVM questions. Based on the distributions, the offset price paid in 2015 and WTP for offset appear to be quite similar. However, the distribution of WTP for offset with co-benefits is clearly more skewed towards the right. The median of offset price paid in 2015 is US$4.01-6. The median WTP for offset alone is US$4.01-6 and the median WTP for offset with co-benefits is US$8.01-10. MWU tests[62] show that the offset price paid in 2015 and the WTP for offset alone are not significantly different. However, the WTP for offset with co-benefits is significantly greater than the offset price paid in 2015, as well

[61] The reported offset prices that respondents paid in 2015 (point data) are assigned to the appropriate price band to enable comparison with WTP which are interval data.
[62] The MWU tests are presented in Appendix 7-9.

WTP for offset alone. These results show that in real life situation, respondents are paying at least what they state they would pay for offset alone. In addition, as previously mentioned, the price respondents pay in real life is likely to be influenced by supply and demand, if respondents can source offset with co-benefits at a lower price, there is no reason for them to pay their indicated maximum WTP amount. Therefore, the WTP amount for offset with co-benefit elicited from this study represents the potential price level that voluntary offsets can achieve if co-benefits are being demonstrated to organisations.

7.5.5 Assessing the effect of offset volume on WTP

Analysis of Survey 1 results shows that offset volume has a significant impact on the offset price respondents pay, as well as their WTP for offset (Section 6.4.2). The same analysis is conducted here to examine the effect of offset volume on offset price and WTP for offset. Not all respondents disclosed the offset volume and price they contracted in 2015. Table 7-7 provides a summary of the response rates.

Table 7-7: Response rates for contracted volume, price and CVM

	Number	**Response rate**
Respondents who are offset users	47	100%
Offset users who provided volume contracted in 2015	34	72%
Offset users who provided average contracted price per offset in 2015	30	64%
Offset users who provided contracted volume and price per offset in 2015	28	60%
Offset users who completed CVM questions	43	91%
Offset users who provided volume contracted in 2015 and completed CVM questions	31	66%

Table 7-8 reports the effect of contracted offset volume on the price respondents paid in 2015. In Model 1, the coefficient of volume is negative as expected but is statistically insignificant. In Model 2 however, the coefficient of log transformation of volume is negative and highly significant at 1% level. This shows the relationship between offset price and offset volume is a non-linear one, which is in-line with the finding from Survey 1.

Table 7-8: The effect of contracted volume on average price paid per offset

	Model 1	**Model 2**
Independent variable	Volume	Log(volume)
Coefficient	-0.000003 (0.000003)	-1.551 (0.476) ***
_Constant	8.236 (1.510) ***	21.603 (4.411) ***
Model fit		
Number of observations	28	28
F (d.f)	0.87 (1,26)	10.60 (1,26) ***

() standard error, ***, **, * = significance at 1%, 5%, 10% level

Table 7-9 shows the effect of contracted volume on respondents indicated WTP for offset and offset with co-benefits. Under WTP for offset, the coefficient of log(volume) is negative and significant at 5% level. This shows that offset volume has a significant and negative impact on respondents stated WTP for offset. In other words, respondents consider offset volume that they need to contract when stating their WTP for offset alone. However, under WTP for offset with co-benefits, the coefficient of log(volume) is insignificant, meaning offset volume has no significant impact on respondents' WTP for offset with co-benefits. One possible explanation is when respondents purchase quality offsets at a premium price, they are likely to purchase in a smaller volume and therefore their WTP are insensitive to offset volume. On the contrary, when they purchase generic offsets to compensate their GHG emissions, their WTP measures become sensitive to the volume as increasing volume of offsets required to meet their ER target corresponds to increasing cost of offsetting.

Table 7-9: The effect of contracted volume on WTP per offset

Dependent variable	**WTP for offset**	**WTP for offset with co-benefits**
Log(volume)	-0.117 (0.048) **	-0.011 (0.024)
_Constant	1.712 (0.458) ***	1.087 (0.233) ***
Model fit		
Number of observations	31	31
LR χ^2 (d.f)	5.55 (1) **	0.19 (1)

() standard error, ***, **, * = significance at 1%, 5%, 10% level

7.6 Conclusions

To investigate the demand for voluntary offsets among organisations, a survey of organisations that include offset users and non-users were undertaken. As many as 40,000 organisations were potentially reached for the survey but only 97 usable responses were received. This could be

attributed to the large number of organisations reached through newsletter circulation which is unlikely to yield a high response rate. Previous studies that involved surveys of organisations that participate in the compliance Kyoto market generated between 19 and 117 usable responses (Parnphumeesup & Kerr, 2011). These studies and the present study illustrate the challenge of getting organisations to take part in surveys, especially unincentivized ones.

Organisations that participated in the survey display a heightened sense of responsibility towards their climate impact. 94% of them feel that organisations should contribute to climate change mitigation on a voluntary basis and 80% of them have carbon management strategy in place. This is unsurprising considering the population targeted by the survey are ICROA members' existing and potential clients and members of UN's Caring for Climate Initiative. However, this also means generalisation of results from this survey needs to be treated with care.

According to offset users who participated in the survey, besides enhanced reputation and brand image, altruistic motivations including sense of responsibility towards their climate impact and care for the environment are also the main drivers for purchasing offsets. Among offset non-users, the main reason for not purchasing offsets is it is not in their priority. Comparisons of offset users and non-users' attitudes and views towards the issues of climate change and VCM show they are not significantly different. Regression analysis on the other hand shows expectation of others' participation following the Paris Agreement has a negative impact on the likelihood of being an offset user. This finding reiterates that majority of existing offset users voluntarily offset for altruistic motivations. The regression analysis also shows organisations' demographic characteristics are significant determinants of the likelihood of organisations participating in voluntary offsetting. This could be attributed to the institutional conditions that organisations operate in. For example, organisations that are based in Annex I countries, especially European countries, are more likely to participate in voluntary offsetting because the level of public regulation and demand for climate mitigation are stronger in these countries. They are also more aware of market-based mechanism as a viable way to abate their emissions due to the presence of Kyoto market in the region (Hamrick, Goldstein & Peters-Stanley, 2015; Goldstein, 2015; Taiyad, 2006). Similarly, organisations that operate in carbon intensive sectors such as energy and transportation sectors are also more likely to face pressure to reduce their carbon emissions. Financial sector is also a key buyer of voluntary offsets which could be attributed to their interest in demonstrating the use of financial tool to address environmental issues (Peters-Stanley et al., 2014).

Respondents' WTP amount for an offset, on the other hand, is mainly driven by their self-ascribed responsibility or internalised norm to abate GHG emissions. Presence of offset co-benefits can also

increase respondents' WTP amount per offset significantly. The estimated marginal WTP for an offset alone and offset with co-benefits are US$3.38 (2.31-4.97) and US$8.98 (7.49-10.76) respectively. MWU test also confirms the two WTP are significantly different. However, provision of monetary values of offset co-benefits has no significant impact on respondents' WTP. Regression analysis shows that respondents' WTP for offset with co-benefits is also positively influenced by their self-ascribed responsibility to abate GHG, indicating that respondents with internalised norm are also more likely to associate themselves with other pro-social and environmental behaviours. As expected, respondents' view on the importance of offset co-benefits also have a significant and positive impact on their WTP for offset with co-benefits.

Similar to Survey 1, the present survey is also subjected to some limitations, including the non-random sampling approach and selection bias, as well as the representativeness of individuals' views on behalf of their organisations. In contrast to Survey 1, Survey 2 did not ask respondents to disclose their position within the organisation to allow for full anonymity upon the request of ICROA. Results in this chapter indicate the potential risk of individuals' preferences, which are not representative of their organisations, are being captured in the CVM. Results in this chapter show that the likelihood of being an offset user, which is based on factual data, is mainly determined by organisations' demographic variables such as organisation type, location and operating sector. WTP amounts which are hypothetical on the other hand are mainly driven by attitudinal variables that are likely to capture the views and preferences of individuals who undertook the survey on behalf of their organisations. Thus, the WTP amounts elicited may not reflect organisations' true WTP. Nevertheless, the WTP amounts for offset provided by offset users are not significantly different from the actual amounts they paid in 2015, which provides some confidence to the CVM results.

Overall, results from this chapter shows that altruistic motivations can play an important role in driving organisations to participate in voluntary offsetting and contribute to climate change mitigation. A number of respondents indicate that they are voluntarily offsetting their emissions due to a sense of responsibility towards their climate impact and their care for the environment. Only around half of the offset users indicated they have observed tangible benefits from their participation in voluntary offsetting and only one is monitoring the benefits. This shows their expectation of the return on their investment in voluntary offsetting is low. Parametric analysis also shows organisations that purchase voluntary offsets have less expectation of other organisations' contributions. Respondents' WTP for offset and offset co-benefits are also found to be predominantly driven by internalised norm to abate GHG emissions. These findings collectively suggest that, in addition to strategic CSR motives, altruistic or philanthropic motives can also promote voluntary contribution to public good (climate mitigation) among organisations.

Nevertheless, purely relying on charitable contributions is unlikely to grow the market. In order to promote further participation, more work needs to be done in monitoring and documenting the return on investment in voluntary offsetting, such as identification of energy saving opportunities, market differentiation and employee motivation. If these private benefits of voluntary offsetting can be demonstrated to organisations, they are more likely to participate.

In addition, organisations need to be convinced of offsetting is a viable way to mitigate climate change. This study finds that majority of respondents have heightened sense of responsibility towards their climate impact, however this has not translated to participation in voluntary offsetting. A comparison of offset users and non-users shows the former has greater belief in the effectiveness of offsetting schemes in abating GHG emissions than the latter, although the difference is not statistically significant. Nevertheless, offset non-users also indicated that increased awareness of the contribution of offsetting in climate change mitigation is the key driver to promote their future participation in the VCM. This shows that scepticisms towards the use of offsets to reduce GHG emissions remain prevalent and organisations may be concerned that using voluntary offsets to abate their emissions will result in public backlash and being accused of greenwash.

Finally, stronger institutional conditions are required to promote further participation in voluntary offsetting. Although this study finds Paris Agreement has limited effect on organisations' willingness to participate in the VCM, offset non-users have indicated that increased global efforts in curbing climate change and greater engagement in voluntary offsetting within their sector can promote their future participation. Furthermore, this study finds a positive relationship between expectations of others' participations and own participation following the Paris Agreement. This shows that as voluntary contribution to climate mitigation is subjected to free-riding, organisations are more likely to contribute if others do the same.

8 Survey 2: An assessment and comparison of demand for offset co-benefits among offset users and non-users

This chapter presents the CE results generated from Survey 2. CL, RPL and LCL models are used to analyse the CE data. Results show respondents are willing to pay substantially more for offset co-benefits and co-benefit verification. However, unobserved preference heterogeneity exits for some of the attributes. To gain further insights into the differences between offset users and non-users, the CE data of offset users and non-users are compared on three levels: their choice patterns, their underlying preference structures and their marginal WTP measures for each offset attribute. Non-parametric analysis shows the choice patterns of offset users and non-users are not significantly different. However, comparison of choice models shows the estimated scale parameter of offset non-users is significantly greater than offset users. This is rather unexpected as it means offset users who have greater experience in contracting voluntary offsets produce less accurate choices between alternatives than offset non-users. The marginal WTP estimates for offset, offset co-benefits and co-benefit verification are not significantly different between offset users and non-users, except for environmental co-benefit. Offset non-users are willing to pay significantly more for environmental co-benefit than offset users. Results from this chapter help inform research sub-question 2.2.

8.1 Choice experiment results

8.1.1 Protest bidders

A total of 97 organisations participated in Survey 2, however three respondents (one offset users and two non-users) did not complete the CE section. After removing the non-responses, the number of respondents for the CE becomes 94. Among the remaining respondents, three consistently selected the opt-out alternative for all five choice sets, indicating the possibility of protest zeros. These respondents are all offset non-users. Review of their responses in other sections of the survey questionnaire provides some indications of whether their zero responses can be treated as protest zeros. One of them stated *'I have no idea'* in both CVM questions, whilst another stated a positive WTP for offset alone but did not provide a WTP for offset with co-benefits. The latter commented '*the co-benefits were not clear so it was not possible to make decision on purchasing offsets*'. Their remarks show that they opted out on all choice sets not because they have zero WTP for offset and offset co-benefits, but because they do not know how to value the goods in question. Providing a zero WTP because of insufficient information to make decision is considered as a form of protest bidding (Lindsey, 1994). Therefore, these responses are treated as protest zeros and are excluded from the analysis.

The third respondent who also opted out on all five choice sets stated that his organisation does not agree in principle with the concept of offsetting for carbon abatement but will purchase offsets if there is a demand from their clients and only as a transition process. Based on the comment, the respondent could have a zero or positive WTP (interestingly, the respondent indicated a >US$20 for offset and offset with co-benefits for the CVM questions). Without further justification to rule his responses as protest zeros and for conservative purpose, they are treated as genuine and are included in the analysis.

Excluding the two respondents who are considered as protest bidders, the final CE dataset consists of 92 respondents with a total number of 1380 observations (92 respondents x 5 choice sets x 3 alternatives).

8.1.2 CL and RPL estimation results

Estimation results of CL and RPL model are presented in Table 8-1. Estimations from both models are relatively similar. All the coefficients are statistically significant at 1% level suggesting that the selected attributes are significant determinants of respondents' offset choice. Furthermore, coefficient estimates have the expected signs. The positive coefficient of the ASC suggests that respondents are more likely to choose to offset than the non-offsetting status quo. The coefficients of co-benefit related attributes are all positive, indicating respondents are more likely to choose alternatives that have social, economic and environmental co-co-benefits, as well as co-benefit verification. The implied rankings of the co-benefit related attributes are also consistent across the two models, with co-benefit verification being the most preferred attribute, follows by social co-benefit, economic co-benefit and lastly environmental co-benefit. The coefficient of price is negative as expected, which means respondents are more likely to choose the cheaper alternative. The RPL estimation results also indicate presence of unobserved preference heterogeneity among respondents, in particularly for offset, economic co-benefit, co-benefit verification and price.

Table 8-1: CL and RPL estimation results

	CL	**RPL**	**RPL with interactions**
Attribute		**Mean**	**Mean**
Offset (ASC)	0.865 (0.208) ***	2.534 (0.593) ***	0.220 (2.602)
Social co-benefit	0.717 (0.166) ***	1.327 (0.270) ***	5.096 (1.559) ***
Economic co-benefit	0.677 (0.170) ***	1.166 (0.277) ***	2.270 (1.399)
Environmental co-benefit	0.527 (0.152) ***	0.981 (0.235) ***	2.281 (1.518)
Co-benefit verification	1.021 (0.127) ***	1.681 (0.308) ***	1.463 (1.545)

	CL	RPL	RPL with interactions
Price	-0.081 (0.012) ***	-2.026 (0.184) ***	-2.046 (0.183) ***
		Standard deviation	**Standard deviation**
Offset (ASC)		2.713 (0.650) ***	2.453 (0.611) ***
Social co-benefit		0.207 (0.871)	-0.048 (1.359)
Economic co-benefit		0.931 (0.429) **	-0.019 (0.604)
Environment co-benefit		0.018 (0.495)	-0.035 (0.508)
Co-benefit verification		1.679 (0.333) ***	1.647 (0.334) ***
Price		0.716 (0.144) ***	0.610 (0.148) ***
Interaction terms			
PROFIT*Social co-benefit			-3.195 (1.328) **
PUBLIC*Social co-benefit			-3.091 (1.432) **
ANNEXI_EU*Social co-benefit			-1.643 (0.714) **
ANNEXI_EU*Economic co-benefit			-1.255 (0.693) *
ANNEXI_NONEU*Social co-benefit			-2.008 (0.839) **
ENERGY*Offset			-3.565 (1.500) **
ENERGY*Economic co-benefit			2.789 (0.835) ***
PROFESSIONAL*Offset			-3.079 (1.436) **
PROFESSIONAL*Economic co-benefit			1.825 (0.750) **
USER*Offset			1.647 (0.988) *
USER*Co-benefit verification			-1.131 (0.611) *
COBENEFITVER*Co-benefit verification			1.573 (0.685) **
Model fit			
No. of observations	1380	1380	1350 [a]
Log likelihood (null)	-505.362	-505.362	-494.376

	CL	RPL	RPL with interactions
Log likelihood (model)	-421.566	-376.289	-319.281
Pseudo R^2	0.166	0.255	0.354
Adjusted pseudo R^2	0.154	0.232	0.219

() standard error, ***, **, * = significance at 1%, 5%, 10% level. [a] Two respondents (30 observations) are excluded from the RPL model with interactions due to not disclosing their location.

To examine the sources of preference heterogeneity, respondents' variables are interacted with the attributes. Table 8-2 presents the descriptive statistics of respondents' variables tested in the RPL model with interactions. The full estimation results of RPL model with interactions are presented in Appendix 8.1, only interaction terms that are significant are reported in the last column of Table 8-1.

The negative coefficients of the interaction terms of PROFIT and PUBLIC with social co-benefits suggest that the base case which includes not-for-profit and other types of organisations are more likely to choose the alternative with social co-benefit. The coefficients of the interaction terms of ANNEXI_EU and ANNEX_NONEU with social co-benefits are also negative, meaning organisations from non-Annex I countries (the base case) are more likely to choose the alternative with social co-benefit. In addition, the coefficient of ANNEXI_EU*Economic co-benefit is also negative, indicating organisations that are based in Annex I and European countries are less likely to choose the alternative with economic co-benefit, but the coefficient is only significant at 10% level. In terms of operating sectors, the results show that ENERGY and PROFESSIONAL are less likely to choose the offsetting alternative as compared to other sectors, but they are more likely to choose the offsetting alternative with economic co-benefit. The interaction terms also show differences in the preferences of offset users and non-users. Offset users are more likely to choose the offsetting alternative than non-users, which is expected, whilst non-users are more likely to choose the alternative with co-benefit verification. However, the coefficients of both USER interaction terms are only significant at 10% level. Finally, as expected, the positive sign of the coefficient of COBENEFITVER*Co-benefit verification indicates respondents who place greater importance on co-benefit verification are more likely to choose the alternative with co-benefit verification.

Table 8-2: Descriptions of respondents' variables specified in RPL model with interactions

Variable name	Variable definition	Mean (Standard deviation) *
Organisation type		
The base case is not-for-profit and other types of organisations such as think tank and social enterprise		
PROFIT	1 if the respondent is a private for-profit organisation, 0 if any other organisation type	0.811 (0.394)
PUBLIC	1 if the respondent is a governmental or public organisation, 0 if any other organisation type	0.122 (0.329)
Organisation location		
The base case is organisation that is located or headquartered in a non-Annex I country		
ANNEXI_EU	1 if the respondent is located or headquartered in an Annex I and European country	0.622 (0.488)
ANNEXI_NONEU	1 if the respondent is located or headquartered in an Annex I and non-European country	0.200 (0.402)
Operating sector		
The base case is all sectors excluding the following five sectors with the most respondents		
ENERGY	1 if the respondent operates in electricity and energy sector, 0 if any other sector	0.144 (0.354)
FINANCIAL	1 if the respondent operates in financial and insurance sector, 0 if any other sector	0.100 (0.302)
TRANSPORT	1 if the respondent operates in transport and tourism sector, 0 if any other sector	0.133 (0.342)
PROFESSIONAL	1 if the respondent operates in professional and administrative sector, 0 if any other sector	0.111 (0.316)
INFORMATION	1 if the respondent operates in information and communication sector, 0 if any other sector	0.078 (0.269)
Offset users		
The base case is offset non-users		
USER	1 if the respondent is an offset user, 0 if otherwise	0.500 (0.500)

Variable name	Variable definition	Mean (Standard deviation) *
Attitude towards offset co-benefits		
COBENEFIT	Respondent's view on the importance of offset co-benefits. 1 – definitely yes and probably yes, 0 – might or might not, probably not, definitely not important.	0.889 (0.316)
COBENEFITVER	It is important for the co-benefits to be independently verified. 1 – strongly agree and somewhat agree, 0 – neither agree or disagree, somewhat disagree and strongly disagree with the statement.	0.811 (0.394)

*Mean and standard deviation are calculated based on 90 respondents. Two respondents are excluded due to incomplete demographic information.

8.1.3 LCL estimation results

The LCL model is also used to analyse the CE data. Due to the small sample size in relative to the number of respondents' variables tested (as described in Table 8-2), the two-class LCL model fails to converge when all the variables are included. Thus, some of the respondents' variables are grouped together and redefined to reduce the number of respondent variables specified in the model. In particularly, for organisation type, only PROFIT is specified in the LCL model. Thus, PUBLIC is grouped with not-for-profit and other types of organisations as the base case. For organisation location, ANNEXI_EU and ANNEXI_NONEU are combined to create a new variable called ANNEXI. INFORMATION is excluded altogether in the final LCL model specification as its coefficient has very large standard error (in the order of thousands). This could be attributed to its small sample size. Furthermore, results from RPL model with interactions show INFORMATION is not a significant factor underlying preference heterogeneity. USER, COBENEFIT and COBENEFITVER are included in the model and their definitions remain the same as described in Table 8-2.

Table 8-3 reports the AIC and BIC statistics of the LCL model when different number of classes is specified. It shows that as the number of classes increases, the log likelihood and AIC decrease but BIC increases. It also shows three-class LCL model fails to converge. BIC indicates that one-class LCL model that is equivalent to the CL model is the most preferred for the dataset. However, results from RPL model clearly indicate presence of unobserved preference heterogeneity among respondents. Thus, the results of two-class LCL model are presented here for discussion.

Table 8-3: AIC and BIC statistics for different number of LCL classes

Model specification	Log likelihood	Parameters	AIC	BIC
CL or LCL with one class	-413.376	6	838.026	869.273
LCL with two classes	-380.397	22	804.793	919.366
LCL with three classes	Convergence not achieved			

Table 8-4: Three-class LCL estimation results

Latent classes	Class 1	Class 2
Attributes		
Offset (ASC)	-14.082 (126.465)	1.538 (0.269) ***
Social co-benefit	1.527 (0.846) *	0.860 (0.187) ***
Economic co-benefit	2.495 (1.007) **	0.736 (0.190) ***
Environmental co-benefit	1.140 (0.690) *	0.580 (0.176) ***
Co-benefit verification	14.909 (126.466)	0.887 (0.1720 ***
Price	-0.195 (0.068) ***	-0.084 (0.014) ***
Class share	0.18	0.82
Respondent characteristics		
PROFIT	0.441 (1.210)	
ANNEXI	1.297 (1.088)	
ENERGY	2.740 (1.536) *	
FINANCE	1.079 (1.757)	
TRANSPORT	1.070 (1.531)	
PROFESSIONAL	2.333 (1.536)	
USER	-1.068 (0.807)	
COBENEFIT	-2.826 (1.360) **	
COBENEFITVER	1.423 (1.087)	
_constant	-2.487 (1.595)	
Model fit		
No. of observations	1,350	
Log likelihood (null)	-494.376	
Log likelihood (model)	-380.397	
Pseudo R^2	0.231	
Adjusted pseudo R^2	0.186	

() standard error, ***, **, * = significance at 1%, 5%, 10% level.

Table 8-4 reports the results of two-class LCL model. It shows that in Class 1, the coefficient of offset is insignificant. As for co-benefit related attributes, the coefficient of economic co-benefit is positive and significant at 5% level, meaning respondents in this class prefer the alternative with economic co-benefit. The coefficients of social and environmental co-benefits are also positive but only significant at 10% level. The coefficient of co-benefit verification is insignificant. The coefficient of price is negative and highly significant, meaning respondents are sensitive to offset price and are more likely to choose the cheaper alternative.

For Class 2, the coefficients of all the attributes are highly significant at 1% level with the expected sign. They show that respondents in Class 2 are more likely to choose the offsetting alternative than the non-offsetting status quo. They also prefer the alternative with co-benefits. Their implied ranking of co-benefit attributes is co-benefit varication, social co-benefit, economic co-benefit and environmental co-benefit. The coefficient of price is negative and highly significant as expected.

The second part of the table reports the relative size of each class and class membership coefficients. 18% of the respondents belong to Class 1 whilst majority of the respondents, 82% belong to Class 2. The class membership coefficients for Class 2 are normalised to zero and the membership coefficients of Class 1 are interpreted in relative to this class. They show that electricity and energy companies are more likely to belong to Class 1. This is in-line with the findings of RPL model with interactions, which show electricity and energy companies are less likely to choose the offsetting alternative but prefer the alternative with economic co-benefit. One possible explanation is electricity and energy companies are likely to be regulated anyway, therefore they are indifferent to offset itself (as the coefficient of offset in Class 1 is insignificant) but will purchase voluntary offsets for their associated co-benefits. Electricity and energy companies are also likely to choose renewable energy and energy efficiency projects that are relevant to their sector (Peters-Stanley et al., 2013). These offset projects are commonly associated with economic co-benefits such as improved energy security, employment creation and clean technology transfer and diffusion. As expected, the coefficient of COBENEFIT is negative and significant at 5% level, which means respondents who place greater importance on offset co-benefits are more likely to belong to Class 2.

To assess which model, RPL model with interactions or LCL model, better explains the CE data and the underlying sources of preference heterogeneity among respondents, they are compared using measures of fit as reported in Table 8-5. All the statistics except BIC indicate RPL model with interactions is superior to two-class LCL model. Furthermore, RPL model with interactions show a number of respondents' variables as significant in explaining the underlying sources of preference heterogeneity, which are not captured in the two-class LCL model. On the other hand, dominance of

RPL model with interactions could be attributed to the high number of parameters estimated in the model, which may result in overfitting the model. BIC statistics that take into account the sample size indicate the two-class LCL model which has less parameters as the preferable model between the two.

Table 8-5: Measures of fit for RPL model with interactions and LCL model

Model	Sample size	No. of parameters	Log likelihood	Pseudo R^2	Adjusted pseudo R^2	AIC	BIC
RPL with interactions	1,350	66	-324.771	0.343	0.210	781.542	1125.261
2-class LCL	1,350	22	-380.397	0.231	0.186	804.793	919.366

8.1.4 Marginal WTP estimations

The estimated marginal WTP for offset and offset co-benefits are reported in Table 8-6. As a reminder, for CL and LCL model, the marginal WTP is the ratio of attribute and price coefficients and the 95% confidence interval is estimated using the Delta method. For RPL model, the marginal WTP is estimated using RPL in WTP space. Only attributes that are significant are presented.

Table 8-6: Marginal WTP measures for offset attributes in US$ per offset

	CL	RPL	LCL		
			Class 1	Class 2	Weighted
Offset (ASC)	US$10.64 (6.03-15.26)	US$15.01 (8.65-21.37)	-	US$18.37 (11.59-25.15)	US$14.99 (9.46-20.53)
Social co-benefit	US$8.82 (5.24-12.41)	US$8.47 (5.09-11.85)	US$7.82 (0.93-14.72)	US$10.27 (6.29-14.25)	US$9.80 (6.35-13.29)
Economic co-benefit	US$8.33 (4.78-11.88)	US$8.02 (4.52-11.53)	US$12.78 (6.78-18.78)	US$8.80 (4.88-12.71)	US$9.53 (6.20-12.86)
Environmental co-benefit	US$6.48 (2.72-10.23)	US$6.64 (3.57-9.70)	US$5.84 (1.04-12.72)	US$6.92 (2.83-11.02)	US$6.72 (3.16-10.29)
Co-benefit verification	US$12.57 (8.66-16.48)	US$11.93 (7.86-15.99)		US$10.59 (6.33-14.86)	US$8.64 (5.16-12.13)

() 95% confidence interval

Table 8-6 shows the marginal WTP measures as estimated from CL and RPL models are relatively similar. This suggests that despite the presence of unobserved preference heterogeneity among

respondents, the marginal WTP estimations are stable across CL and RPL model. The marginal WTP measures as estimated from the LCL model are also relatively similar to CL and RPL models, except for co-benefit verification. The marginal WTP measure for co-benefit verification as estimated from the LCL model is lower than those estimated from CL and RPL models. Furthermore, its implied ranking has changed. In the CL and RPL model, co-benefit verification is the most preferred co-benefit related attribute and is ranked before social and economic co-benefits whilst in the LCL model, it is ranked third after social and economic co-benefits.

Table 8-7 summarises the WTP measures as elicited from Survey 2 through CVM and CE. The WTP measures of CVM and CE are not directly comparable as the survey is not designed specifically for comparing CVM and CE. Nevertheless, a preliminary comparison can provide some insights. In general, WTP measures as elicited from CE are considerably greater than CVM. This finding is in-line with Survey 1 and previous studies (see discussion in Section 6.4.3). However, for this round of survey, not only CVM WTP for offset is considerably smaller than CE WTP for offset alone, CVM WTP for offset with co-benefits is also smaller than CE WTP for offset alone. These findings seem to support Blaine et al. (2005)'s expectation that when presenting respondents with a range of possible payment levels, as in the case of PC CVM used in this study, respondents will choose the relatively low amount.

Table 8-7: A comparison of CVM and CE WTP estimations

CVM results	**Mean (95% confidence interval)**		
Offset	US$3.38 (2.31-4.97)		
Offset that creates employment, improves public health and reduces water pollution	US$8.98 (7.49-10.76)		
CE results	**CL**	**RPL**	**LCL weighted**
Offset (ASC)	US$10.64 (6.03-15.26)	US$15.01 (8.65-21.37)	US$14.99 (9.46-20.53)
Social co-benefit	US$8.82 (5.24-12.41)	US$8.47 (5.09-11.85)	US$9.80 (6.35-13.29)
Economic co-benefit	US$8.33 (4.78-11.88)	US$8.02 (4.52-11.53)	US$9.53 (6.20-12.86)
Environmental co-benefit	US$6.48 (2.72-10.23)	US$6.64 (3.57-9.70)	US$6.72 (3.16-10.29)
Co-benefit verification	US$12.57 (8.66-16.48)	US$11.93 (7.86-15.99)	US$8.64 (5.16-12.13)

8.2 A comparison of offset users and non-users

8.2.1 A comparison of choice patterns

Table 8-8 compares the choice patterns of offset users and non-users. During the survey, the choice sets that were presented to the respondents, whether Block A or Block B were randomised. The table shows that more offset users received Block A, whilst more offset non-users received Block B. However, chi-square test shows the proportions of offset users and non-users that received Block A and Block B are not significantly different.

Comparisons of choice shares within Block A and Block B show the choice shares are relatively similar for offset users and non-users. In Block A, majority of offset users and non-users prefer Alternative A, follows by Alternative B and then the opt-out alternative. The same is observed for Block B. As expected, a greater proportion of offset non-users choose the opt-out alternative than offset users. Chi-square tests for both blocks show the choice shares are not significantly different between offset users and non-users.

Table 8-8: A comparison of choice patterns of offset users and non-users

	Offset users		**Non-users**		**Chi-square**
	Number	**Percentage**	**Number**	**Percentage**	**test [a]**
Number of respondents	46	100%	46	100%	
Number of respondents received:					
• Block A	24	52%	20	43%	$\chi^2 = 0.70$
• Block B	22	48%	26	57%	$p = 0.40$
Number of choices for:					
Block A					
• Alternative A	50	42%	36	36%	
• Alternative B	57	48%	49	49%	$\chi^2 = 1.22$
• Opt out	13	11%	15	15%	$p = 0.54$
• Total number of choices	120	100%	100	100%	
Block B					
• Alternative A	38	35%	41	32%	
• Alternative B	53	48%	62	48%	$\chi^2 = 0.55$
• Opt out	19	17%	27	21%	$p = 0.76$
• Total number of choices	110	100%	130	100%	

[a] The chi-square tests are presented in Appendix 8-2.

8.2.2 A comparison of RPL estimation results

To compare the preferences of offset users and non-users, their CE datasets are analysed separately using RPL model. Table 8-9 reports the estimation results. For both offset users and non-users, all coefficient estimates are significant and have the expected signs. The positive coefficients of offset show that both offset users and non-users are more likely to choose the offsetting alternative than the non-offsetting status quo. The coefficients of all co-benefit related attributes are also positive, implying both offset users and non-users are more likely to choose an alternative that delivers co-benefits. The implied ranking of co-benefit attributes is consistent across the two groups, with co-benefit verification being the most preferred attribute, follows by social co-benefit, economic co-benefit and environmental co-benefit. The coefficients of price are negative for both groups as expected.

For both offset users and non-users, the standard deviations of the coefficients of offset and co-benefit verification are highly significant at 1% level, indicating presence of unobserved preference heterogeneity within each group. For offset users, preference heterogeneity is also significant for economic co-benefit, whilst for non-users, preference heterogeneity exists for social co-benefit but only significant at 10% level. In addition, heterogeneity in sensitivity to price attribute also present among offset non-users and is significant at 1% level. This is unsurprising given the hypothetical nature of the CE, some offset non-users may choose the more expensive alternative that deliver greater co-benefits. In comparison, offset users are expected to be more sensitive to price as they purchase voluntary offsets in real life, therefore they are more aware of the volume of offsets they need to contract and their budget for voluntary offsetting.

RPL estimation results for the pooled dataset as discussed in the previous section is also presented here in the last column of Table 8-9 for comparison. The pooled results are consistent with offset users and non-users in terms of coefficients that are significant, coefficient signs and the implied ranking of offset attributes. The standard deviations of the coefficients of offset and co-benefit verification are highly significant in the full sample as expected as they are also highly significant in the individual samples of offset users and non-users. For the coefficients of social co-benefit, economic co-benefit and price, their standard deviations in the full sample reflect the joint effects of offset users and non-users.

Table 8-9: RPL estimation results for offset users and non-users

	Offset users	Offset non-users	Pooled
Attributes	**Mean**	**Mean**	**Mean**
Offset (ASC)	2.816 (0.734) ***	3.020 (1.460) **	2.534 (0.593) ***
Social co-benefit	0.917 (0.338) ***	2.421 (0.736) ***	1.327 (0.270) ***
Economic co-benefit	0.845 (0.413) **	2.163 (0.655) ***	1.166 (0.277) ***
Environmental co-benefit	0.698 (0.295) **	1.834 (0.586) ***	0.981 (0.235) ***
Co-benefit verification	1.383 (0.367) ***	2.826 (0.791) ***	1.681 (0.308) ***
Price	-1.968 (0.204) ***	-1.891 (0.341) ***	-2.026 (0.184) ***
	Standard deviation	**Standard deviation**	**Standard deviation**
Offset (ASC)	2.453 (0.680) ***	5.334 (1.918) ***	2.713 (0.650) ***
Social co-benefit	0.342 (1.195)	1.236 (0.736) *	0.207 (0.871)
Economic co-benefit	1.586 (0.536) ***	0.100 (0.778)	0.931 (0.429) **
Environmental co-benefit	0.089 (0.660)	0.084 (0.700)	0.018 (0.495)
Co-benefit verification	1.482 (0.418) ***	2.878 (0.927) ***	1.679 (0.333) ***
Price	-0.195 (0.292)	1.013 (0.198) ***	0.716 (0.144) ***
Model fit			
No. of obs	690	690	1380
Log likelihood (null)	-252.681	-252.681	-505.362
Log likelihood (model)	-190.502	-174.122	-376.289
Pseudo R^2	0.246	0.311	0.255
Adjusted pseudo R^2	0.199	0.263	0.232

() standard error, ***, **, * = significance at 1%, 5%, 10% level.

8.2.3 Test for equality of preference and scale parameters

Swait & Louviere (1993) test procedures are used to formally assess if the choice behaviours of offset users and non-users are significantly different. First, the two datasets, X_{user} and $X_{non\text{-}user}$ are concatenated vertically. The scale parameter for X_{user}, μ_{user} is normalised to 1, whilst the scale parameter for $X_{non\text{-}user}$, $\mu_{non\text{-}user}$ is set in relative to μ_{user}. Then, a one-dimensional grid search with different trial values for $\mu_{non\text{-}user}$ ('rescaling') is conducted to identify $\mu_{non\text{-}user}$ that maximises the likelihood value of the model of pooled dataset. The aim is to identify the relative scale parameter, i.e. the ratio of the scale parameter of one dataset to another. Figure 8-1 shows the log-likelihood value at different $\mu_{non\text{-}users}$. It shows that the log-likelihood is optimised when $\mu_{non\text{-}users}$ is 2.15. This means the relative scale parameter of offset non-users to offset users is 2.15. After the relative scale

parameter is identified, Swait & Louviere (1993)'s two-stage hypothesis testing of parameter and scale equality between datasets can be carried out.

Figure 8-1: Log-likelihood of pooled data with different relative scale adjustment for non-user dataset

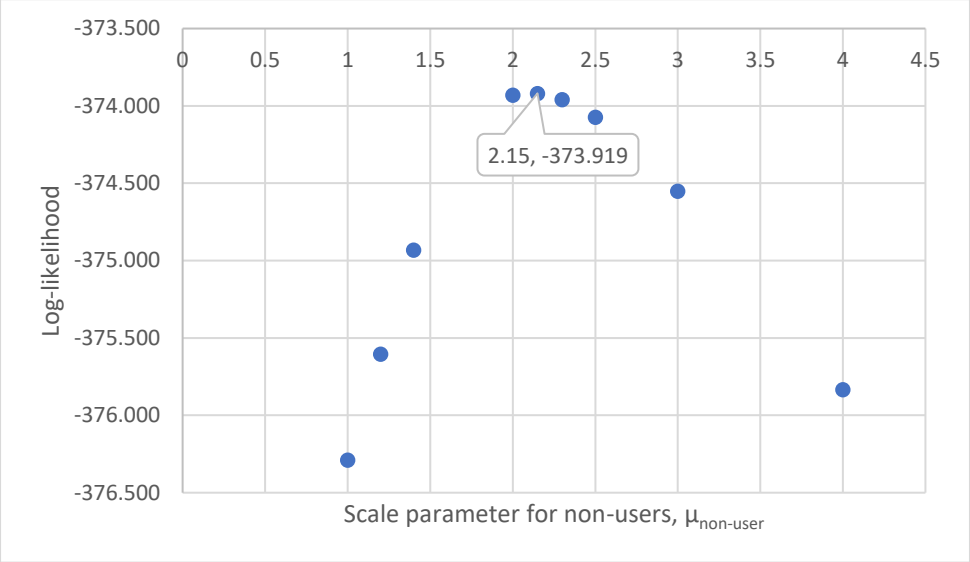


Table 8-10: A summary of Swait & Louviere test results

Test 1: Equality of preference parameters	
Log-likelihood value for offset users, L_{users}	-190.502
Log-likelihood value for non-users, $L_{non\text{-}users}$	-174.122
Log-likelihood value for pooled model, setting $\mu_{non\text{-}user}$ at 2.15, L_{μ}	-373.919
Likelihood ratio test statistic, $\lambda_1 = -2[L_{\mu} - (L_1 + L_2)]$	18.59
Chi-squared statistics for 13 d.f. and 95% confidence level	22.36
Reject H1: $\beta_{1\,(user)} = \beta_{2\,(non\text{-}user)}$?	No
Test 2: Equality of scale parameters	
Log-likelihood value for pooled model, L_p	-376.289
Test statistic, $\lambda_2 = -2[L_p - L_{\mu}]$	4.74
Chi-squared statistics for 1 d.f. and 95% confidence level	3.84
Reject H2: $\mu_{1\,(user)} = \mu_{2\,(non\text{-}user)}$?	Yes

Table 8-10 reports Swait & Louviere (1993)'s test procedures and results. The first test shows that equality of preference parameters between offset users and non-users cannot be rejected at 5% level. However, the second test shows equality of scale parameters can be rejected at 5% level. This means the scale factor of offset non-users is significantly greater than offset users. The scale

parameter is inversely related to the variance of the error component in random utility model with greater choice variability corresponding to smaller scale parameter and vice versa (Schaafsma et al., 2014). In this case, the dataset of offset users has significantly greater error variance than non-users. This finding is rather surprising as offset users are expected to have greater experience in contracting voluntary offsets than non-users, thus are expected to produce more accurate choices between choice sets (lower error variance). One possible explanation is offset users may contract from a range of projects with different co-benefits to make up their voluntary portfolios. Thus, they may choose differently between choice sets in the attempt to build a balance portfolio at the lowest cost possible.

8.2.4 A comparison of WTP measures

Table 8-11 reports the marginal WTP measures of offset users and non-users that are estimated separately using RPL model in WTP space. It shows that offset users are willing to pay more for offset than non-users, but offset non-users are willing to pay more for offset co-benefits and co-benefit verification than offset users. The last column of Table 8-11 presents the results of Poe test. The numbers reported here are the p-values. They show that the differences in the marginal WTP measures of offset users and non-users for offset, social co-benefit, economic co-benefit and co-benefit verification are not significant even at 10% level. However, the difference in their marginal WTP measures for environmental co-benefit is highly significant at 1% level, with the marginal WTP of offset non-users significantly greater than offset users.

Table 8-11: A comparison of marginal WTP measures of offset users and non-users

	Mean WTP in US$ per offset		**Poe-test**
	Offset user	**Offset non-user**	
Offset (ASC)	19.67 (9.91-29.43)	9.78 (-0.13-19.68)	0.36
Social co-benefit	6.39 (2.38-10.40)	11.31 (5.37-17.26)	0.30
Economic co-benefit	6.02 (0.84-11.19)	10.76 (5.85-15.67)	0.34
Environmental co-benefit	4.88 (1.01-8.75)	9.06 (3.85-14.26)	0.00
Co-benefit verification	9.82 (5.13-14.52)	15.30 (7.51-23.09)	0.41

() 95% confidence interval

8.3 Conclusions

This chapter explores organisations' demand for offset co-benefits and whether such demand differ between offset users and non-users. Results from Survey 2 CE show offset co-benefits and co-benefit verification are significant determinants of respondents' offset choice. However, considerable unobserved preference heterogeneity also exists among respondents, in particularly

for offset itself, economic co-benefit and co-benefit verification. In addition, heterogeneity in sensitivity to price is also present. Further analysis shows that heterogeneity in the treatment of price is mainly present among offset non-users but not offset users. This is expected as offset users are purchasing offsets in real situation and therefore most of them are likely to be sensitive to price Furthermore, they are more aware of the volume of offsets they need to purchase and thus the total cost of voluntary offsetting.

Both RPL with interactions and LCL models are used to investigate the underlying sources of preference heterogeneity. Results from RPL model with interactions show organisations' location, type and operating sector are significant factors that can influence their preference for offset co-benefit types. For examples, not-for-profit organisations and organisations that are based in non-Annex I countries prefer offset with social co-benefit, whilst organisations that operate in energy and electricity sector and professional and administrative services prefer economic co-benefit. As expected, organisations that view co-benefit verification as important also prefer offset with co-benefit verification. Results from two-class LCL model show there exists a small class of buyers among respondents that are indifferent to offset itself but can be encouraged to purchase voluntary offsets through offset co-benefits, in particularly economic co-benefit. Electricity and energy companies are more likely to belong to this class of buyers.

For this round of survey, I found RPL model with interactions has greater flexibility than LCL model to investigate a range of potential variables that could influence respondents' preferences for offset co-benefits and co-benefit verification. However, there is a risk of specifying too many variables which could result in overfitting the model. On the other hand, whilst LCL model has great potential in analysing CE data, especially from the point of practicality, its application in this study is limited by the small sample size as BIC statistics show single-class LCL model is preferable for the dataset in this study.

The choice behaviours of offset users and non-users are also analysed independently and compared. The choice patterns of offset users and non-users are not significantly different. Independent RPL model results show all the attributes are significant determinants of offset choice for both offset users and non-users. The implied ranking of co-benefit attributes is also consistent across both groups, with co-benefit verification being the most preferred attribute, follows by social co-benefit, economic co-benefit and environmental co-benefit. Results from Swait & Louviere test procedures show the preference parameters of offset users and non-users are not significantly different. However, the scale parameter of offset non-users is significantly greater than offset users. As the scale parameter is inversely related to the error variance, this means offset users have significantly

greater error variance than non-users. One possible explanation is offset users source offsets from a mixture of projects to try to balance between different co-benefit types, as well as cost, thus result in greater variability in their choices.

In terms of marginal WTP estimates for each attribute, offset users have greater WTP for offset than non-users as expected. However, offset non-users have greater WTP for offset co-benefits and co-benefit verification than offset users. Nevertheless, results of Poe test show WTP measures for the attributes are not significantly different between offset users and non-users, except for environmental co-benefit which offset non-users are willing to pay significantly more than offset users.

9 Survey 1 & 2: An assessment of demand stability for offset co-benefits among offset users

To assess temporal stability of stated preferences and WTP measures of offset users for offset co-benefits and co-benefit verification (research sub-question 2.3), the same CE was administered in Survey 1 and Survey 2. Survey 1 was conducted between 31st of January and 8th of March 2014, whilst Survey 2 was conducted between 12th September and 1st November 2016. Thus, the two surveys are around two and a half years apart. In this chapter, comparisons of CE results from Survey 1 and 2 takes place at three levels: choice consistency, underlying preference structure and WTP measures. Results suggest that choice shares do not differ significantly between the two surveys. Furthermore, parametric analysis shows that preference estimates are robust over the two-and-a-half-year period. Offset users' marginal WTP for offset co-benefits and co-benefit verification are also stable over time, except for environmental co-benefit which WTP measure has increased over time. Stability of preferences and WTP measures among offset users for offset co-benefits and co-benefit verification provide some assurance to the VCM to continue to invest in offset projects that deliver a range co-benefits.

9.1 A comparison of respondents' profiles

55 offset users undertook the CE in Survey 1, whilst 46 undertook the CE in Survey 2. The sample populations of the two surveys were independently drawn. However, as the clients of ICROA members were targeted in both rounds of survey, some organisations could be repeat respondents. Nevertheless, as Survey 2 is completely anonymised, organisations that undertook both surveys cannot be identified. Therefore, the sample populations of Survey 1 and Survey 2 are assumed to be independent.

Table 9-1 reports the respondents' profiles of Survey 1 and Survey 2. Majority of the offset users in both surveys are private for-profit organisations and are based in Annex I countries. The top five sectors that participated in the survey are also the same for both sample populations, which are electricity and energy, finance and insurance, information and communication, transport and tourism, and professional and administrative services. Chi-square tests, which results are reported in the last column of Table 9-1, confirm that the profiles of respondents in Survey 1 and Survey 2 are not significantly different.

Table 9-1: A comparison of Survey 1 and Survey 2 respondents' profiles

	Survey 1	Survey 2	Chi-square test [a]
Organisation type			
Private for-profit	50 (91%)	38 (83%)	
Government	1 (2%)	7 (15%)	$\chi^2 = 1.539$
Non-profit & other	3 (5%)	1 (2%)	$p = 0.21$
Undisclosed	1 (2%)	-	
Location			
Annex I European country	38 (69%)	31 (67%)	
Annex I non-European country	12 (22%)	10 (22%)	$\chi^2 = 0.09$
Non-Annex I country	1 (2%)	4 (9%)	$p = 0.96$
Multinational	3 (5%)	-	
Undisclosed	1 (2%)	1 (2%)	
Sector (Top five)			
Electricity and energy	3 (5%)	8 (15%)	
Finance and insurance	12 (22%)	7 (15%	
Information and communication	6 (11%)	6 (13%)	$\chi^2 = 4.24$
Transport and tourism	9 (16%)	7 (15%)	$p = 0.52$
Professional and administrative services	9 (16%)	6 (13%)	
Other	16 (29%)	12 (28%)	
Sample size	55 (100%)	46 (100%)	

[a] The chi-square tests are presented in Appendix 9-1.

9.2 A comparison of choice patterns

Table 9-2 compares the choice patterns of offset users in Survey 1 and Survey 2. The shares of respondents who received Block A and Block B are comparable, with slightly more respondents receiving Block A in both surveys. Chi-square test confirms that the proportions of respondents in Survey 1 and 2 that received Block A and Block B are not significantly different.

Among respondents who received Block A, the choice shares are relatively similar between Survey 1 and 2, with most respondents choosing Alternative B, follows by Alternative A and then then opt-out alternative. The percentage of opt outs is slightly higher in Survey 1 than Survey 2. Similar pattern is also observed for the choice shares for Block B. Chi-square tests also confirm that the choice shares within Block A and Block B are not significantly different between respondents of Survey 1 and 2.

Table 9-2: A comparison of choice patterns of Survey 1 and Survey 2 offset users

	Survey 1		Survey 2		Chi-square test [a]
	Number	Percentage	Number	Percentage	
Number of respondents	55	100%	46	100%	
Number of respondents received:					$\chi^2 = 0.06$
• Block A	30	55%	24	52%	$p = 0.81$
• Block B	25	45%	22	48%	

	Survey 1		Survey 2		Chi-square test [a]
	Number	Percentage	Number	Percentage	
Number of choices for:					
Block A					
• Alternative A	60	40%	50	42%	
• Alternative B	66	44%	57	48%	$\chi^2 = 1.52$
• Opt out	24	16%	13	11%	p = 0.47
• Total number of choices	150	100%	120	100%	
Block B					
• Alternative A	38	30%	38	35%	
• Alternative B	54	43%	53	48%	$\chi^2 = 2.83$
• Opt out	33	26%	19	17%	p = 0.24
• Total number of choices	125	100%	110	100%	

[a] The chi square tests are presented in Appendix 9-2.

9.3 A comparison of RPL estimation results

Table 9-3 reports results of RPL model for Survey 1, Survey 2 and the pooled dataset. Following Brouwer, Logar & Sheremet (2017) and Liebe, Meyerhoff & Hartje (2012), only choice attributes and no interaction terms are presented. This approach is justifiable for the present study as the respondents' profiles in Survey 1 and 2 are not significantly different as previously demonstrated.

Table 9-3: RPL estimation results of Survey 1 and Survey 2 offset users

	Survey 1	Survey 2	Pooled
Attributes	**Mean**	**Mean**	**Mean**
Offset (ASC)	1.486 (0.367) ***	2.816 (0.734) ***	1.860 (0.322) ***
Social co-benefit	1.240 (0.407) ***	0.917 (0.338) ***	1.096 (0.276) ***
Economic co-benefit	0.760 (0.314) **	0.845 (0.413) **	0.808 (0.248) ***
Environment co-benefit	0.206 (0.260)	0.698 (0.295) **	0.382 (0.182) **
Co-benefit verification	1.812 (0.323) ***	1.383 (0.367) ***	1.564 (0.240) ***
Price	-1.884 (0.169) ***	-1.968 (0.204) ***	-1.958 (0.135) ***
	Standard deviation	**Standard deviation**	**Standard deviation**
Offset (ASC)	0.876 (0.515) *	2.453 (0.680) ***	1.310 (0.379) ***
Social co-benefit	1.807 (0.501) ***	0.342 (1.195)	1.410 (0.374) ***
Economic co-benefit	0.695 (0.615)	1.586 (0.536) ***	1.106 (0.375) ***
Environment co-benefit	0.009 (0.505)	0.089 (0.660)	0.060 (0.428)

Co-benefit verification	0.942 (0.379) **	1.482 (0.418) ***	1.214 (0.270) ***
Price	0.269 (0.171)	-0.195 (0.292)	0.302 (0.186)
Model fit			
No. of observations	825	690	1515
Log likelihood (null)	-302.118	-252.681	-554.799
Log likelihood (model)	-231.743.	-190.502	-432.366
Pseudo R^2	0.233	0.246	0.221
Adjusted pseudo R^2	0.193	0.199	0.199

() standard errors. ***, **, * = significance at 1%, 5%, 10% level.

The most notable difference between Survey 1 and Survey 2 is the significance of the coefficient of environmental co-benefit. In Survey 1, environmental co-benefit is not a significant determinant of respondents' offset choice, but it is in Survey 2. Apart from environmental co-benefit, the remaining results are relatively similar across the two surveys. All the coefficient estimates have the expected signs. The coefficients of offsets are positive and highly significant in both surveys as expected, meaning offset users in both surveys are more likely to choose an offsetting alternative than the opt-out status quo. The coefficient estimates of co-benefit related attributes are also positive and the implied ranking is consistent across the two surveys, with co-benefit verification being the most preferred attribute, follows by social co-benefit, economic co-benefit and environmental co-benefit. The coefficients of price are negative and highly significant as expected, which indicate offset users in both surveys are sensitive to offset price and are more likely to choose the cheaper alternative. The pseudo R^2 indicators also show both models, Survey 1 and 2, have comparable fit (23 and 25% respectively).

In terms of unobserved preference heterogeneity, the standard deviations of the coefficients of offset and co-benefit verification are significant in both surveys, although in Survey 1, the standard deviation of the coefficient of offset is only significant at 10% level. There is also evidence of preference heterogeneity for social co-benefit in Survey 1 and for economic co-benefit in Survey 2.

In the pooled model, all attributes are highly significant and have the expected signs. The implied ranking of offset co-benefit related attributes is also consistent with Survey 1 and 2. The standard deviations of all the coefficients are significant except for environmental co-benefit and price. The results of the pooled model reflect the combined results of Survey 1 and 2. The pseudo R^2 indicator is also comparable with Survey 1 and 2.

9.4 Test for equality of preference and scale parameters

To carry out Swait & Louviere (1993)'s test procedures, the pooled model is estimated using different relative scale adjustment for Survey 2 dataset ($\mu_{Survey2}$). Figure 9-1 shows the log-likelihood value at different $\mu_{Survey2}$. The grid search procedure shows the log-likelihood is optimised when $\mu_{Survey2}$ is set at 1.025, implying that Survey 2 dataset has slightly lower error variance than Survey 1.

Figure 9-1: Log-likelihood of pooled data with different relative scale adjustment for Survey 2 dataset

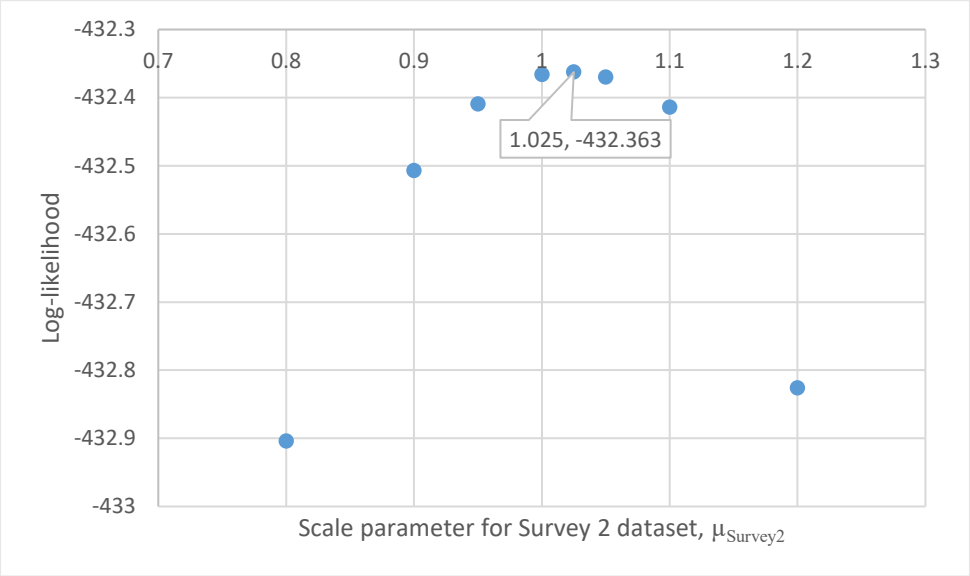


Table 9-4: A summary of Swait & Louviere test results

Test 1: Equality of preference parameters	
Log-likelihood value for Survey 1, $L_{Survey1}$	-231.743
Log-likelihood value for Survey 2, $L_{Survey2}$	-190.502
Log-likelihood value for pooled model, setting $\mu_{Survey2}$ at 1.025, L_{μ}	-432.363
Likelihood ratio test statistic, $\lambda_1 = -2[L_{\mu} - (L_{Survey1} - L_{Survey2})]$	20.235
Chi-squared statistics for 13 d.f. and 95% confidence level	22.362
Reject H1: $\beta_{Survey1} = \beta_{Survey2}$?	No
Test 2: Equality of scale parameters	
Log-likelihood value for pooled model, L_p	-432.366
Test statistic, $\lambda_2 = -2[L_p - L_{\mu}]$	0.007
Chi-squared statistics for 1 d.f. and 95% confidence level	3.841
Reject H2: $\mu_{Survey1} = \mu_{Survey2}$	No

Table 9-4 summarises Swait & Louviere (1993)'s test procedures and results. For the first test, the test statistic indicates equality of parameters assuming difference in scale parameters cannot be rejected. For the second test, the test statistic indicates equality of scale parameter across datasets cannot be rejected. Overall, the test results show that the underlying preference structures for offset co-benefits among offset users in Survey 1 and 2 are not significantly different. In other words, preferences of offset users for offset co-benefits are stable across the two surveys that are around two and a half years apart.

9.5 A comparison of WTP measures

The marginal WTP measures for offset attributes as estimated from Survey 1 and 2 using RPL model in WTP space are summarised in Table 9-5. Comparisons of WTP estimates between two surveys show they are relatively similar except for offset and environmental co-benefit. The marginal WTP for offset has more than doubled between Survey 1 and 2, whilst the marginal WTP for environmental co-benefit has changed from not significantly different from zero to US$4.88 (1.01-8.75). For all other attributes, the relative changes in marginal WTP estimates between Survey 1 and 2 are around 20%. The p-values of Poe test are reported in the last column of Table 9-5. They show that the marginal WTP estimates for the attributes have not changed significantly between the two surveys except for environmental co-benefit. The difference in the marginal WTP measures for environmental co-benefit between Survey 1 and 2 is significant at 1% level, which means the marginal WTP for environmental co-benefit has increased significantly over time. Besides environmental co-benefit, the marginal WTP for offset and offset co-benefits among offset users remain stable over the two-and-a-half-year period.

Table 9-5: A comparison of marginal WTP measures of Survey 1 and Survey 2 offset users

	Mean WTP in US$ per offset		**Poe-test**
	Survey 1	**Survey 2**	
Offset (ASC)	9.15 (5.19-13.11)	19.67 (9.91-29.43)	0.29
Social co-benefit	8.01 (3.38-12.63)	6.39 (2.38-10.40)	0.44
Economic co-benefit	4.96 (1.28-8.63)	6.02 (0.84-11.19)	0.46
Environmental co-benefit	-	4.88 (1.01-8.75)	0.00
Co-benefit verification	11.90 (8.13-15.66)	9.82 (5.13-14.52)	0.45

() 95% confidence interval

9.6 Conclusions

SP studies only provide information about preferences at a particular point of time, which may change over time. Thus, assessing temporal stability of offset users' preferences and WTP measures

for offset co-benefits and co-benefit verification can provide some insights to the dynamic of buyers' demand. In this study, the same CE was administered to two independent groups of offset users approximately two and a half years apart. Tests for stability take place in three levels: choice consistency, underlying preference structure and WTP measures. Results show that choice patterns have not changed significantly between Survey 1 and 2. A comparison of results from RPL models shows preferences for offset and offset co-benefits among offset users are stable, except for environmental co-benefit. Environmental co-benefit is not a significant determinant of respondents' offset choice in Survey 1 but it is in Survey 2. The outcomes of Swait & Louveire test procedures confirm the preference and scale parameters of Survey 1 and Survey 2 are not significantly different, meaning the underlying preference structure of offset users is stable over time. Differences in the marginal WTP measures for offset and offset co-benefits are also not statistically significant between the two surveys, except for environmental co-benefit. Respondents in Survey 2 are willing to pay significantly more for environmental co-benefit than respondents in Survey 1. Without further information, it is difficult to speculate the factors that cause an increase in WTP for environmental co-benefit among offset users.

Overall, findings from this chapter suggest that offset users' preferences for offset co-benefits and co-benefit verification are temporally stable. This provides some assurance to the market to continue to invest and develop offset projects that deliver a range of co-benefits. From methodological point of view, this study generates some promising results in terms of validity of SP studies, despite the differences between Survey 1 and 2 that could have influenced the outcomes. Firstly, the sample populations of Survey 1 and 2 are independent. Secondly, the survey questionnaire which the CE is embedded in is different for Survey 1 and 2. In particularly, in Survey 1, OE CVM is presented after the CE, whilst in Survey 2, PC CVM is presented prior to the CE. This may result in ordering effects. Existing studies have found ordering effects to most likely affect CVM WTP. More specifically, WTP values provided in CVM are significantly anchored on the price level of the preferred alternative in the last choice set of CE (Brouwer, Logar & Sheremet, 2017). Therefore, ordering effects are likely to be limited in this study. Finally, the survey modes of Survey 1 and Survey 2 are different. Survey 1 was conducted through telephone interview whilst Survey 2 was a web-based survey. Therefore, Survey 1 respondents were subjected to interviewer interference but Survey 2 respondents were not. The fact that CE results of Survey 1 and 2 are not significantly different supports my previous expectation that presence of social desirability bias and interviewer effects are likely to be limited in Survey 1 (as discussed in Section 6.1.2).

10 An assessment of voluntary offset projects

Empirical analyses so far have been focusing on the demand-side of the VCM, in particularly organisations' demand for SD co-benefits. This chapter examines the supply-side of the market by providing a quantitative analysis of the offset projects that VCM supports. The aim is to address research sub-question 3.1 to 3.3:

3.1. Which project types and locations does the VCM promote?
3.2. Do the VCM and CDM support different project types and locations?
3.3. Does the VCM perform better than the CDM in promoting SD?

In contrast to existing studies, this study assesses the VCM based on offset generation rather than market transaction data. Results show that the VCM supports a range of project types, in particularly renewable and household energy projects that are commonly associated with a range of SD co-benefits. However, from the volume of ERs perspective, the market is at risk of being dominated by a few large-scale LULUCF projects. A comparison of voluntary and CDM project portfolios confirms that the size of the VCM is considerably smaller than the CDM, therefore its climate impacts is also limited in comparison. Moreover, the VCM is found to support a considerable number of pre-CDM projects, which further undermines its ability to promote additional carbon finance beyond the compliance market. Large-scale offset projects contribute to substantial portions of ERs in both markets, in particularly LULUCF projects in the VCM and industrial gas projects in the CDM. African region benefits greater from the VCM due to its potential for LULUCF projects. Overall, the main difference between the two instruments is the VCM's active support for LULUCF projects that is absent in the CDM. As existing case studies on the SD contributions of LULUCF projects have shown mixed outcomes, whether the VCM performs better than the CDM in promoting SD remains inconclusive.

10.1 Development of project databases

This is the first study that assesses the VCM based on offset generation rather than market transaction data. Offset generation data provides a more accurate picture of the projects that the VCM promotes than offset transaction data as once an offset is generated, it can be transacted multiple times until it is retired. According to Hamrick & Goldstein (2016), around 330 million offsets have been issued in the VCM since 2005, however the cumulative volume of offsets transacted has reached around 1 billion.

The fragmented nature of the VCM with competing standards means a central database of voluntary projects is absent. Thus, a novel voluntary project database is developed for this study. Ideally, the

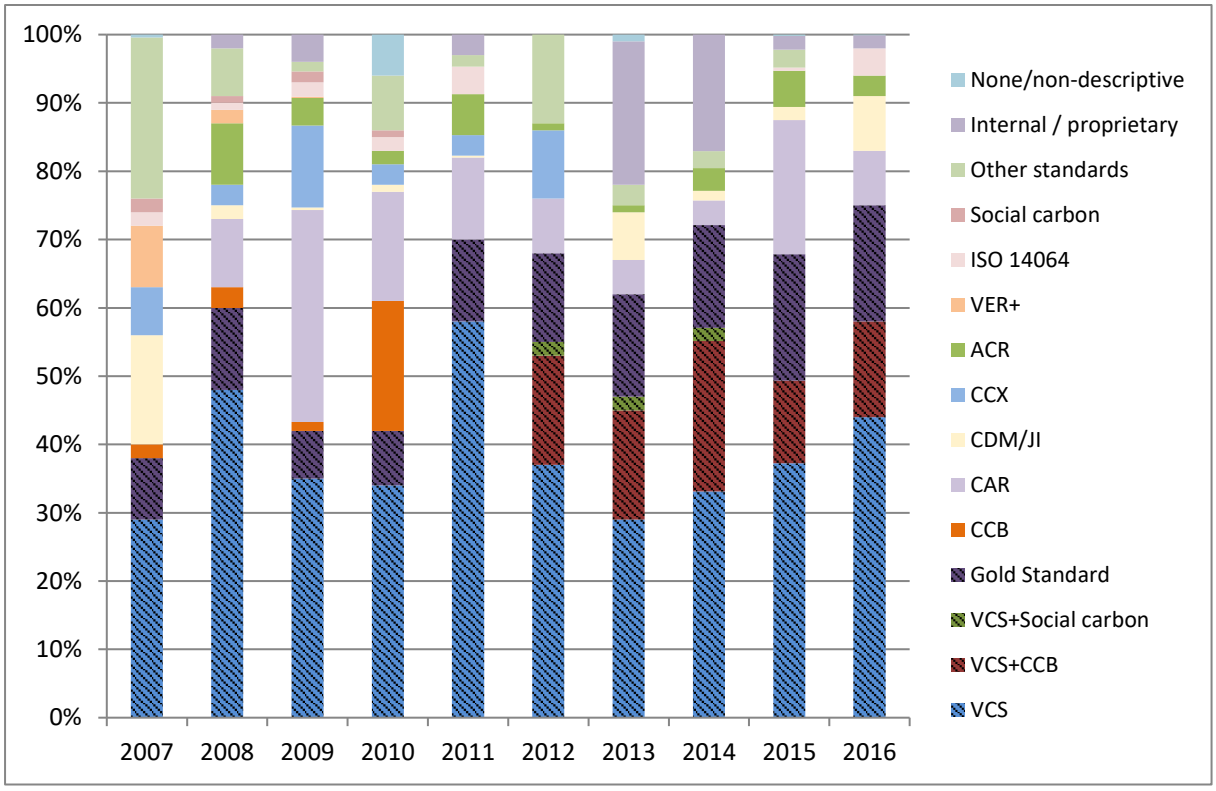
voluntary project database would comprise all offset projects that are developed beyond compliance carbon markets. However, from practical point of view, it is impossible to seek out all voluntary offset projects developed around the world, especially those that are conducted bilaterally without going through offset retailers or applying for a third-party standard. Thus, a set of criteria for project inclusion is defined with an aim to build a database that is representative of the VCM.

10.1.1 Project inclusion criteria

Criterion 1: Project standard

In 2016, 99% of the volume transacted in the VCM are certified by a third-party standard, a continuous trend since 2008 (Hamrick & Gallant, 2017). Therefore, the first step of developing the voluntary project database is to collate all offset projects approved by different voluntary standards into one single database. Over the years, a number of voluntary standards have been developed. Year-on-year market shares of different voluntary standards in terms of volume of offsets transacted are shown in Figure 10-1.

Figure 10-1: VCM year-on-year market share by project standard



Data source: ESMP report series (Hamrick & Gallant, 2017; Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2014; Peters-Stanley et al., 2013; Peters-Stanley et al., 2012; Peters-Stanley et al., 2011; Hamilton et al., 2010; Hamilton et al., 2009; Hamilton et al., 2008)

Figure 10-1 shows that since 2011, the combined market share of VCS (including VCS with additional sustainability certification such as CCBS and Social Carbon) and GS has been stable at around 70%. Considering their relatively large market shares, both VSC and GS are included in the voluntary project database.

Besides VCS and GS, other prominent voluntary standards are mainly developed in the US for its domestic carbon markets, namely CAR and ACR, as well as CCX in the earlier years. Following the closure of CCX in 2010, trading of CCX offsets ceases completely after 2012, therefore CCX offsets are not being considered in this study. Most projects that are developed under CAR and ACR are hosted in the US[63]. In recent years, these standards are also shifting their focus from voluntary to compliance markets as they put forward their protocols and projects to be accepted by California's compliance CaT (Hamrick & Goldstein, 2016; Hamrick, Goldstein & Peters-Stanley, 2015; Peters-Stanley et al., 2013). Thus, offset credits issued by these standards could become compliance in the future. Considering their strong focus on the US market and potential shift to compliance markets in the future, CAR and ACR are also not being considered in this study.

As for the remaining standards, Figure 10-1 shows they have relatively small market shares in the VCM with occasional exceptions in specific years. For example, CDM and JI had a relatively high market share in 2007 but their market shares in the following years weakened considerably. This could be due to the popularity of compliance offsets in the early years of VCM as they were regarded as more credible than offsets issued from voluntary standards (Hamilton et al., 2009). Internal/ proprietary standards also have low market shares in general except for 2013 and 2014. Their increased market shares in 2013 and 2014 were attributed to the large-volume government-to-government REDD Early Movers programme[64] that took place in the respective year. ISO-14064's unusually high market share in 2016 was also attributed to a single large transaction at a very low price (Hamrick & Gallant, 2017). Further details of the deal are not available. Excluding these exceptional cases, voluntary standards other than VCS and GS generally have very limited presence in the VCM, therefore are not included in the voluntary project database. In view of VCS and GS have consolidated majority of the market shares over the years, inclusion of these two standards in the voluntary project database are considered representative of the VCM.

[63] As of September 2017, CAR project registry shows 500 projects, all are hosted in the US except four in Mexico (Climate Action Reserve, 2017). ACR project registry shows 235 projects of which 233 are hosted in the US and 71 of them are eligible for compliance California CaT programme (American Carbon Registry, n.d.).
[64] For details, refer to footnote in page 78.

Criterion 2: Programme of activities

To overcome the high transaction cost associated with small-scale projects, the CDM EB has set up a new type of project framework called the programmatic CDM or programme of activities (PoAs) (UNFCCC, n.d.a). PoA is defined by UNFCCC (2017) as:

'*A voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary programmes) that leads to GHG emission reductions or net anthropogenic GHG removals by sinks that are additional to any that would occur in the absence of the PoA, via an unlimited number of CPAs*.' (p.15)

Thus, a PoA is not a standalone project. Rather, it is made up of multiple project activities known as CDM programme activities (CPAs) that use similar measure or technology to reduce GHG emissions but are geographical dispersed. Once a PoA is registered, unlimited number of CPAs can be added into the PoA without having to undergo validation and registration processes, thus reducing the transaction cost and approval time for small-scale projects. VCS and GS also have similar frameworks that are called VCS Grouped Projects (VCS, 2017) and GS PoAs (GS, 2017) respectively. PoAs are included in the analysis of this study, with each activity developed under a PoA being considered as an individual project.

Criterion 3: Issuing projects

In this study, only offset projects (or activities under a PoA) that have successful offset issuance are being considered. Offset projects that are in other stages of development, such as in the process of being validated or registered, or are registered but yet to generate offsets, are not being considered for the following reasons. Firstly, an offset project that is yet to be registered with a voluntary standard or the CDM means its claimed ERs are yet to be confirmed as real, additional and permanent. Secondly, an offset project that is registered but is not generating offsets may imply that the project has not taken off the ground, thus its associated SD co-benefits are not being realised. Another possibility is that the project has been implemented but the project developer has not requested for offset issuance. If the project is able to operate without claiming carbon finance, the project's additionality is questionable, thus should not be considered in this analysis.

10.1.2 Data source

Voluntary Carbon Standard (VCS)

The VCS has a multiple-registry system that is provided by APX and Markit (VCS, n.d.a). However, to avoid double-counting, the multiple-registry system is supported by a central VCS project database[65] that is publicly available. It is the central repository that contains all VCS projects, as well as for tracking and retiring offsets that are issued by the VCS, called the Verified Carbon Units (VCUs). This central database is the main source of information for VCS projects that are considered in this study. On the database website, projects are listed under separate tabs for VCS, CCBS and California CaT's compliance projects. Only projects that are listed under the VCS are included in the voluntary project database developed for the present study. Projects that apply for both VCS and CCBS are listed twice, each under the respective standard. Therefore, to avoid double counting, projects listed under the CCBS section are not included again. As California CaT's projects are for compliance purpose, they are also excluded. In the VCS section, the list of VCS projects can be found under the '*Projects*' tab. Project specific webpages that contain detailed project information and documentations can be accessed by clicking on the project name.

Gold Standard (GS)

The GS is linked to Markit Environmental Registry (GS, n.d.b). All GS projects are publicly listed on the Markit Environmental Registry website[66], under the '*Projects*' tab. The online database can be filtered by standard using the drop-down menu located on the top right of the website. Links to project specific webpages that contain detail project information and documentations are also provided. The registry's online database forms the main source of information for GS projects analysed in this study.

Clean Development Mechanism (CDM)

In this study, the voluntary project portfolio is also being compared to the CDM project portfolio to investigate if the two instruments support similar or different project types and locations. Information about CDM projects and PoAs are obtained from UNEP DTU Partnership. For years, UNEP DTU, formerly known as UNEP Risø Centre, has been tracking mitigation activities developed under the UN's mechanisms, including CDM, JI, PoA and Nationally Appropriate Mitigation Actions (NAMAs)[67]. The resultant databases, one for each mechanism, are stored in excel files and can be

[65] The VCS project database can be accessed by public via its website: http://vcsprojectdatabase.org/#/home.
[66] Markit Environmental Registry: https://mer.markit.com/br-reg/public/index.jsp?s=cp
[67] Assessing NAMAs is beyond the scope of this study. Further information about NAMAs can be found in UNFCCC's website: http://unfccc.int/focus/mitigation/items/7172.php

downloaded from UNEP DTU's database website[68]. Its CDM database in particular, has become a useful source of information for a number of academic studies, including Lovell & Liverman (2010) on the different carbon offset technologies, Corbera, Estrada & Brown (2009) on comparing the VCM and the CDM, and Dechezleprêtre, Glahant and Ménière (2008) on the extent of the CDM in promoting technology transfer.

10.1.3 Project classification

Offset project types are classified differently under the VCS, GS and CDM[69]. To enable like-to-like comparison, definition of project types needs to be standardised across the three databases. This study follows UNEP DTU's classification of CDM projects with some minor adjustments as follow:

- HFCs, N2O, PFCs and SF6 are grouped together as industrial gas.
- Energy efficiency (EE) household is renamed as household energy that includes all household and community level renewable and energy efficiency projects, such as clean stoves, water filtration, domestic biogas and solar cooking/ water heating.
- Cement, EE industry and EE own generation are combined under EE industry that comprises all energy efficiency measures in the industrial setting.
- Forest is renamed as LULUCF that includes REDD and forest management projects that are mainly developed in the VCM.

Table 10-1 provides a description of project types as defined for this study.

[68] UNEP DTU Partnership CDM/JI pipeline analysis and database: http://cdmpipeline.org/
[69] Project classifications under different standards are presented in Appendix 10-1.

Table 10-1: Project classification as defined for this study

Type	Description
Agriculture irrigation	Dissemination of treadle pumps in place of diesel powered pumps for agriculture irrigation.
Biomass	Use of renewable biomass, such as agricultural or forest biomass, in place of fossil fuel for power or heat generation.
CO2 usage	Use of renewable sources of CO_2 as an input to industrial production or manufacturing processes.
Coal bed/mine methane (CMM)	Capture of methane generated from coal mines for flaring or power generation.
Energy efficiency – industry (EE industry)	Implementation of EE measures in industrial setting, such as installation of waste heat recovery system or energy efficient boiler, or retrofitting existing process to reduce energy consumption.
Energy efficiency – power (EE power)	Implementation of EE measures in power sector, such as cogeneration, district heating, connection of isolated grid, or higher efficiency coal power plant.
Energy efficiency – services (EE services)	Implementation of EE measures in building services, such as improved insulation, energy efficient heating, ventilating and air conditioning (HVAC) and energy efficient lightbulbs.
Fossil fuel switch	Switching to less carbon intensive fossil fuel, such as switching from coal to natural gas, oil to natural gas, or new natural gas plant.
Fugitive	Reduction of fugitive gas release through detection and repair of leaks in gas production or distribution system or gas recovery from oil wells.
Household energy	Dissemination of renewable or EE measures at the household or community level, including clean stoves, solar cooking and water heating, water filtration, domestic biogas and energy efficient lightbulbs.
Hydro	Use of hydro power in place of fossil fuel for power generation.

Type	Description
Industrial gas	Capture and destroy of GHGs, including HFCs, N2O, PFCs and SF6 generated from industrial or chemical processes.
Landfill gas	Reduction of methane generation from landfill sites through capture of landfill gas for flaring or power generation, or avoidance of municipal solid waste (MSW) from going into landfill through improved waste management, composting, or combustion.
Other renewables	Use of renewable or a combination of renewables for power generation such as geothermal, tidal, solar and wind.
Solar	Use of solar power in place of fossil fuel for power generation.
Transport	Implementation of energy saving measures in transport sector, such as cable cars, switch from road to rail and more efficient vehicles.
Wind	Use of wind power in place of fossil fuel for power generation.
Methane avoidance	Capture and destroy of methane gas from various sources such as wastewater, composting and manure.
LULUCF	Forest or land-based projects such as afforestation and reforestation, REDD and improved forest management.

10.1.4 Data collection and treatment

The following project information were collected for the development of voluntary project database:

1. Project type
2. Project country and region
3. The estimated annual ERs in tCO_2e
4. Project status under the CDM, whether the project is registered, rejected, validation terminated or withdrawn
5. If the offset project has other add-on quality or sustainability standards such as CCBS, SC and ISO.

Voluntary project database

The VCS database was downloaded from the VCS Project Database website on the 8th of January 2016. The VCS project database was downloaded in excel file and the following information was readily available: project ID, project name, project proponent, project country, sectoral scope, estimated annual ERs and additional certification (if any). As information about the project status was not available, each project was checked against its project webpage to establish if it had started generating offsets. Projects that had not started generating offsets were removed from the database. If the project had started generating offsets, the project document was downloaded and reviewed to collect the relevant information. Most of the information required could be found in the general description of project activity section of the project document. Finally, each project was checked against UNFCCC CDM project website[70] to identify the project status under the CDM. At the end of data collection which lasted around two months, a total of 1,011 issuing VCS projects were recorded.

The GS database was also downloaded on the 8th January 2016. First, the '*Project*' page on Markit Environmental Registry website was filtered to only display GS projects. Then, the database was copied, page-by-page, into an excel spreadsheet. In total, there were 1,029 GS projects. Information that were readily available included project name, project category, standard name, project type, project status, additional certification (if any), project validator, project developer, project country and region within the country, and a project web link for further information. Unlike the VCS database, information on the project status (listed, validated, registered, issued or discarded) was readily available, therefore there was no need to check each project against its webpage to establish which project had started generating offsets. After filtering the database by project status to only

[70] CDM project search page: http://cdm.unfccc.int/Projects/projsearch.html

include '*issued*' projects, the database was reduced to 347 projects. Further examination of the database revealed some projects were listed twice in the GS database as pre- and post-CDM. For example, Fujian Zhangpu Liuao 45 MW Wind Power Project was listed twice as '*Fujian Zhangpu Liuao 45 MW Wind Power Project*' and again as '*Fujian Zhangpu Liuao 45 MW Wind Power Project_preCDM VERs*'. For such cases, one of the listing was removed to avoid double-counting. After removing the repeat entries, the number of issuing projects became 339. Project documents of the issuing GS projects were downloaded from the respective project webpage and reviewed to collect the relevant information. Each issuing project was also checked against the UNFCCC CDM website to identify the project status under the CDM. After data collection was completed, GS issuing projects were combined with VCS issuing projects to form the voluntary project database.

The final voluntary project database consists of 1,349 issuing projects. The total number of projects does not equal to the total number of VCS and GS issuing projects because one project has applied for both VCS and GS, which is only counted as one in the final database. The final voluntary project database consists of the following information:

- Standard (VCS/GS)
- Project name
- Type
- Country
- Region
- Estimated annual ERs
- CDM status
- Additional standards (if any)

CDM database

The excel files, CDM Pipeline Overview and PoA Pipeline Overview, were downloaded from UNEP DTU's website on the 8th of January 2016. At the time, the CDM and PoA databases[71] were updated to 1st of January 2016. The CDM project database consisted of 12,337 projects at various development stages. The database was filtered by the column titled '*Total issuance (kCERs)*' and projects that had not had any successful issuance were removed. This resulted in 2,864 issuing projects. The database contained comprehensive information about the projects, from project type

[71] The CDM database can be found in the spreadsheet named *'CDM_Projects'* in the CDM Pipeline Overview file, whilst the PoA database can be found in the spreadsheet named *'PoAs'* in the PoA Pipeline Overview file.

and location to investment cost and credit buyer. Thus, no further data collection was needed. The only data treatment required was reassigning project type according to Table 10-1.

Information collected from UNEP DTU's CDM database for the present study are summarised in Table 10-2.

Table 10-2: Data collection for CDM database

CDM database for this study	**Corresponding columns in**	
	UNEP DTU CDM Pipeline	**UNEP DTU PoA Pipeline**
Standard	CDM Standalone	CDM PoA
Project name	Title	Title
Type	Type	CPA-Type
Country	Host country	Host country
Region	Region	Region
Estimated annual ERs	1st period ktCO2e/yr, 2nd period ktCO2e/yr or 3rd period ktCO2e/yr, whichever that is latest[a]	1st period ktCO2e/yr

[a] A CDM project can apply for a seven-year crediting period that can be renewed twice or a ten-year crediting period with non-renewal (UN, 2006). Therefore, UNEP DTU's CDM database shows the estimated annual ERs for 1st, 2nd and 3rd crediting period. Estimated annual ERs from the latest period is taken for this study.

The PoA database consisted of 481 PoAs, which collectively hosted 1,060 CPAs. As mentioned, each CPA is considered as a project in this study. To clean the database, rows with IDs that contain *'PoA'* were removed from the database as these are the overarching programmes that host the CPAs. Then, the database was filtered using the column '*Total issuance (kCERs)*' and CPAs that had not started generating CERs were removed from the database. The final database contained 166 issuing CPAs. Information extracted from the database are described in Table 10-2. Similar to the CDM project database, no further data collection was needed and the only data treatment required was reassigning project type according to Table 10-1.

The issuing CDM projects and CPAs were combined to form the CDM database used in this study. The final CDM database consists of 3,030 issuing projects, which corresponds to the total number of issuing CDM projects and CPAs.

10.2 Voluntary project database

A summary of the voluntary project database is provided in Table 10-3. The database consists of 1,349 projects. These projects are expected to generate 154 $MtCO_2e$ of ER per year. 75% of the projects are VCS projects and the remaining 25% are GS projects. In terms of volume of ER generation, 86% are expected from VCS projects and 14% from GS projects. These results are in-line with the market transaction data which shows the VCS has greater share of the VCM, whilst GS represents a niche market for high SD quality offsets. The relatively smaller share of GS projects in terms of ER generation suggests GS mostly promote small-scale projects that are often associated greater SD contributions.

Table 10-3: A summary of voluntary project database

	Number of projects	**Estimated annual ERs in $MtCO_2e$**
All issuing projects	1,349 (100%)	154 (100%)
-Of which are VCS	1,011 (75%)	133 (86%)
-Of which are GS	339 (25%)	21 (14%)
-Of which are also registered under the CDM	628 (47%)	70 (45%)

The database also reveals 47% of the voluntary projects are registered with the CDM. These projects are expected to contribute 45% of the voluntary portfolio's annual ERs. These findings confirm previous comments that offset supply in the VCM is closely linked to the CDM as many projects that are waiting to be approved by the CDM start to generate carbon finance from the VCM (Peters-Stanley et al., 2012; Lovell, 2010). These pre-CDM voluntary projects cannot be considered as purely financed by the VCM. Their substantial share in the VCM also raises question on the ability of the VCM to promote further carbon finance beyond the compliance regime.

This study also found VCS has approved and issued offset credits to one project that has been rejected by the CDM. The project is a household energy project that distributes thermally insulated bags, called the Wonderbag to low-income families in South Africa[72]. The project faces scrutiny from the CDM EB regarding its baseline calculation and monitoring plan, and is subsequently rejected

[72] The VCS project is called *'Saving the plant, one stew at a time'* (VCS project ID: 935). Its PDD states that the project has previously been rejected by the CDM. Further investigation reveals that the project has applied for CDM PoA under a different name called *'Heat retention cooking in South Africa'* (CDM reference: PoA5174). Further information about the project/PoA are available through the VCS and CDM websites (VCS: http://www.vcsprojectdatabase.org/#/project_details/935 and CDM: https://cdm.unfccc.int/ProgrammeOfActivities/poa_db/MUFTXDO7WK510PSRLY3IGH4NZ286CJ/view).

(UNFCCC, n.d.e). However, the project is approved by the VCS, enabling it to earn carbon finance through the VCM (Wonderbag, n.d.). This example shows the less stringent VCM can support projects that face challenges in ER quantification, in particularly household energy and LULUCF projects. The VCS has also approved nine other projects that have withdrawn their application or terminated validation under the CDM. These projects' shift to the VCM could be due to the rigorous CDM approval process and the resultant long delay. However, their shift could also be due to their inability to meet CDM's strigent project requirements. Thus, there is a risk that the VCM could be financing projects that are non-additional. Nevertheless, these projects make up less than 1% of the voluntary project database, in terms of number of projects and volume of ERs.

10.2.1 Voluntary project types

Figure 10-2 presents project types that the VCM supports. It shows the VCM promotes 17 project types, including renewable energy, LULUCF, household energy and methane avoidance projects. Focusing on Figure 10-2(a) that includes all projects in the database, the top project types are wind (33%), distantly follows by hydro (15%) and household energy (15%). Collectively, these top three project types constitute 63% of the voluntary project database. This shows despite the range of project types that the market supports, a few dominate the market. Renewable energy projects in particularly has strong presence in the VCM as wind, hydro and biomass projects together make up 58% of the voluntary project database. Following renewables, household energy also has relatively considerable share in the portfolio. Household energy projects are well-known for the co-benefits they bring to the beneficiary households. It is also worth mentioning that majority of these household energy projects (92%) are approved by GS that verifies project's co-benefits.

Excluding CDM registered projects (Figure 10-2(b)), wind remains the most popular project type although its relative share reduces considerably. 60% of wind projects in the voluntary database are also registered with the CDM. According to the CDM database, wind projects are also the most popular project type in the CDM, constituting 28% of the total issuing CDM projects. This implies the CDM can influence project types that are supported by the VCM as many CDM projects are also seeking voluntary carbon finance.

As expected, the relative share of LULUCF increases considerably after excluding CDM registered projects. LULUCF projects, especially REDD projects have historically met with strong oppositions and obstacles in the CDM due to their associated permanence and leakage issues. Thus, most LULUCF projects are developed within the voluntary space. None of the LULUCF projects in the voluntary database are seeking CDM registration, confirming LULUCF projects are mainly supported by the VCM. Another project type with notable increase in its relative share is CMM. Majority of

voluntary CMM projects are hosted in Annex I countries. 78% of the CMM projects are located in Germany and 12% are in the US.

Figure 10-2: Voluntary project types by % of projects

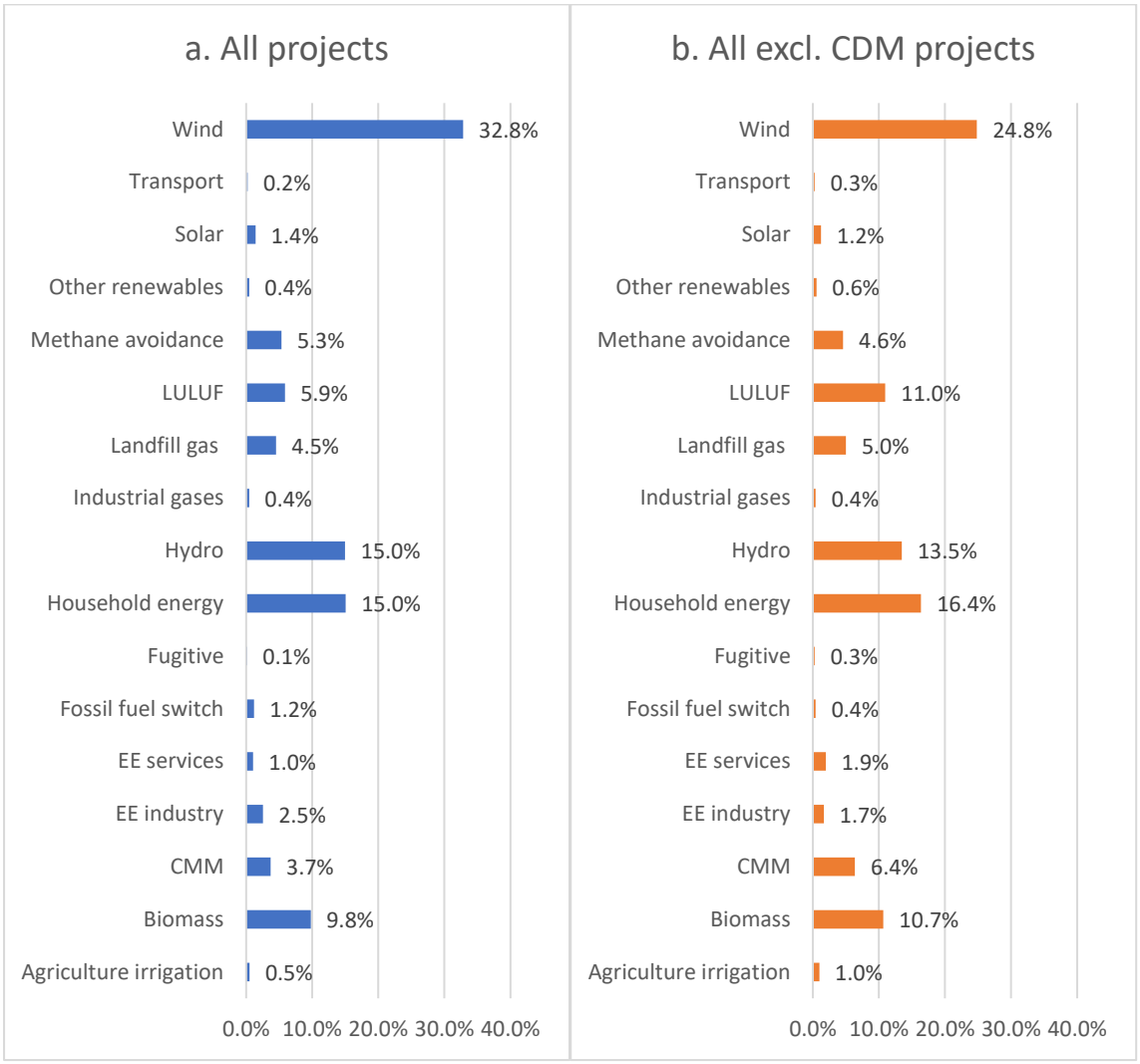
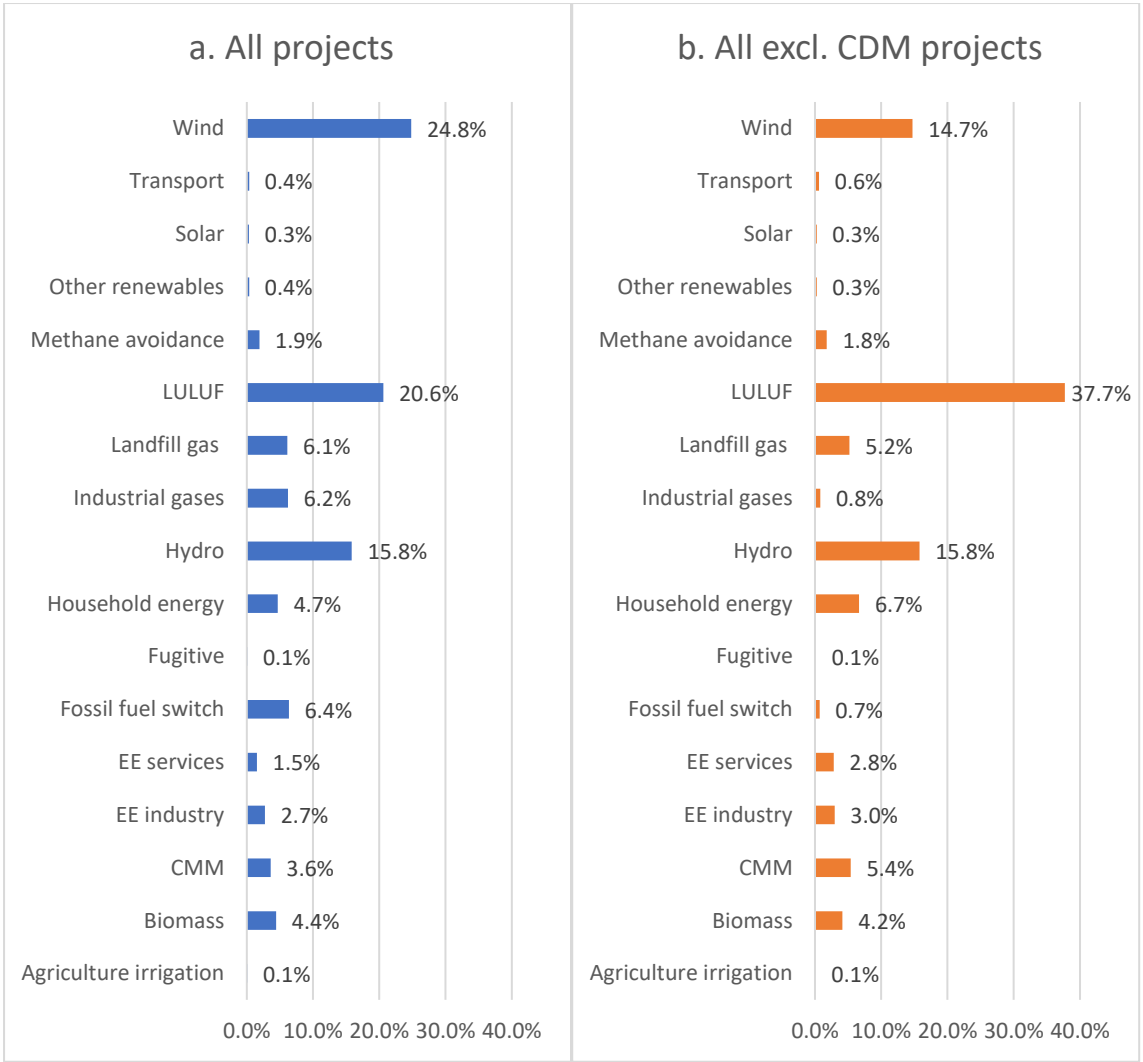


Figure 10-3 depicts voluntary project types by estimated annual ERs. Focusing on Figure 10-3(a) which represents all voluntary projects, wind remains the top project type, contributing around a quarter of the portfolio's estimated annual ERs. As compared to Figure 10-2(a), the share of LULUCF project increases considerably, whilst the share of household energy projects reduces. These observations suggest that a few LULUCF projects can generate large volume of ERs, whilst ERs generated from household energy projects are generally in smaller-scale. The share of LULUCF's contribution further increases when excluding CDM registered projects, as shown in Figure 10-3(b). Further analysis shows that the VCM could be at risk of being dominated by a few large-scale LULUCF projects. The two largest LULUCF projects, Kariba REDD+ project in Zimbabwe and Mai Ndombe REDD+ projects in Congo Democratic Republic (DR), are expected to contribute 15% of the

voluntary portfolio's annual ERs (after excluding CDM projects). Review of their PDDs shows both projects aim to conserve local forests by tackling the drivers of deforestation. They also claim to deliver positive outcomes to local communities and both projects achieve CCBS Gold level, a sustainability standard for forestry projects. However, the additionality of Mai Ndombe REDD+ project has recently come under scrutiny[73]. If claims about the project being non-additional were true, allowing large-volume of non-additional offsets to enter the VCM will have serious climate consequences and undermines the market's integrity in tackling climate change.

Figure 10-3: Voluntary project types by % of estimated annual ERs

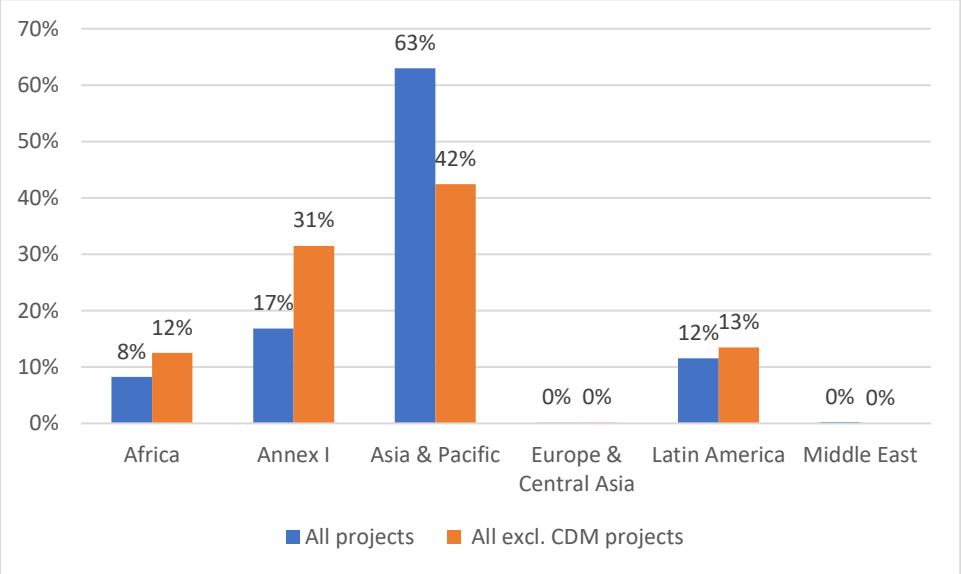


[73] Mai Ndombe REDD+ project in Congo DR argues its additionality based on the logging concessions in the project area, which leads to imminent commercial logging and subsequent illegal clearing of the areas by local people for subsistence agriculture and fuelwood. However, in a public comment submitted by Jutta Kill and Rainforest Foundation UK (2017) in response to the second verification of the project's ERs, they challenge the legality of logging concessions in the project area. In the absence of legal logging concessions, then the project's claim of imminent logging in the project area as the baseline scenario lacks credibility, therefore the project's additionality becomes questionable.

10.2.2 Geographical distribution of VCS projects

The regional distribution of voluntary projects is depicted in Figure 10-4. Majority of the projects are located in Asia & Pacific (63%), distantly follows by Annex I (17%), Latin America (12%) and Africa (8%). When excluding CDM registered projects, the regional distribution of voluntary projects is more even, with the share of Asia & Pacific reduces considerably, whilst the shares of other regions increase. This shows majority of projects hosted in Asia & Pacific are also seeking CDM registration. The VCM is also financing offset projects in Annex I countries that are not active in Kyoto markets, namely Turkey and the US (as shown in Table 10-4). However, its presence in Europe & Central Asia and Middle East is very limited.

Figure 10-4: Regional distribution of voluntary projects by % of projects



Further analysis of project location by country is presented in Table 10-4. China and India together host more than half of the voluntary projects in the database, distantly follows by Turkey, Brazil and the US. When excluding CDM registered projects, the share of China reduces considerably. 80% of voluntary projects in China are also approved by the CDM. Nevertheless, China remains one of the top five voluntary project host countries. Together with India, Turkey, the US and Brazil, these developed countries or large emerging economies host 66% of voluntary projects, thus challenges the common presumption that the VCM benefits Africa and LDCs where carbon finance is most needed.

Nevertheless, it is worth noting that the VCM's support for countries that are not active in the international compliance regime, in particularly Turkey. The special circumstances of Turkey under the KP means it neither has a mandatory cap, nor it is eligible for CDM or JI (Erdogdu, 2010). The voluntary project database shows Turkey hosts 100 voluntary offset projects, the second largest

after India (after excluding CDM projects). Most of the projects in Turkey are wind (46%) and hydro (43%). 96% of Turkish wind projects are certified by GS, which demonstrates the SD contributions of these projects. Thus, Turkey is an example that has lost out on the international compliance market but benefited greatly from the VCM.

Table 10-4: Top 10 voluntary project host countries by % of projects

All projects		**All excl. CDM projects**	
China	28%	India	24%
India	27%	Turkey	14%
Turkey	7%	China	11%
Brazil	6%	United States	9%
United States	5%	Brazil	8%
Germany	3%	Germany	5%
Thailand	3%	Kenya	3%
Kenya	2%	Thailand	2%
Vietnam	1%	South Africa	2%
South Africa	1%	Uganda	2%

Figure 10-5 shows regional distribution of voluntary projects by estimated annual ERs. 59% of the annual ERs are expected from Asia & Pacific, follows by Annex I (28%), Africa (25%) and Latin America (15%). After excluding CDM registered projects, the regional distribution of ERs is more equitable. The share of African region especially increases considerably and becomes comparable to Asia & Pacific and Annex I.

Figure 10-5: Regional distribution of voluntary projects by % of estimated annual ERs

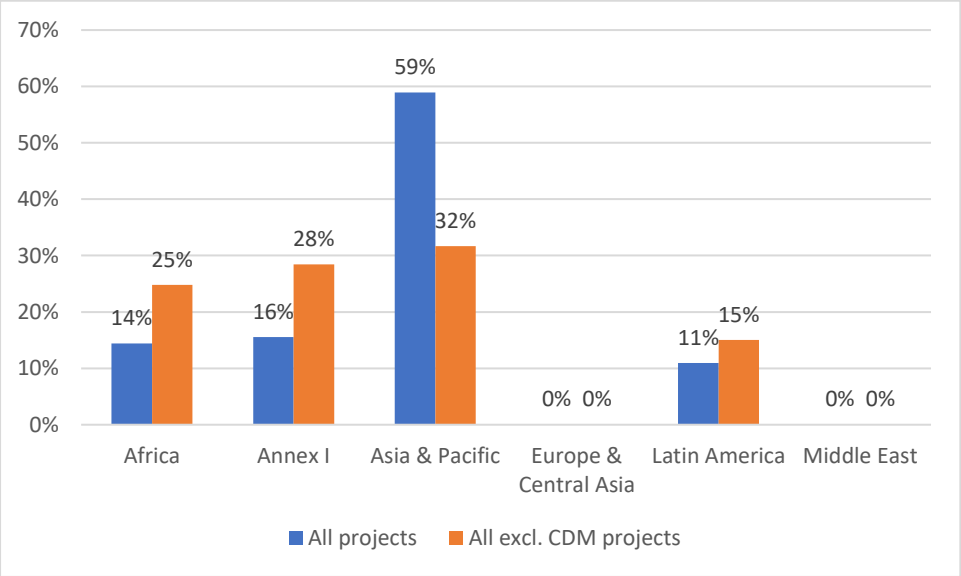


Table 10-5 reports ER distribution on the country level. It shows China and India are the main contributors of the ERs, 33% and 13% respectively. It also shows after excluding CDM projects, India and Turkey are the main contributors of ERs. The share of China, on the other hand, falls considerable as 90% of ERs from China are also eligible under the CDM. Zimbabwe becomes the third largest contributor of ERs, however its ERs are entirely attributed to one single REDD project. After Zimbabwe is Congo DR, which ERs are jointly produced from two REDD projects. Therefore, based on volume of ERs, the African region seems to be attracting considerable climate finance from the VCM. However, ERs achieved in the region are mainly from a handful of large-scale REDD projects. The three largest REDD projects in the region, the ones in Zimbabwe and Congo DR, are expected to contribute 60% of the ERs generated from the region. Thus, any carbon revenue and potential SD impacts generated from the VCM are likely to be limited to these few localised project areas. Household energy projects that have greater replicability and involve diffusion of clean technology, such as clean stoves, energy saving lightbulbs and domestic solar power are expected to benefit larger population, especially the poorer households that do not have access to clean energy.

Table 10-5: Top 10 voluntary project host countries by % of estimated annual ERs

All projects		**All excl. CDM projects**	
China	33%	India	12%
India	15%	Turkey	12%
Turkey	7%	Zimbabwe	8%
Brazil	4%	Congo DR	7%
Indonesia	4%	Brazil	7%
Zimbabwe	4%	Peru	7%
Congo DR	4%	Kenya	6%
Kenya	4%	Indonesia	6%
Peru	4%	United States	6%
United States	3%	China	6%

10.3 A comparison of VCM and CDM projects

Table 10-6 provides an overview of voluntary and CDM projects. To enable like-to-like comparison, voluntary projects that are hosted in Annex I countries are excluded from the analysis. In addition, for the voluntary project database to represent projects that are purely financed by the VCM, VCS and GS projects that are also registered with the CDM are excluded. After excluding Annex I and CDM registered projects, the voluntary project database consists of 494 projects with an expected annual ERs of 60MtCO_2e. In comparison, the CDM database has 3,030 projects with an estimated annual ERs of 507 MtCO_2e. Therefore, in terms of number of projects, the size of the VCM is only

16% of the CDM, whilst in terms of estimated annual ERs, it is only 12% of the CDM. This confirms that the VCM is considerably smaller than the CDM.

Table 10-6: An overview of voluntary and CDM project portfolios

	Voluntary	**CDM**
Number of projects issuing credits - Excluding projects in Annex I countries and registered with the CDM	1,349 494	3,030
Estimated annual ERs in $MtCO_2e$ - Excluding projects in Annex I countries and registered with the CDM	154 60	507

10.3.1 Comparison by project type

Figure 10-6 shows a comparison of voluntary and CDM projects by project type. Top voluntary project types are wind (26%), household energy (23%), LULUCF (14%), biomass (14%) and hydro (11%). Collectively, these top five project types attribute to 88% of voluntary projects. The CDM is dominated by renewable projects, namely wind, hydro and biomass which together represents 64% of CDM projects. The renewable projects are distantly followed by methane avoidance (9%) and EE industry projects (7%). A comparison of voluntary and CDM projects show both instruments have strong support for wind projects. Notable differences between the two are the greater presences of household energy and LULUCF projects in the voluntary portfolio. This may indicate that the VCM is promoting projects with SD contributions, especially household energy projects that are known to deliver a range of co-benefits. However, due to the sheer size of the CDM, the compliance instrument is still financing greater number of household energy projects than the VCM in absolute term.

Figure 10-6: A comparison of voluntary and CDM project types by % of projects

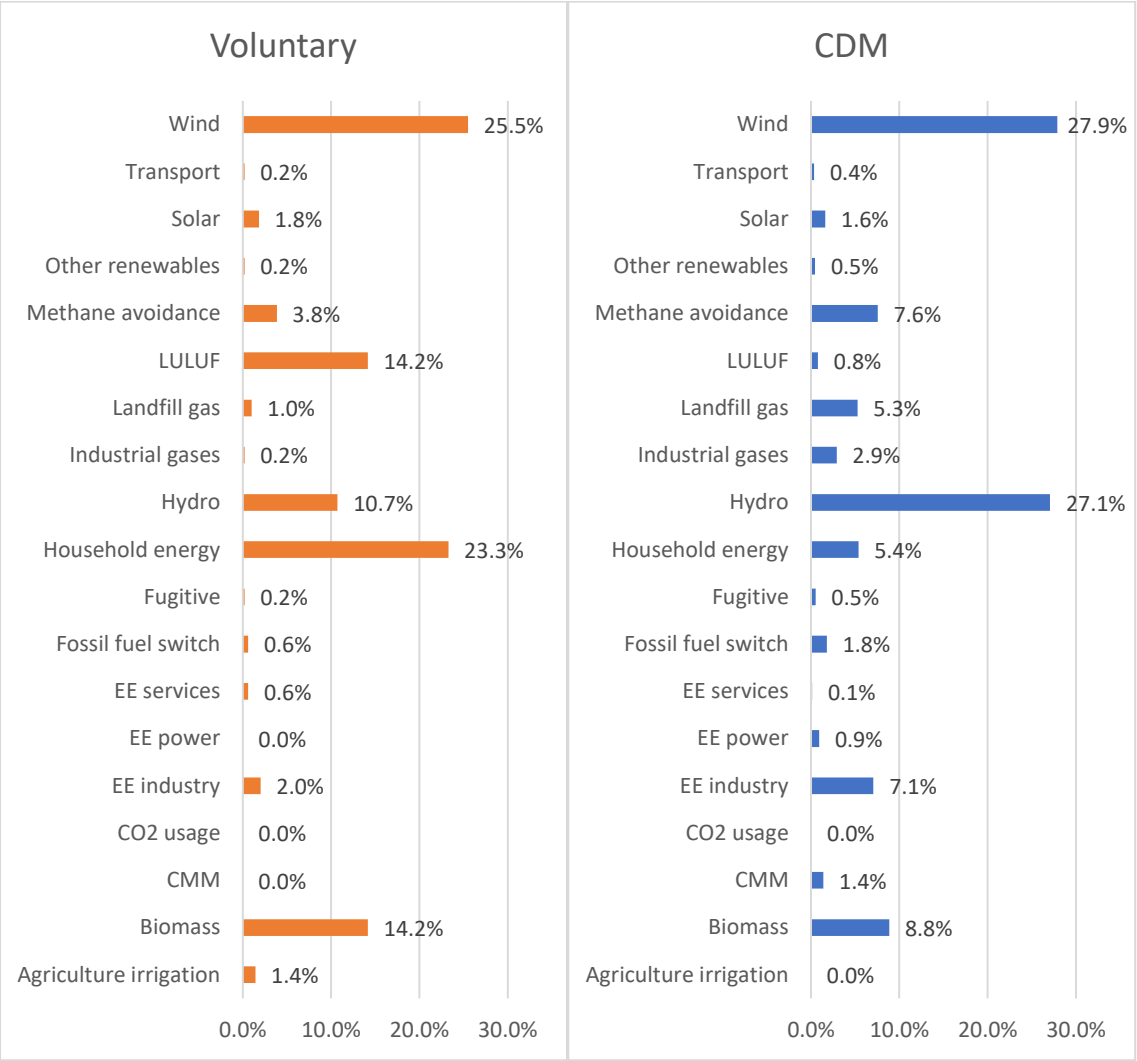
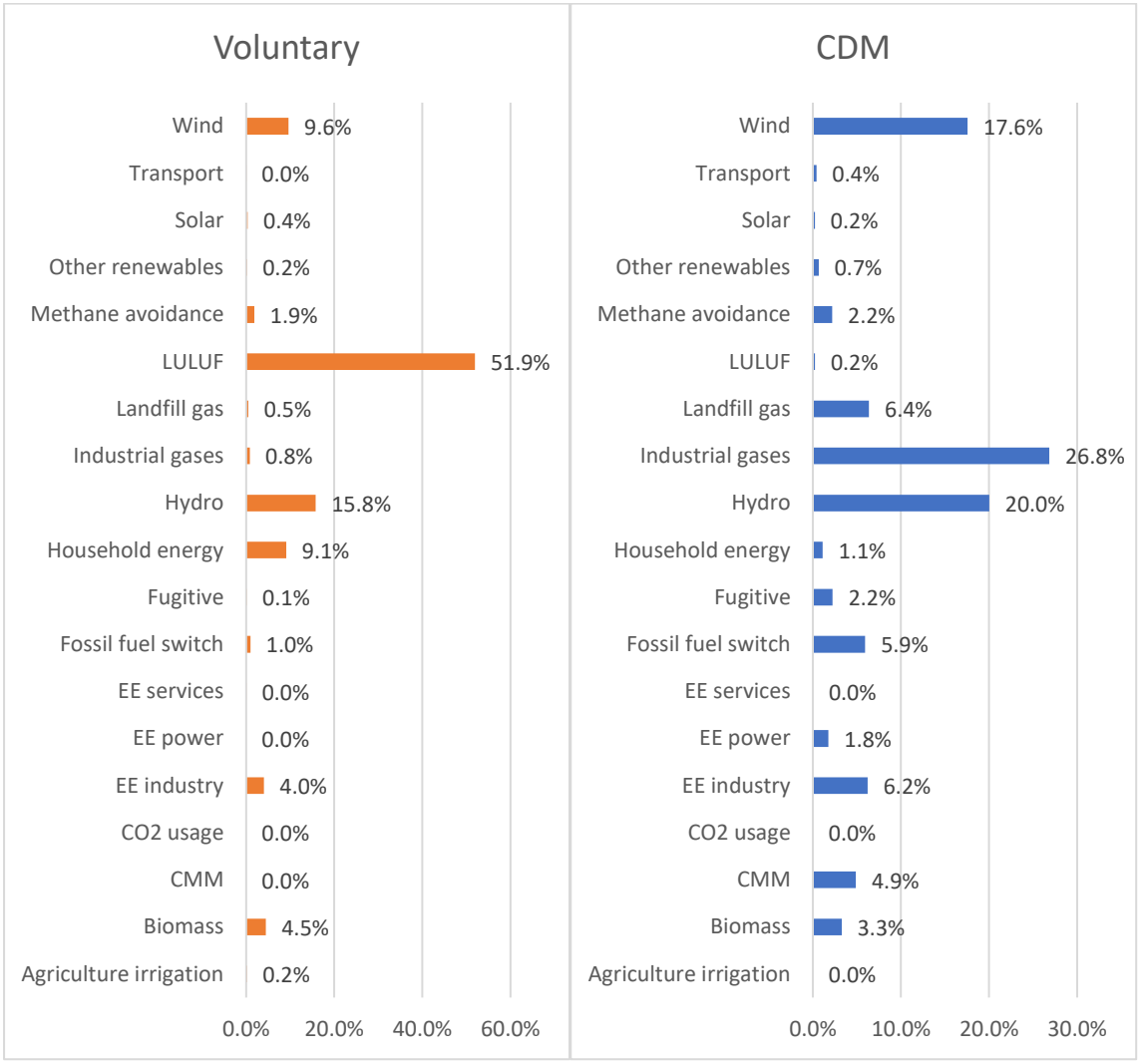


Figure 10-7 presents voluntary and CDM project types by estimated annual ERs. The distributions of ER generations for both voluntary and CDM do not correlate with Figure 10-6 above. For the voluntary portfolio, although LULUCF only accounts for 14% of the projects, it contributes 52% of the total estimated annual ERs. In comparison, wind and household energy projects that make up 26% and 23% of the voluntary projects respectively, only contribute 10% and 9% of the total estimated annual ERs. For CDM, industrial gas constitutes 3% of its projects but contributes 27% of its estimated annual ERs. After industrial gas, wind and hydro which make up most of CDM projects contribute majority of the remaining ERs. Together, these three project types generate 64% of CDM's estimated annual ERs. Analysis by volume of ERs confirms that the CDM market is dominated by a few cheap large-scale industrial gas projects that have limited SD co-benefits. The VCM is also at risk of being dominated by a few large-scale offset projects, but in this case, they are LULUCF projects which SD contributions remain inconclusive and highly dependent on the specific design of the project.

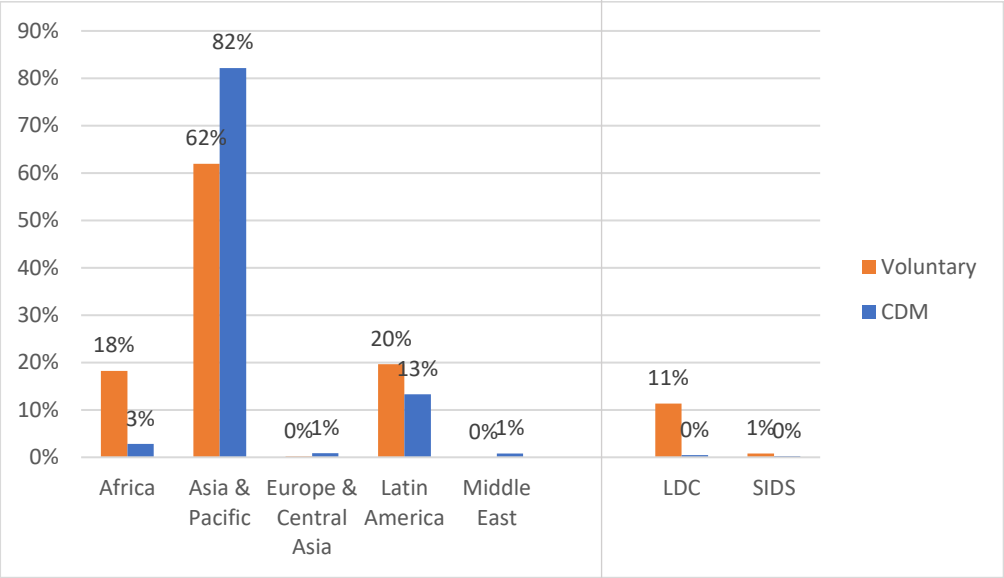
Figure 10-7: A comparison of voluntary and CDM project types by % of estimated annual ERs



10.3.2 Comparison by project geography

Voluntary and CDM project distributions by regions are depicted in Figure 10-8. It shows that majority of CDM and voluntary projects are located in Asia & Pacific. The share of CDM projects in Asia and Pacific (82%) is considerably greater than voluntary projects (62%). On the other hand, the VCM has greater presence in Africa and Latin America than the CDM. Greater shares of voluntary projects are also located in LDCs and SIDS than the CDM, 12% in total as compared to CDM that only has around 1% of its projects in these countries. It is also worth mentioning that in absolute term, the VCM has greater number of projects in LDC and SIDS than the CDM.

Figure 10-8: Regional distributions of voluntary and CDM projects by % of projects



Further breakdown of project locations by country is presented in Table 10-7. It shows that both VCM and CDM have the highest number of projects in China, India and Brazil. These three countries collectively host 63% of issuing voluntary projects and 76% of issuing CDM projects. This shows that both instruments have uneven geographical distributions with both being dominated by projects in large emerging economies, therefore they are not as different as some presumed.

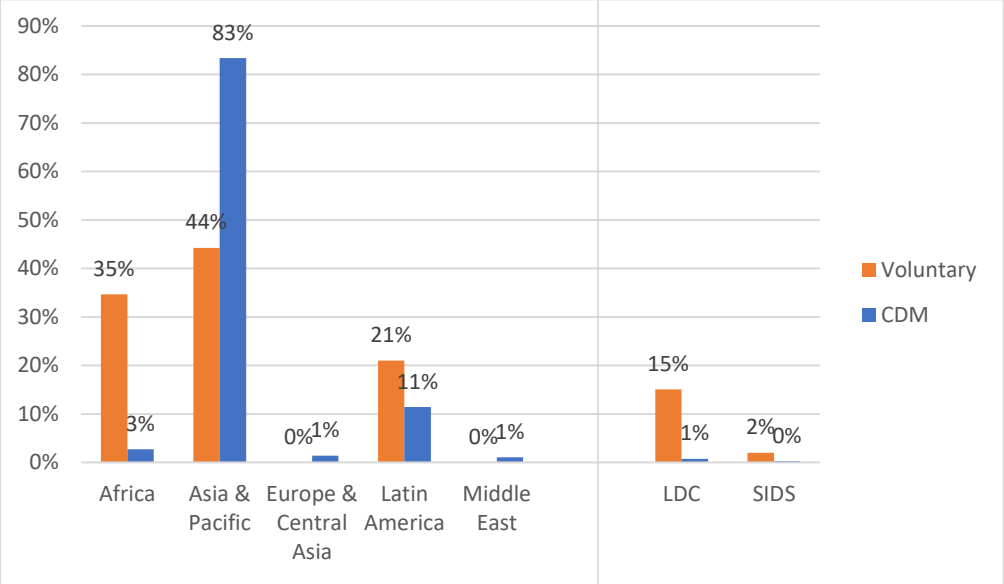
Table 10-7: Top 10 voluntary and CDM project host countries by % of projects

Rank	Voluntary		CDM	
1	India	35%	China	50%
2	China	16%	India	21%
3	Brazil	12%	Brazil	5%
4	Kenya	4%	Mexico	2%
5	Thailand	3%	Vietnam	2%
6	South Africa	3%	Thailand	2%
7	Uganda	3%	Malaysia	2%
8	Peru	2%	South Korea	2%
9	Rwanda	2%	Indonesia	1%
10	Indonesia	2%	Chile	1%

Regional distributions of voluntary and CDM ER generations are depicted in Figure 10-9. It shows that Asia & Pacific remains the main contributor for both portfolios. However, whilst the CDM distribution remains relatively similar to Figure 10-8, for the voluntary portfolio, the relative contribution of Asia & Pacific reduces whilst the relative contribution of Africa increases due to the large-scale REDD projects hosted in the region. 15% of the estimated annual ERs of voluntary

projects are from LDCs and 1% from SIDS, whilst for CDM, only around 1% of its annual ERs are expected from these countries.

Figure 10-9: Regional distributions of voluntary and CDM projects by % of estimated annual ERs



Analysis of estimated annual ERs by country is reported in Table 10-8. The most notable observation is the dominance of China in the CDM market. The country is responsible for 65% of CDM's estimated annual ERs, distantly follows by India (9%) and Brazil (5%). In comparison, ERs from voluntary projects are more evenly distributed, with India contributing most of the annual ERs (17%), follows by Zimbabwe (11%) and Congo DR (10%). Again, as previously mentioned, African countries are among the top contributors of voluntary ERs due to the large-scale REDD projects that take place in these countries. Analysis by ER generation shows that China is the clear winner of the CDM due to its favourable investment climate and strong government policies to promote CDM investments (Wang, 2010; Ellis et al., 2007).

Table 10-8: Top 10 voluntary and CDM project host countries by % of estimated annual ERs

Rank	Voluntary	%	CDM	%
1	India	17%	China	65%
2	Zimbabwe	11%	India	9%
3	Congo DR	10%	Brazil	5%
4	Brazil	9%	South Korea	4%
5	Peru	9%	Mexico	2%
6	Kenya	9%	Indonesia	1%
7	Indonesia	9%	Chile	1%
8	China	8%	Vietnam	1%
9	South Korea	3%	Argentina	1%
10	Madagascar	2%	Uzbekistan	1%

10.4 Conclusions

Based on offset generation data, this study confirms the size of the VCM is considerably smaller than the CDM. Thus, the climate impact of the VCM is rather limited and regulatory actions are required to address the issue of climate change more effectively. Furthermore, the VCM is supporting a number of pre-CDM projects. The long delay in CDM registration cycle has caused offset project developers to register their projects with VCS or GS to start generating offsets and carbon finance from the VCM while waiting for their project to be approved by the CDM. Around half of VCS issuing projects and a third of GS issuing projects are also registered with the CDM, thus cannot be considered as purely financed by the VCM. In the US, the VCM is also financing a number of offset projects that later become eligible for compliance under the Californian CaT (Peters-Stanley et al., 2014). Supporting pre-CDM or pre-compliance projects further undermines the climate impact of the VCM and its ability to promote additional climate finance beyond compliance regimes.

Analysis of voluntary project types, after excluding CDM registered projects, shows that the VCM is promoting offset projects that are commonly associated with sustainability co-benefits, such as renewable energy and household energy projects. The VCM is also supporting projects that are not eligible under the CDM, mainly LULUCF projects. In terms of ERs, the VCM is dominated by LULUCF projects. SD contributions of LULUCF projects remain controversial and case studies to-date have found mixed outcomes (as discussed in Section 3.3.1). 40% of the LULUCF projects, which are responsible for 75% of ERs from LULUCF, are certified by CCBS, which supposed to provide some assurance to the sustainability quality of these projects. However, according to Melo, Turnhout & Arts (2014), due to the nature of offset markets that involves commodification and trading of carbon, even CCBS certified projects are likely to prioritise delivery of ERs over generating benefits to local communities. Furthermore, preliminary review of the two largest LULUCF projects, both of which are REDD projects in Africa reveals one of them is facing challenges regarding its additionality. The additionality of REDD projects has always been a concern of carbon markets. The complex local social-economic context and environmental factors often make additionality of REDD projects ambiguous. As the result, there is a risk that the VCM is financing large-volume of non-additional offsets from REDD projects, which can compromise the integrity of the carbon market.

Analysis of voluntary projects by project locations show most voluntary projects are located in Asia & Pacific, mainly China and India. The VCM is also supporting projects in countries that are not active in the international compliance regime, in particularly Turkey and the US. The geographical distribution of ER generation shows a different and more equitable picture. In particularly, it shows African countries also benefit greatly from the VCM. However, this is attributed to a few large-scale

REDD projects. Thus, any potential SD contributions of the VCM in the region are likely to be limited to these few project areas.

The voluntary project portfolio is also being compared to the CDM portfolio. To enable like-to-like comparison, voluntary projects that are hosted in Annex I countries are excluded. Results show both instruments support renewable projects, in particularly wind, hydro and biomass projects. In relative terms, the voluntary portfolio has considerably greater shares of household energy and LULUCF projects than the CDM. However, in absolute term, the CDM is supporting greater number of household energy projects. Both renewable and household energy projects are well-known in the carbon markets for their positive contributions to SD. Therefore, both markets appear to be promoting projects that deliver SD co-benefits. However, analysis from volume of ERs perspective tells a different story as both markets are at risk of being dominated by a few large-scale mitigation projects that have limited co-benefits. In particularly, industrial gas destruction projects that only constitute 3% of CDM projects contribute 27% of its estimated annual ERs, thus confirming previous criticisms that the market is supporting cheap large-scale industrial gas projects. The voluntary portfolio, on the other hand is dominated by LULUCF projects that are expected to generate 52% of its annual ERs. This finding supports Jung (2005)'s argument that LULUCF projects could flood carbon markets with large volume of offsets and crowding out investments into the more expensive mitigation options.

In terms of project location, both the VCM and CDM have the highest number of projects in China, India and Brazil. These are large emerging economies that are already attracting considerable FDI. China alone hosts around half of CDM issuing projects, whilst around a third of voluntary projects are located in India. In comparison, the VCM has greater presence in Africa than the CDM. It also has a greater number of issuing projects in LDCs and SIDS than the CDM. When analysing geographical distribution by volume of ERs, the share of African region in the voluntary portfolio is even more prominent, 35% as opposed to only 3% in the CDM portfolio. However, this is attributed to the few large-scale voluntary REDD projects hosted in the region.

To conclude, results from this study show the main difference between the VCM and CDM lies in LULUCF projects that the VCM actively supports. As SD contributions of LULUCF projects are questionable, it remains inconclusive if the VCM outperforms CDM in promoting SD.

11 Synthesis

This thesis set out to explore *"Does voluntary carbon offsetting contribute to sustainable development?"* Grey literature often claim that the VCM has greater potential than its compliance counterpart to promote SD due to its unregulated nature and the unique motivations of voluntary buyers (Peters-Stanley et al., 2013; Harris, 2007; Taiyad, 2005). Using CVM and CE, I demonstrated that significant WTP exist for offset co-benefits among organisations that are offset users. Furthermore, their WTP measures are stable over time. Significant demand for offset co-benefits also exists among organisations that are offset non-users. Thus, offset co-benefits can potentially promote their future participation in voluntary offsetting. To assess SD contributions of the VCM on the supply-side, a novel database of voluntary offset projects is developed to analyse mitigation options that the VCM finances. The database reveals that the VCM is at risk of being dominated by a handful of large-scale LULUCF projects. Whilst LULUCF projects are commonly presumed to have pro-poor and conservation qualities, existing case studies have found mixed results. Thus, despite substantial demand exist among organisations for offset projects that promote SD, it remains unclear whether the VCM delivers the SD outcomes that many have presumed. Based on findings from this study, a set of recommendations are made (research sub-questions 4.1 and 4.2).

11.1 Key findings

This section revisits the research sub-questions posed at the beginning of this thesis (Table 1-1) and summarises key findings under each research sub-question.

What are voluntary offsets and how are they created?

Each voluntary offset represents one tCO_2e ER generated from projects that reduce or sequester GHGs. Its creation is based on baseline-and-credit system whereby each offset represents an additional tCO_2e reduction as compared to the baseline scenario (Bumpus, 2011; Bumpus & Liverman, 2008). As ERs in the atmosphere are abstract, offsets are a complex and novel commodity which requires a series of administrative procedures to define its existence. These procedures broadly involve establishment of hypothetical baseline scenario, justification of project additionality, determination of ER amount and allocation of rights to the ERs. The non-tangible nature of offsets also means governance plays an important role in offset markets to ensure market's credibility in mitigating climate change. Consuming offsets that are non-additional or double-counting will result in a net increase of GHG emissions in the atmosphere, thus compromise the integrity of carbon markets. As described in Section 3.4, the highly regulated CDM has a hierarchical governance structure and is administered by the CDM EB at the international level to ensure the generated compliance offsets called the CERs represent real and additional ERs. The VCM, on the other hand, is

more informal and mainly governed by market actors. As the result, it faces scepticisms regarding its ability to abate GHG emissions. In order to grow the market, the VCM addresses some of the negative criticisms through self-regulation, using third-party standards and independent registries to provide confidence to voluntary buyers (see Section 2.2.1).

How do offset projects contribute to local SD?

Offset projects that are financed through carbon markets can deliver a range of benefits to their host countries and local communities. For examples, in addition to abating GHG emissions, renewable energy projects also promote energy security and clean technology transfer, whilst household energy projects also alleviate fuel poverty and conserve local forests. These positive externalities of offset projects are collectively known as the co-benefits of carbon markets, which are defined as the '*social and environmental benefits that go beyond the GHG reduction benefits of offset projects*' (Kollmuss, Zink & Polycarp, 2008, p.92). Through the generation of co-benefits, offset projects not only contribute to climate mitigation at the global level but also help promote SD at the local level. Different offset projects generate different co-benefits (as well as co-costs) to local communities and studies have found project type is a determinant of SD contributions. The co-benefits of various offset project types are discussed in 3.3.1.

What are the factors that lead to CDM's failure to promote SD?

CDM's failure to deliver its SD objective is attributed to various factors at project- and market-level. At the project level, trade-offs exist between SD contributions and cost-efficient mitigation, project additionality, and ER measurability as discussed in Section 3.3 and summarised in Table 3-2. These inherent trade-offs, combined with CDM's strict rules for approving projects and obsession with carbon accounting accuracy have resulted in the compliance market unintentionally incentivises certain project types, namely industrial gas destruction projects that generate large-scale cheap ERs but have very limited SD contributions. Furthermore, although the CDM is set up with twin objectives of promoting SD and enabling cost efficient GHG mitigation, only the carbon element is enforced and monetised at the Kyoto level, whilst determination of project's contribution to SD is predominantly the prerogative of the host country, which has led to a race to the bottom as developing countries compete for CDM investments. As the result, the CDM has been heavily criticised for its failure to promote SD.

Why the VCM is better positioned than the CDM in promoting SD?

The unregulated nature of the VCM means it can sidestep the lengthy bureacratic processs and high transaction cost, which provides it the capacity to support small-scale community-based projects

that deliver a range of co-benefits. Furthermore, narratives about offset projects and the benefits they bring to local communities play an important role in giving meaning and materiality to the novel and non-tangible environmental product, thus help engage potential buyers and encourage uptake (Lovell, Bulkeley & Liverman, 2009). Unlike compliance buyers that are mainly regulatory and economic drive, the unique motivations of volutary buyers also result in demand for offset co-benefits. As many organisations participate in voluntary offsetting as a way to demonstrate CSR, they often actively seek offset projects that deliver co-benefits to help communicate their abatement effort to their stakeholders and avoid being accused of greenwash. Therefore, in contrast to the CDM that places strong emphasis on producing credible and fully fungible carbon credits, the VCM focuses more on the story behind offset production and voluntary offsets are differentiated based on their SD quality.

Why do organisations participate in voluntary offsetting?

According to ESMP annual survey reports, CSR is the prevalent motivation among organisations that purchase voluntary offsets. In this study, rather than consider CSR as a motivation for voluntary offsetting, I approach voluntary offsetting as inherently a CSR activity that is undertaken for various reasons (as discussed in Section 4.3). Through a survey of organisations that are offset users (Survey 1), this study found most organisations voluntarily offset for strategic CSR motivations, including to enhance reputation and brand image, market differentiation and employee engagement. Majority of them also claimed they have observed tangible benefits from their investment in voluntary offsetting schemes but attempts to measure and quantify these benefits remain limited.

In the more recent survey (Survey 2), altruistic motives such as a sense of responsibility towards climate impact and care about the environmental are emerging as the main drivers of organisations' engagement in voluntary offsetting. Only around half of offset users in Survey 2 have observed tangible benefits from their participation in voluntary offsetting and only one is monitoring the return on their investment in voluntary offsetting. The lack of tangible benefits indicates that these organisations voluntarily offset their emissions for altruistic reasons. In addition, parametric analysis of the likelihood of organisations purchasing offset shows that offset users have less expectation of others' contribution, which reiterates their altruistic motivations.

The parametric analysis also shows that organisations' demographic characteristics are strong determinants of the likelihood of organisations' participation in voluntary offsetting. In particularly, the results show public institutions, organisations in Annex I countries (especially European countries) and certain sectors such as electricity/energy and financial/insurance sectors are more likely to participate in voluntary offsetting. This could be attributed to the institution conditions that

these organisations operate in, especially the level of public awareness and demand for climate mitigation.

Overall, this study found majority of offset users have claimed strategic CSR related motives as their drivers for engaging in voluntary offsetting, however demonstration or expectation of the return on their investment is generally low. The lack of tangible benefits and institutional commitment for immediate climate mitigation actions (Paris Agreement is found to have limited impact on organisations' participation in voluntary offsetting) may explain recent market stagnation. Although altruistic motives are emerging as important drivers for voluntary offsetting among organisations, relying on charitable contributions is unlikely to grow the market.

What are organisations' demand and WTP for offset and offset co-benefits?

Organisations' demand for offset co-benefits are explored in various parts of this thesis but mainly through CEs that are presented in Chapter 6, 8 and 9. Marginal WTP measures for offset and offset co-benefits as elicited from the CEs are summarised in Table 11-1.

Table 11-1: A summary of marginal WTP measures as elicited from CEs

	Mean WTP in US$ per offset		
	Survey 1 **Offset users**	**Survey 2** **Offset users**	**Survey 2** **Offset non-users**
Offset (ASC)	9.15 (5.19-13.11)	19.67 (9.91-29.43)	9.78 (-0.13-19.68)
Social co-benefit	8.01 (3.38-12.63)	6.39 (2.38-10.40)	11.31 (5.37-17.26)
Economic co-benefit	4.96 (1.28-8.63)	6.02 (0.84-11.19)	10.76 (5.85-15.67)
Environmental co-benefit	-	4.88 (1.01-8.75)	9.06 (3.85-14.26)
Co-benefit verification	11.90 (8.13-15.66)	9.82 (5.13-14.52)	15.30 (7.51-23.09)

() 95% confidence interval. WTP measures reported here are based on estimations from RPL in WTP space.

Results show organisations generally are willing to pay significantly more for offset co-benefits and co-benefit verification. The most preferred co-benefit attribute among organisations is co-benefit verification, follows by social co-benefit, economic co-benefit and environmental co-benefit (although respondents in Survey 1 do not display significant WTP for environmental co-benefit). However, results from RPL model also show significant unobserved preference heterogeneity among respondents. Sources of preference heterogeneity include organisation type, location and operating sector. However, no variable is consistently found across Survey 1 and 2 to be a significant factor that influences organisations' preference for certain co-benefit type. As expected, organisations that view co-benefit verification as important prefer offset with co-benefit verification.

Demand for offset co-benefits are also examined using CVM (see Section 7.5) and the results are summarised in Table 11-2. MWU test shows that presence of offset co-benefits can increase organisations' WTP for voluntary offset significantly. Parametric analysis shows organisations' WTP amounts for offset and offset with co-benefits are positively influenced by their internalised norm to abate GHG emissions. Organisations that view offset co-benefits as important are also willing to pay more for offset with co-benefits.

Table 11-2: A summary of CVM results

	Mean WTP in US$ per offset
Offset	US$3.38 (2.31-4.97)
Offset that also creates employment, improves public health and reduces water pollution	US$8.98 (7.49-10.76)

() 95% confidence interval

Are their demand and WTP for offset co-benefits stable over time?

Temporal stability of preferences and WTP measures among offset users for offset co-benefits and co-benefit verification are formally tested in Chapter 9. Results show their underlying preference structure and WTP measures for offset co-benefits and co-benefit verification are stable over the two-and-a-half-year time lag between the two surveys. The only significant difference is offset users' WTP for environmental co-benefit which has increased over time. However, it is beyond the scope of this study to investigate the underlying causes of the increase in WTP for environmental co-benefit among offset users.

Which project types and locations does the VCM promote?

The voluntary project database developed for this study shows that majority of voluntary projects (after excluding projects that are also registered with the CDM) are renewable energy and household energy projects which are commonly associated with SD contributions. However, analysis of voluntary projects in terms of ER generation shows a different picture, mainly the share of LULUCF projects increases considerably due to the few large-scale REDD projects developed under the VCS. Although LULUCF projects are often presumed to deliver co-benefits such as poverty alleviation and biodiversity conservation, existing case studies have found mixed outcomes. Therefore, SD contributions of LULUCF projects are yet to be substantiated and are expected to be highly context specific.

In terms of project location, majority of voluntary projects are located in emerging economies, mainly India and China. The VCM is also supporting offset projects in countries that are not active in

Kyoto markets, such as Turkey and the US. When analysing geographical distribution from volume of ERs perspective, the share of African countries increases considerably which is attributed to the large-scale REDD projects hosted in the region. The three largest voluntary REDD projects in the region, one in Zimbabwe and two in Congo DR, are expected to contribute 60% of the ERs generated from the region. Thus, any potential SD impacts of the VCM are likely to be limited to these project areas, rather than the wider population in the continent.

More importantly, this study finds a considerable number of offset projects that the VCM support are pre-CDM projects. Around half of VCS issuing projects and a third of GS issuing projects are also eligible to claim compliance offsets under the CDM. Thus, these offset projects cannot be considered as purely voluntary. Supporting pre-CDM projects has an implication on the ability of the VCM in mobilising further carbon finance beyond compliance regimes.

Do the VCM and CDM support different project types and locations?

A comparison of the voluntary[74] and CDM project portfolios shows both markets finance a wide range of offset project types and both markets promote renewable energy projects, mainly wind, hydro and biomass. Besides renewable energy projects, the VCM also supports household energy and LULUCF projects. In terms of volume of ER generation, a few large-scale offset projects provide substantial portions of ERs in both markets, with LULUCF and industrial gas projects dominating the VCM and CDM respectively.

With regards to offset project location, both markets have uneven distributions with majority of offset projects being hosted in Asia & Pacific. Further analysis shows both VCM and CDM have most projects located in China, India and Brazil, the three largest emerging economies that are already attracting considerable FDI. However, in terms of ER generation, the VCM has more even distribution across the regions than the CDM that is highly skewed towards Asia & Pacific, especially China. African countries are among the top contributors of ERs generated in the VCM which is attributed to its potential for LULUCF projects. The VCM also has greater shares of ERs generated from LDC and SIDS than the CDM.

Does the VCM perform better than the CDM in promoting SD?

The VCM appears to be more promising than the CDM in promoting SD as it has greater shares of household energy and LULUCF projects. However, in absolute term, the CDM is still financing slightly

[74] As a reminder, the voluntary portfolio here excludes voluntary projects that are hosted in Annex I countries to enable like-to-like comparison with the CDM. Offset projects that are registered under both voluntary standards and CDM are not considered as purely voluntary and therefore are also excluded.

greater number of household energy projects that the VCM. The VCM also appears to benefit Africa more than the CDM, however this is attributed to the few large-scale LULUCF projects in the region. Therefore, the main difference between the VCM and CDM is the former's support for LULUCF projects. As SD contributions of LULUCF projects remain debatable, whether the VCM is performing better than the CDM in promoting SD remains inconclusive.

11.2 Methodological insights

In addition to the main objective of investigating the contribution of voluntary offsetting in promoting SD, some methodological issues related to SP techniques are also being explored in this thesis. Methodological insights generated from this study include:

Application of SP techniques on organisations

This study is one of the very few studies that use SP methods to elicit organisations' demand for environmental good. One potential issue of applying SP techniques on organisations is they may capture the preference and demand of individuals who completed the survey, which may not be representative of their organisations. This issue is highlighted in Chapter 7 whereby the logistic regression shows the likelihood of being an offset user (which is based on factual data) is mainly influenced by organisations' demographic characteristics, such as their location and operating sector, while positive WTP for offset as elicited from the CVM (which is hypothetical) is mostly driven by attitudinal variables, mainly respondents' self-ascribed responsibility to abate GHG emissions. One potential way of mitigating this issue is by targeting the right person within the organisation for the survey, preferably someone in a senior position that has strong influence on the organisation's decision-making process. Despite the potential issue, this study found SP methods provide valuable insights to organisations' demand for public and environmental goods. Thus, the advantages and limitations of applying SP methods on organisations need to be further explored in future studies.

Model selection for analysing CE data

This study uses both RPL model with interaction and LCL model to investigate the underlying sources of preference heterogeneity. Comparisons of the models using measures of fit show inconclusive result as to which model is a better fit for the dataset. In terms of practicality, I agree with Boxall & Adamowicz (2002) and Sagebiel (2017) that it is difficult to derive meaningful outcomes from RPL model with interactions that can be used to inform the market, especially when large number of interaction terms are included in the model. In addition, when interaction terms are added to the RPL model, they alter the mean parameters of the attributes considerably, which complicate result interpretation and estimation of marginal WTP measures (Sagebiel, 2017). In comparison, LCL results

which are in the form of market segmentation are easier to interpret and transform into marketing recommendations. However, this study illustrates the limitation of LCL model in analysing small dataset. In both surveys, BIC statistics indicate preference for single-class LCL model, which is also the CL model, despite RPL model clearly shows presence of unobserved preference heterogeneity among respondents. Disregarding the BIC statistic and choosing a number of classes that is sub-optimal for the dataset could lead to very different conclusions as see in Survey 1 (Section 6.3.3). Based on findings in this study, I agree with Sagebiel (2017) that there is no straightforward way of deciding which model is best for a dataset and researchers are advised to spend times on testing out different models to ensure the most appropriate model is used to analyse their dataset.

A comparison of CVM and CE

It is worth mentioning first that this study is not specifically designed to compare CVM and CE method. Nevertheless, a comparison of CVM and CE results in this study can provide some methodological insights. In this study, CE method consistently yields greater WTP measures than CVM. This finding is in-line with previous studies that compare CE and CVM, such as Foster & Mourato (2003), Scarpa & Willis (2006) and Christie & Azevedo (2009). The discrepancy between CE and CVM estimated WTP measures could be attributed to sub-additivity effects as discussed in Section 6.4.3. Through this study, I find CE is useful in informing the market on the offset attributes that organisations most prefer, but I also concur with Foster & Mourato (2003) that aggregating WTP measures for all the attributes tested in the CE can result in an extremely over-estimated value for the bundle of goods. Therefore, I agree with those who have reservation over the use of CE to estimate the total economic value of a bundle of goods based on the assumption that the marginal WTP for the bundle is equal to the sum of marginal WTP for each of its attribute. For this study, the CVM yields a more realistic WTP measure that is closer to the price level respondents pay per offset in real life.

Temporal stability of CE results

SP studies only provide information about preferences at a particular point of time, which may change over time. Thus, temporal stability or test-retest reliability of SP results is an important criterion in environmental valuation as there is often a time lag between the SP survey and implementing the marketing or policy recommendations. In this study, temporal stability of offset users' preferences and WTP measures for offset co-benefits is assessed. Results show their preferences and WTP measures are robust over time, except for their WTP for environmental co-benefit which has increased over the period between surveys. Overall, the results are promising in

terms of demonstrating temporal stability of CE results, despite the differences between Survey 1 and 2, such as the survey populations, survey mode and questionnaire design.

11.3 Recommendations

Over the years, as climate awareness rises, a number of companies have committed to manage and reduce their GHG emissions on a voluntary basis. However, the number of companies that purchase voluntary offsets as part of their carbon management strategy remains small. Of the 1849 companies that disclosed their carbon emissions to CDP in 2015, only 11% of them purchase voluntary offsets to abate their emissions (Goldstein, Peters-Stanley & Gonzalez, 2016). The growth of VCM has stalled in the recent years with limited new entrants. As the market is heavily oversupplied, new investments into climate mitigation and adaptation measures are limited. Although the climate impact of the VCM is relatively small as compared to compliance markets, it nevertheless represents a valuable source of private finance into efforts to curb climate change. Furthermore, the market is also a source of private finance for projects that can deliver SDGs, in particularly renewable energy, household energy and LULUCF projects. The relevance of the market to anyone or any organisation as long as they have a carbon footprint means it has substantial potential to grow. Based on findings from this study, the following recommendations are made.

Demonstration of the benefits of voluntary offsetting

This study finds monitoring of benefits incurred to organisations from voluntary offsetting remains in nascent stage. As the result, any potential benefits of voluntary offsetting are not well documented. If tangible benefits of voluntary offsetting such as identification of energy saving opportunities, contracting advantages, increased market share or premium price for green products or services can be demonstrated to organisations, they are more likely to participate. A number of organisations that participated in Survey 2 have indicated their concern regarding the risks that climate change poses to their operation. Offset providers could work with organisations to identify opportunities for insetting, which uses offset co-benefits to mitigate some of these climate related risks and strengthen their supply-chain (see Section 4.3.2 for examples of insetting).

Greater awareness of the role of offsetting in mitigating climate change and promoting SD

This study found offset users have greater belief in the effectiveness of offsetting schemes in abating GHG emissions than non-users, although the difference is not statistically significant. Nevertheless, offset non-users have also suggested that greater recognition of the contribution of offsetting in mitigating climate change is the key factor that can promote their future participation. Therefore, work needs to be done to mitigate some of the controversies still surrounding the market and gain

recognition on the potential of offsetting in achieving rapid and drastic ERs, as well as delivering SDGs. On the market level, this may require education and raising awareness, as well as endorsements from independent and credible bodies such as governmental agency and NGOs to help build confidence among buyers. On the project level, radical changes to the way project additionality is assessed are required. Scepticisms towards the current approach of assessing project additionality remain as it is considered as arbitrary. One possible way of overcoming this issue is linking the project's contribution to host country's climate objective or nationally determined contribution (NDC) which provides more transparent or tangible way of demonstrating additionality. However, how the linkage can be established requires further research and steps to avoid double-counting of ERs are critical.

Invest in offset co-benefits and co-benefit verification

Being a demand-driven market, the VCM is attuned to buyers' preferences. In the past, buyers' demand for credible offsets has driven the market to self-regulate through third-party standards and independent registries. This study demonstrates significant demand for offset co-benefits among offset users. Furthermore, their demand is stable over time. Significant demand for offset co-benefits also exists among offset non-users, thus offset co-benefits can help promote their future participation. Overall, results from this study shows it is worthwhile for the market to invest in offset projects that contribute positively to local communities and environment. In addition, the VCM should also invest in getting the co-benefits verified as this study finds co-benefit verification is the most valued attribute among organisations. This should not come as a surprise as voluntary offsets are non-tangible and the VCM is plagued with information asymmetry, therefore co-benefit verification is an effective way to differentiate SD quality of offsets and provide assurance to potential buyers that the claimed co-benefits are real. However, some offset co-benefits such as local capacity building, women empowerment, or conservation of ecosystem services are inherently difficult to monitor and verify, thus some innovations are required to create monitoring methodologies that are credible but without significantly increasing the transaction cost so more carbon finance can go to benefitting local communities rather than the administrative work to demonstrate the co-benefits.

Government interventions are required for more drastic reductions

This study shows that the VCM is considerably smaller in size than the CDM, therefore its climate impact is also very limited in comparison. This is not surprising due the voluntary nature of the market that is subjected to free-riding. Furthermore, free-riding issue is expected to be dominant in this context due to the scale of climate change. Individuals and organisations may feel their impacts

are trivial in comparison and therefore do not feel the need to contribute through voluntary offsetting (Kotchen, 2009a). As the result, relying on voluntary actions to address climate change is unlikely to yield substantial impact and government's interventions are required. The effects of government's strong commitment to tackle climate change are double-fold. In addition to the GHG emissions that are directly regulated and reduced, it also sends a clear signal to organisations that are beyond regulation to start managing and reducing their GHG emissions, whether to prepare for or to avoid future regulation. It also helps address the issue of free-riding and promotes collective participation effect. Offset non-users have indicated that greater efforts on the global level to curb climate change and engagement within their sector in voluntary offsetting can promote their future participation.

Future offsetting scheme under the Paris Agreement will require radical reform

In the NDCs submitted by Parties that ratified to the Paris Agreement, the use of carbon pricing covers almost 60% of global GHG emissions (Zechter et al., 2017). In addition, 112 developing countries have indicated they need financial and/or technical assistance to meet their pledges (ibid). Therefore, although the use of offsetting mechanism remains to be controversial, it is likely to play a role in the future international climate policies as a way to transfer finance and technology to countries that require support. Article 6 of the Paris Agreement outlines the operational framework for international cooperation to achieve emission targets and it has made provision for a mechanism similar to the CDM (UN, 2015). Lessons learned from CDM suggest that a number of factors need to be considered in the design of future schemes that succeed CDM for success in the long-term. Based on findings in this study, the following recommendations are made:

- For the new mechanism to catalyse a permanent transition to a low-carbon pathway, SD needs to be a central and integral part of the mechanism. Although it is pragmatic to assume development priorities differ between countries, it is important for the UNFCCC to provide guidance on what SD contributions entail to avoid a race to the bottom among project host countries as observed in the CDM. One potential approach is to utilise the SDG framework as seen in the latest version of GS standard (GS4GG) which requires projects to demonstrate their contributions to at least two SDGs in addition to SDG13 – Climate impact. After the rules for SD contribution are set at the UNFCCC level, country specific needs can be accounted for by letting project host countries prioritise the SDGs that are the most relevant to them.
- Project's SD contributions also need to be enforced at the UNFCCC level as relying on project developers' goodwill to deliver SD co-benefits is unlikely to yield the desirable outcome. For

example, the voluntary Sustainable Development co-Benefits Tool launched by the UNFCCC, which encourages CDM projects to showcase their SD co-benefits has had a very disappointing uptake with just over 50 CDM projects using the tool to-date (UNFCCC, n.d.g). Thus, formal requirement for demonstration of project's SD contributions need to be in place. However, there needs to be a balance between the level of details required for demonstrating and monitoring SD contributions and keeping the transaction cost low, especially considering some SDGs such as promoting local wellbeing and gender equality are challenging to monitor. Introducing complex measuring and monitoring procedures may hinder projects from promoting these SDGs.

- The CDM has been criticised on its arbitrary and subjective approach to assess project's additionality, which has sometimes resulted in non-additional projects being approved. Thus, a more standardised and transparent way of assessing a project's additionality is required. This may require drastic changes to the way projects' additionality is assessed. For example, one possible way of demonstrating additionality is by linking a project's contribution in reducing GHGs to the host country's NDC. In this approach, the project needs to demonstrate its resultant ERs are beyond the level stipulated in the NDC and are therefore additional. However, care should be taken to ensure the project's ERs are not being counted towards meeting the NDC. This is particularly important as under the Paris Agreement, both the project host country and financing country have emission caps, thus ownership of ERs needs to be clear and transparent to avoid double-counting.
- In the past, CDM's obsession with the accuracy of ER measurement has unintentionally disincentivised certain offset projects that are inherently difficult to monitor but have positive impacts on local communities, such as household energy projects and LULUCF projects. Although stringent carbon accounting is important to ensure accurate ER delivery, a more innovative approach is required to ensure small-scale community-based projects that often lack the technical capability and financial resource to monitor their performance do not miss out on future carbon finance. One way to overcome this issue is to follow GS approach that allows micro-scale projects to be exempt from third-party validation and verification but pay a flat fee towards a fund that is used for the validation and verification of randomly selected micro-scale projects.

11.4 Limitations

Limitations of this study are as follows:

Non-random sampling

The non-random, convenient sampling approach employed in this study means generalisation of survey results need to be treated with care. In addition, self-selection bias is expected to be present in both surveys with organisations that have keen interest or strong opinions about the VCM are more likely to participate. I also acknowledge that the target populations in this study, which are contacts of ICROA members and members of UN's Caring for Climate Initiative, are small. These organisations are also found to have high level of awareness and sense of responsibility towards their climate impact, which may not apply to majority of organisations across the world. As the result, generalisation of the attitudes and WTP measures of these organisations to the larger population need to be treated with care.

Hypothetical bias

Hypothetical bias is a common limitation of SP methods and it is also expected in this study. Two forms of hypothetical bias exist in this study. First, this study finds majority of offset non-users have indicated a positive WTP for offset. Many of them have quoted offsetting is not in their priority as the reason for not purchasing voluntary offsets in real life. This finding is not surprising due to the voluntary nature of the market, therefore free-riding issue is likely to be prevalent. Nevertheless, exploring their demand for voluntary offsets provide some valuable insights on how to encourage their uptakes in the future. Second, this study finds offset users have indicated a WTP amount that is greater than the price level they pay in real life. The discrepancy could be attributed to hypothetical bias, but could also be attributed to the market condition. The VCM is currently heavily oversupplied, thus buyers are able to negotiate a competitive price. If offset users are able to source offsets at a price level that is lower than their stated WTP, there is no reason for them to pay their maximum WTP. Thus, their WTP measures elicited in this study can be considered as the maximum price level that voluntary offset with demonstrated sustainability co-benefits can achieve.

Representativeness of individuals' views on behalf of their organisations

Another limitation of this study, which also applies to all surveys is the reliance on respondents' stated motivations and behaviours (Wiser, Fowlie & Holt, 2001). There is a risk that their responses may not reflect their true feeling about the issue or good in question. In this study, the unit of survey respondent is organisation. However, the survey was undertaken by individuals within the responding organisations. Although respondents were specifically asked to answer the questionnaire

from the perspective of their organisation, some of their personal views or preferences could be captured in their responses. This issue is highlighted in Chapter 7 and also discussed in Section 11.2 under application of SP techniques on organisations. Nevertheless, a comparison of offset users' WTP for an offset with the actual price they paid show they are not significantly different, which provides some confidence to the CVM results.

Generalisation of offset co-benefits

This study generalises co-benefits that are associated with certain project types. Informed by existing studies, I assume that industrial gas projects that the CDM support have very limited co-benefits whilst renewable and household energy projects generally deliver greater SD co-benefits. However, some variations in project's co-benefits are expected within the same project type due to project specific design or condition. For example, some industrial gas projects may utilise their carbon revenues for CSR related activities such as building local schools, health centres or transport infrastructure, thus increasing the project's indirect co-benefits. Therefore, despite project type is a strong determinant of the expected co-benefit delivery, this study recognises generalisation of co-benefits by project types may not always hold true. Furthermore, there are variations in how offset project's SD contributions are assessed. Most existing studies assess CDM projects' SD contributions using desk-based MCA, whilst assessment of LULUCF projects are often done through case studies with a focus on local stakeholder participation and equitable benefit distribution. The latter represents a more critical approach of assessing project's SD contributions and if applied to CDM projects may generate very different results.

11.5 Areas for further research

Through this study, some interesting issues have been identified which require further research. They are as follows:

Voluntary offsetting to achieve deeper emission cut

As Kotchen (2009a) concludes whether offsetting contributes positively or negatively to climate depends on how it is used. Thus, there is a need to understand whether organisations use voluntary offsetting to achieve more ambitious ER or simply to delay undertaking more challenging changes to reduce emissions. One way to investigate this through empirical research is by comparing the ER commitments and other environmental performances of offset users and non-users to assess if they are significantly different. If offset users are found to perform better than non-users, this shows the use of voluntary offsetting is to further their ER commitment rather than merely for green marketing (greenwash).

Benefits of voluntary offsetting

The future of the VCM will depend, to a large extent, on consumer demand. At the moment, organisations appear to gain very limited private benefits from voluntary offsetting. Moving forward, empirical research is required to explore tangible benefits that voluntary offsetting deliver to organisations as purely relying on altruistic contributions is unlikely to grow the market substantially.

The role of the VCM in post-Paris climate regime

The historic Paris Agreement requires all, both developed and developing countries, to contribute to climate mitigation. Nearly all the countries in the world have made pledges to reduce their emissions through their submitted NDCs. The gain in international momentum to address climate change is likely to encourage organisations to act on their emissions voluntarily. However, the question remains what is the role of the VCM in future international climate regime which almost all countries have national emission target. To explore this issue further, research into the potential risks and opportunities the Paris Agreement poses to the VCM is required.

Uniform method for assessing SD

This study found there is a lack of uniform approach to assess SD contributions of offset projects. Most existing studies on the SD impacts of CDM projects use desk-based MCA. However, different studies have considered different criteria, therefore the results are not fully comparable. MCA also represents weak sustainability approach of assessing SD contributions (Alexeew et al., 2010) and studies have argued that renewable projects that generally score well in MCA do not alleviate energy poverty (Schneider, 2007; Sirohi, 2007). SD impact studies of LULUCF projects on the other hand are more critical as they tend to focus on the benefits offset projects deliver to the poorest and most vulnerable groups (Olsen, 2007). To enable comparable SD contributions of offset projects so the market can be informed on which projects to invest in to maximise the returns, a more standardised way of assessing SD contributions is required.

Alturistic motives for engaging corporate environmentalism

This study finds in addition to strategic CSR motives, altruistic factors are also emerging as important drivers for organisations to engage in voluntary environmental initiatives. This is intuitively plausible and is in-line with philanthropic CSR. Organisations are after all managed by individuals who have personal values and may choose to sacrifice profits to provide public good. Wiser, Fowlie & Holt (2001) found altruism is the main motivator that drives businesses in the US to purchase green power. According to them, existing literature put too much emphasis on private benefits and economic gains as motivations for organisations to improve their environmental performance, whilst

altruistic related motives have received very little attention. Based on findings in this study, I agree with their argument and recommend that the role of altruism in promoting corporate environmentalism should be explored further to inform future environmental policy.

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Appendixes

Appendix 6-1: Survey 1 questionnaire

Section 1: Introduction

Thank you for taking time to participate in this survey.

This survey aims to help us understand buyers' motivations for voluntary carbon offsetting, buyers' preferences for carbon offsetting and the benefits accrued to businesses that offset. This survey is part of a study investigating the wider socio-economic and environmental benefits delivered by the voluntary carbon market.

The survey will take around 15-25 minutes to complete for offset buyers and 10 minutes for non-offset buyers.

Please answer the questionnaire from the perspective of your organisation.
All data are confidential and will not be shared with third parties. The option for anonymity is also provided.

Reports will refer to average or aggregate values and overall findings, therefore will not be traced to specific organisation. If we need to state your organisation or quote your specific response in the report, we will get in touch to obtain your consensus before proceeding.

Thank you again for your time, your participation is valuable to us.

Section 2: Organisation information

Q2. What is the name of your organisation?

☐ Organisation name:……

☐ Prefer not to disclose

Q3. Please indicate your position in the organisation.

☐ Position:……

☐ Prefer not to disclose

Q4. Which of the following best describes the type of your organisation?

☐ International corporation

☐ Domestic corporation

☐ Small to medium sized enterprise (SME) (<250 employees and <US$680 (or €500) million turnover)

☐ Governmental agency / public sector

☐ Multilateral development institution (organisations that provide finance and supports to development projects)

☐ Non-profit organisation / NGO

☐ Other:.....

Q5. What sector does your organisation operate in?

☐ Agriculture and forestry

☐ Mining and quarrying

☐ Manufacturing

☐ Electricity / energy

☐ Paper and printing

☐ Construction

☐ Food and drink

☐ Textile and leather

☐ Wholesale and retail

☐ Transportation and tourism

☐ Financial and insurance

☐ Education

☐ Information and communication

☐ Carbon offset retailers

☐ Professional and administrative services

☐ Arts, entertainment and recreation

☐ Other:……

Q6. In which country is your organisation incorporated or where its head office is located?

Country dropdown list

Q7. Which region is your organisation active in?

(Please tick all that apply)

☐ Africa ☐ Latin America

☐ Asia ☐ Middle East

☐ Europe ☐ Eastern Europe & Central Asia

☐ North America ☐ Oceania

Q8. Does your organisation purchase carbon offsets?

☐ Yes *(survey will direct to section 2: Buyer survey)*

☐ No *(survey will direct to section 3: Non-buyer survey)*

Section 3: Buyer survey

Q12. If yes, what do you offset?

☐ A specific product

☐ A specific activity, such as electricity consumption, business travels

☐ A specific event or conference

☐ The whole organisation operation

☐ Other:.....

Q13. What is your main driver for offsetting?

(Please tick all that apply)

☐ Reputation / brand image

☐ Market differentiation

☐ Pre-compliance

☐ Employees' motivation and retention / education and awareness

☐ Cost reduction, as internalising carbon cost drives efficiency

☐ Supply chain management or "insetting"

☐ Philanthropy / simple to abate emissions

☐ Other:……

Q14. Does voluntary carbon offsetting deliver tangible benefits to your organisation?

☐ Yes ☐ No

Q15. If yes, please briefly describe how these benefits are measured and evaluated?

(Question only appears if yes is selected to question above)

Q16. If no, please explain why no tangible benefits have been observed?

(Question only appears if no is selected to question above)

Q17. Do you select your suppliers based on sustainability criteria?

☐ Yes ☐ No

Q18. If yes, do the criteria include carbon offsetting?

(Question only appears if yes is selected to question above)

☐ Yes ☐ No

Q19. Which project type do you prefer when purchasing offset?

(Please tick all that apply)

☐ Renewable energy (e.g. wind, hydro, solar, geothermal)

☐ Household device distribution (e.g. clean cookstoves, efficient lighting, household biodigester, water purification)

☐ Forestry and land use (e.g. afforestation, reforestation, avoided deforestation, avoided forest degradation)

☐ Energy efficiency and fuel switching (e.g. waste heat recovery, biomass)

☐ Methane avoidance (e.g. landfill gas capture, manure management, wastewater treatment)

☐ Industrial gases (e.g. HFC destruction, N_2O abatement)

☐ Other:……

☐ No preference

Q20. Please briefly explain why you prefer certain type of carbon offset project?

Q21. Where do you prefer the offset to take place?

(Please tick all that apply)

☐ Africa ☐ Asia ☐ Oceania

☐ Europe ☐ Latin America Middle ☐ Middle East

☐ North America ☐ Eastern Europe & Central Asia

☐ No preference

Q22. Please briefly explain why you prefer the offset to take place in certain region or country?

Q23. When purchasing offsets, which of the following criteria do you consider important?

(Please rank by importance, 1 – most important to 4 – least important)

☐ Carbon price

☐ Project registration and issuance risk

☐ Co-benefits

☐ Relevance to business

Q24. Currently, most project developers only provide qualitative description of the project's co-benefits in project documents. Would you like to see more quantification and valuation of these co-benefits?

For example,

Qualitative reporting	Quantitative reporting
The project generates local employment.	The project employs 15 full-time positions locally, providing around US$60,000 of total income per year.
The project reduces local air pollution.	The project reduces around 12 tonnes of air pollutant emissions (SO_2, NO_x and $PM_{2.5}$) per year, which corresponds to avoiding around US$15,000 of environmental damage cost.

☐ Yes ☐ No ☐ No preference

Q25. Please provide the reason to your answer.

In the following section, you will be presented with a series of 5 scenarios and in each scenario, you will be asked to make a choice.

Please imagine you are seeking carbon offsets to abate your organisation's emissions. In each scenario, you will be presented with two projects, Project A and B, with different co-benefits and price. Co-benefits refer to additional benefits delivered by the project beyond greenhouse gas emission reduction. Different projects deliver different types of co-benefit:

- Social co-benefit: positive contribution to social development such as local community empowerment, enhanced public health and intellectual capital development.
- Economic co-benefit: positive contribution to local or regional economy, such as employment creation, sustainable technology transfer and market development.
- Environmental co-benefit: positive contribution to local environmental quality, such as improvement in air and water quality, resource conservation and biodiversity protection.

For some projects, co-benefits are verified using standards such as the Gold Standard, the Climate Community & Biodiversity (CCB) Standard and ISO standards. The price of carbon credit from each project is also provided in US$ per tCO_2.

Assuming all other features of the two projects are equal, you will be asked to choose the project you would prefer to source your carbon offsets from. You will also be given the 'opt out' option, i.e. you choose neither of the projects presented.

The projects and carbon prices presented in the choice scenarios are only illustrative, however please answer as truthfully as possible, bearing in mind the budget you might have for purchasing carbon offsets.

You will be asked to answer either Block A or Block B.

BLOCK A

Q27. Scenario A1

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit			N/A
Economic co-benefit	√		
Environmental co-benefit	√	√	
Co-benefit verification	None	Verified	
Price per tCO_2	US$25	US$7	0
Your preferred option	O	O	O

Q28. Scenario A2

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit		√	N/A
Economic co-benefit	√		
Environmental co-benefit	√	√	
Co-benefit verification	Verified	None	
Price per tCO_2	US$18	US$18	0
Your preferred option	O	O	O

Q29. Scenario A3

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit			N/A
Economic co-benefit	√	√	
Environmental co-benefit			
Co-benefit verification	None	Verified	
Price per tCO_2	US$7	US$25	0
Your preferred option	O	O	O

Q30. Scenario A4

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit	√	√	N/A
Economic co-benefit		√	
Environmental co-benefit		√	
Co-benefit verification	None	Verified	
Price per tCO_2	US$12	US$25	0
Your preferred option	O	O	O

Q31. Scenario A5

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit	√		N/A
Economic co-benefit			
Environmental co-benefit		√	
Co-benefit verification	Verified	None	
Price per tCO_2	US$18	US$7	0
Your preferred option	O	O	O

BLOCK B

Q32. Scenario B1

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit	√		N/A
Economic co-benefit		√	
Environmental co-benefit			
Co-benefit verification	None	None	
Price per tCO_2	US$25	US$25	0
Your preferred option	O	O	O

Q33. Scenario B2

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit		√	N/A
Economic co-benefit	√	√	
Environmental co-benefit		√	
Co-benefit verification	Verified	None	
Price per tCO_2	US$7	US$12	0
Your preferred option	O	O	O

Q34. Scenario B3

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit			N/A
Economic co-benefit		√	
Environmental co-benefit		√	
Co-benefit verification	N/A	Verified	
Price per tCO_2	US$7	US$25	0
Your preferred option	O	O	O

Q35. Scenario B4

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit	√		N/A
Economic co-benefit	√		
Environmental co-benefit	√	√	
Co-benefit verification	None	Verified	
Price per tCO_2	US$12	US$7	0
Your preferred option	O	O	O

Q36. Scenario B5

	Project A	Project B	Neither
Carbon offset	Yes	Yes	No
Social co-benefit	√	√	N/A
Economic co-benefit			
Environmental co-benefit	√		
Co-benefit verification	None	Verified	
Price per tCO_2	US$25	US$12	0
Your preferred option	O	O	O

Q37. What was the volume of offsets (in tCO2) your organisation contracted over 2013?

Q38. Please indicate how much did your organisation pay to compensate one tonne of CO2 in 2013?

☐ If you paid a flat rate, please indicate the price you paid per tCO2:

☐ If you paid variable prices, please indicate the price range and the reason for the variation:

Q39. What is the maximum amount your organisation would be willing to pay per tCO2 from a project with verified social, economic and environmental co-benefits?

Q40. Do you envisage your organisation to increase its participation in voluntary offsetting in the future?

☐ Yes ☐ Maybe ☐ No

Q41. Please provide a brief explanation to your answer above.

Q42. In your opinion, what is the greatest obstacle to participating in voluntary carbon market?

(Please tick all that apply)

☐ High transaction cost

☐ Information barrier

☐ Lacks transparency, which reduces buyers' confidence

☐ Shareholders or senior management do not fully understand the reasons/benefits of carbon offsetting

☐ Lack of demand among the customers to offset emissions with product use

☐ Lacks political leadership as seen in compliance market

☐ Other:.....

☐ None

Q43. What do you think can be done to improve the market situation?

Section 4: Non-buyer survey

Q9. Please provide the reason your organisation chooses not to offset.

(Please tick all that apply)

☐ We do not agree with the concept of offsetting for carbon abatement

☐ We are not interested in the market

☐ We are interested, but we do not know where to start (entry barrier)

☐ Lack of support from stakeholders, such as the senior management, shareholders and customers

☐ Too costly

☐ It is currently not on our list of priorities

☐ Other:.....

Q10. What would help to encourage your organisation's participation in voluntary carbon offsetting?

(Please tick all that apply)

☐ A consumer report on offset retailers to increase confidence and reduce transaction cost

☐ Step up the communication on climate change and the role of offsetting to promote supports from stakeholders

☐ Report on the voluntary carbon market's contribution to sustainable development

☐ Better understanding of the benefits accrued to businesses from voluntary offsetting

☐ Clearer signal from the compliance market / political commitment to reduce emissions

☐ Other:.....

Appendix 6-2: Full results of Survey 1 RPL model with interactions

	RPL with interactions
Mean	
Offset (ASC)	2.648 (1.308) **
Social co-benefit	0.009 (1.547)
Economic co-benefit	0.800 (1.227)
Environmental co-benefit	-0.720 (1.163)
Co-benefit verification	3.135 (1.110) ***
Price	-1.712 (0.168) ***
Standard deviation	
Offset (ASC)	0.877 (0.567)
Social co-benefit	1.835 (0.549) ***
Economic co-benefit	0.004 (0.649)
Environment co-benefit	0.042 (0.690)
Co-benefit verification	0.917 (0.443) **
Price	0.202 (0.147)
Interactions	
PROFIT * Offset	0.834 (1.352)
PROFIT * Social co-benefit	-0.039 (1.627)
PROFIT * Economic co-benefit	1.839 (1.266)
PROFIT * Environmental co-benefit	-1.112 (1.195)
PROFIT * Co-benefit verification	-0.088 (1.109)
EUROPE * Offset	-1.328 (0.844)
EUROPE * Social co-benefit	1.029 (0.974)
EUROPE * Economic co-benefit	-0.866 (0.730)
EUROPE * Environmental co-benefit	1.401 (0.773) *
EUROPE * Co-benefit verification	-0.851 (0.641)
FINANCE * Offset	-1.304 (0.959)
FINANCE * Social co-benefit	1.191 (1.120)
FINANCE * Economic co-benefit	-0.926 (0.856)

	RPL with interactions
FINANCE * Environmental co-benefit	1.148 (0.823)
FINANCE * Co-benefit verification	-0.527 (0.751)
PROFESSIONAL * Offset	-1.108 (1.299)
PROFESSIONAL * Social co-benefit	1.676 (1.383)
PROFESSIONAL * Economic co-benefit	0.826 (0.993)
PROFESSIONAL * Environmental co-benefit	1.204 (1.087)
PROFESSIONAL * Co-benefit verification	-0.273 (0.856)
TRANSPORT * Offset	-1.340 (0.999)
TRANSPORT * Social co-benefit	0.491 (1.177)
TRANSPORT * Economic co-benefit	-0.949 (0.860)
TRANSPORT * Environmental co-benefit	1.803 (0.873)
TRANSPORT * Co-benefit verification	-0.790 (0.796)
INFORMATION * Offset	0.005 (1.188)
INFORMATION * Social co-benefit	1.681 (1.454)
INFORMATION * Economic co-benefit	-3.519 (1.251) ***
INFORMATION * Environmental co-benefit	1.201 (1.079)
INFORMATION* Co-benefit verification	-1.701 (1.070)
Model fit	
No. of obs	750
Log likelihood (null)	-274.653
Log likelihood (model)	-187.653
Pseudo R^2	0.317
Adjusted pseudo R^2	0.164

Appendix 6-3: Pairwise t-test for comparing offset users' WTP and actual payment

Pairwise t-test was performed to investigate if respondents stated WTP for a voluntary offset with verified social, economic and environmental co-benefits is significantly different from the average offset price they paid in the previous year. The null hypothesis, H_0 states that they are not significantly different.

t-Test: Paired Two Sample for Means

	Price paid per offset in 2013	WTP for offset with verified social, economic and environmental co-benefits
Mean	10.655	15.079
Variance	31.700	41.135
Observations	30	30
Pearson Correlation	0.681	
Hypothesized Mean Difference	0	
df	29	
t Stat	-4.985	
P(T<=t) one-tail	0.000	
t Critical one-tail	1.699	
P(T<=t) two-tail	0.000	
t Critical two-tail	2.045	

Probability that H_0 is true	2.647E-05

Appendix 7-1: Survey 2 questionnaire

Introduction

Thank you for taking time to participate in this survey.

The aim of this survey is to help us understand organisations' attitudes and perceptions towards the role of voluntary carbon offsetting in abating greenhouse gas emissions, and their preferences for offset types.

The survey will take around 15-20 minutes to complete, depending on your knowledge about the voluntary carbon market. Please answer all the multiple choice questions. Open-ended questions are optional but can provide us more insights on the topic. If you have any queries about the questions, please do not hesitate to contact us.

If you exit the survey at any point, your answers will be saved and the next time you click on the survey link, you will be able to continue from where you left off, providing that you return to the survey on the same computer.

Please answer the questionnaire from the perspective of your organisation and as truthfully as possible. All responses are collected anonymously. Information collected from this survey will be treated as confidential and will not be shared with third parties. Reports generated from this study will only refer to the average or aggregate values and overall findings.

Thank you again for your time, your participation is valuable to our study.

Organisations' day-to-day operations release greenhouse gases (GHGs) into the atmosphere and contribute to climate change that has damaging impacts on our society and environment. For example, an average office in the United States with 50 staff members emits around 530 tonnes of carbon dioxide per year as the result of electricity and gas consumption, employees' travel, water use and waste generation[1]. This is equivalent to the energy use of an average American household for 41 years[2].

Organisations can implement a set of measures to reduce their carbon emissions internally and then purchase offsets from the voluntary carbon market to abate their remaining emissions. Offsets are certified emission reductions generated from projects that avoid or sequester GHGs such as renewable energy, energy efficiency and tree planting projects. Each offset represents one tonne of carbon dioxide (tCO2) emission reduction achieved elsewhere that organisations can purchase and use it to compensate or 'neutralise' one tonne of their CO2 emission.

[1] Source: The Green Office (http://www.thegreenoffice.com/carboncalculator/calculator/)

[2] Source: You Sustain (http://www.yousustain.com/footprint/howmuchco2?co2=530+tons)

Q1. Do you agree or disagree with the statement that organisations should voluntarily reduce their GHG emissions and contribute towards climate change mitigation?

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

Q2. How much do you know about the voluntary carbon market?

- ❍ A great deal
- ❍ A lot
- ❍ A moderate amount
- ❍ A little
- ❍ None at all

Q3. Do you agree or disagree with the statement that carbon offsetting is an effective way to abate GHG emissions?

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

Q4. Do you think the recent Paris Agreement on climate change (http://unfccc.int/paris_agreement/items/9485.php) will increase organisations' participation in voluntary carbon offsetting?

- ❍ Definitely yes
- ❍ Probably yes
- ❍ Might or might not
- ❍ Probably not
- ❍ Definitely not

Q5. Do you think the recent Paris Agreement on climate change will increase your organisation's participation in voluntary carbon offsetting?

- ❍ Definitely yes
- ❍ Probably yes
- ❍ Might or might not
- ❍ Probably not
- ❍ Definitely not

Q6. Do you consider climate change as a risk to your organisation?

- ❍ Definitely yes *(go to Q7)*
- ❍ Probably yes *(go to Q7)*
- ❍ Might or might not *(go to Q8)*
- ❍ Probably not *(go to Q8)*
- ❍ Definitely not *(go to Q8)*

Q7. What type(s) of risk do you think climate change is posing to your organisation?

Please select a maximum of three choices.

- ❑ Reputational risk
- ❑ Potential future regulation
- ❑ Extreme weather events, such as floods and droughts
- ❑ Supply chain disruption
- ❑ Change in consumer behaviour
- ❑ Other, please specify: _____

In addition to reducing GHG emissions, some carbon offset projects deliver various types of co-benefits, such as:

- Social co-benefits: poverty alleviation, women empowerment, and improved public health
- Economic co-benefits: job creation, technology transfer and market development
- Environmental co-benefits: improved air quality, ecosystem services conservation and biodiversity protection

For example, efficient cookstove dissemination projects promote cleaner indoor air and better health among women and children. Renewable energy projects facilitate technology transfer and improve energy security. Forest conservation projects protect local ecosystem services and biodiversity.

Offset projects' co-benefits can be verified using third-party standards such as the Gold Standard (GS), the Climate Community & Biodiversity (CCB) Standard and Social Carbon Standard. Projects developed under the Clean Development Mechanism (CDM) can also self-report their co-benefits using the UNFCCC's Sustainable Development Co-Benefits Tool.

Q8. In your view, is it important for carbon offset projects or programmes that are designed to abate GHG emissions to also deliver sustainable development co-benefits?

- ❍ Definitely yes
- ❍ Probably yes
- ❍ Might or might not
- ❍ Probably not
- ❍ Definitely not

Q9. Please provide reason(s) to your answer:

Q10. If you are looking to purchase offsets, which of the following co-benefits would you prefer to support in a voluntary offset project?

Please select a maximum of three choices.

- ❑ Alleviates poverty
- ❑ Improves food security
- ❑ Improves local health and well-being
- ❑ Contributes towards local education facilities
- ❑ Empowers women
- ❑ Improves access to clean drinking water and sanitation
- ❑ Improves energy security
- ❑ Provides quality jobs
- ❑ Contributes towards local public infrastructure and basic services
- ❑ Reduces wealth inequality
- ❑ Contributes to the development of sustainable citites and communities
- ❑ Promotes efficient resource (other than energy) production and consumption
- ❑ Promotes sustainable use of the oceans, seas and marine resources
- ❑ Conserves local natural ecosystems and biodiversity
- ❑ Builds local capacity and strengthens institutions
- ❑ Promotes partnership between public and private sectors or between developing and developed countries
- ❑ Facilitates sustainable technology transfer
- ❑ Other, please specify: _____
- ❑ No preference

Q11. Do you agree or disagree with the statement that it is important for the co-benefits to be independently verified against a third party standard?

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

In the online survey, respondents will only be presented with either Q12 (a and b) or Q13 (a and b). The survey software randomly selects one of the question sets for respondents to answer.
Q12

Suppose you have calculated the GHG emissions generated from your organisation and implemented a set of measures to reduce some of the emissions, including installing energy efficiency equipment, engaging your employees and purchasing renewable energy. You can abate the residual emissions through offsetting programmes.

In the following questions, you will be asked the maximum price you would be willing to pay for one carbon offset. Please assume that the carbon offset meets all your requirements, except for its co-benefit delivery. Please answer as truthfully as possible, keeping in mind the budget you may need to allocate for the offsetting programme.

Q12a. What is the maximum price you would be willing to pay in US$ for one carbon offset without co-benefits?

- ❍ 0
- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

Q12b. What is the maximum price you would be willing to pay in US$ for one carbon offset that also creates employment, improves public health and reduces water pollution?

- ❍ 0
- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

(go to Q14)

Q13

Suppose you have calculated the GHG emissions generated from your organisation and implemented a set of measures to reduce some of the emissions, including installing energy efficiency equipment, engaging your employees and purchasing renewable energy. You can abate the residual emissions through offsetting programme.

In the following questions, you will be asked the maximum price you would be willing to pay for one carbon offset. Please assume that the carbon offset meets all your requirements, except for its co-benefit delivery. Please answer as truthfully as possible, keeping in mind the budget you may need to allocate for the offsetting programme.

Q13a. What is the maximum price you would be willing to pay in US$ for one carbon offset without co-benefits?

- ❍ 0
- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

Q13b. What is the maximum price you would be willing to pay in US$ for one carbon offset that also creates employment, improves public health and reduces water pollution? Each offset generates

around US$2 of local income, saves local households around US$5 of medical bills and avoids US$3 of water pollution clean-up costs.

- ❍ 0
- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

In the online survey, respondents will only be presented with either Q14 (a to e) or Q15 (a to e). The survey software randomly selects one of the question sets for respondents to answer.

Q14

Now imagine you are looking for offsets to abate the residual emissions of your organisation and you have been presented with the following sets of choices. Each set of choices contains two hypothetical GHG emission reduction projects, Project A and Project B. Please select which project you would most likely purchase offsets from based on the offset price, project's co-benefits and verification of co-benefits, assuming all other project attributes are equal. There is also an 'opt out' option, if you feel you would not purchase offsets from either project. Please answer as truthfully as possible, keeping in mind the budget you may have to allocate for offsetting programme.

For example in Scenario A1, you can purchase offsets from Project A or Project B. Project A delivers economic and environmental co-benefits and each offset costs US$25. Project B delivers only environmental co-benefits, but the co-benefits are third party verified and each offset costs US$7. Which project would you purchase offsets from? Alternatively, you can choose 'Neither' if you prefer not to purchase offsets from either project.

Q14a. Scenario A1:

	Project A	**Project B**
Carbon offset	✓	✓
Social co-benefit		
Economic co-benefit	✓	
Environmental co-benefit	✓	✓
Co-benefit verification		✓
Price per tCO_2	US$25	US$7

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q14b. Scenario A2:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit		✓
Economic co-benefit	✓	
Environmental co-benefit	✓	✓
Co-benefit verification	✓	
Price per tCO_2	US$18	US$18

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q14c. Scenario A3:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit		
Economic co-benefit	✓	✓
Environmental co-benefit		
Co-benefit verification		✓
Price per tCO_2	US$7	US$25

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q14d. Scenario A4:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit	✓	✓
Economic co-benefit		✓
Environmental co-benefit		✓
Co-benefit verification		✓
Price per tCO_2	US$12	US$25

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q14e. Scenario A5:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit	✓	
Economic co-benefit		
Environmental co-benefit		✓
Co-benefit verification	✓	
Price per tCO_2	US$18	US$7

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

(go to Q16)

Q15

Now imagine you are looking for offsets to abate the residual emissions of your organisation and you have been presented with the following sets of choices. Each set of choices contains two hypothetical GHG emission reduction projects, Project A and Project B. Please select which project you would most likely purchase offsets from based on the offset price, project's co-benefits and verification of co-benefits, assuming all other project attributes are equal. There is also an 'opt out' option, if you feel you would not purchase offsets from either project. Please answer as truthfully as possible, keeping in mind the budget you may have to allocate for offsetting programme.

For example in Scenario B1, you can purchase offsets from Project A or Project B. Project A delivers social co-benefits and each offset costs US$25. Project B delivers economic co-benefits and each offset also costs US$25. Both projects' co-benefits are not third party verified. Which project would you purchase offsets from? Alternatively, you can choose 'Neither' if you prefer not to purchase offsets from either project.

Q15a. Scenario B1:

	Project A	**Project B**
Carbon offset	✓	✓
Social co-benefit	✓	
Economic co-benefit		✓
Environmental co-benefit		
Co-benefit verification		
Price per tCO_2	US$25	US$25

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q15b. Scenario B2:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit		✓
Economic co-benefit	✓	✓
Environmental co-benefit		✓
Co-benefit verification	✓	
Price per tCO_2	US$7	US$12

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q15c. Scenario B3:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit		
Economic co-benefit		✓
Environmental co-benefit		✓
Co-benefit verification		✓
Price per tCO_2	US$7	US$25

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q15d. Scenario B4:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit	✓	
Economic co-benefit	✓	
Environmental co-benefit	✓	✓
Co-benefit verification		✓
Price per tCO_2	US$12	US$7

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q15e. Scenario B5:

	Project A	Project B
Carbon offset	✓	✓
Social co-benefit	✓	✓
Economic co-benefit		
Environmental co-benefit	✓	
Co-benefit verification		✓
Price per tCO_2	US$25	US$12

Please select your preferred option:

- ❍ Project A
- ❍ Project B
- ❍ Neither

Q16. Offset projects can take place anywhere around the world, from developed countries to least developed countries. Through the support of carbon finance, local communities within and around the carbon offset project can benefit from its implementation. Which of the following project locations would you prefer to source your offsets from?

Please select a maximum of three choices.

- ❑ Least developed countries *(go to Q23)*
- ❑ Developing (emerging) countries *(go to Q23)*
- ❑ Developed or newly industrialised countries *(go to Q23)*
- ❑ Within your supply chain *(go to Q20)*
- ❑ Domestic projects *(go to Q17)*
- ❑ Other, please specify: _____
- ❑ No preference

Q17. Would you be willing to pay more for an offset that is generated domestically as compared to an offset generated elsewhere?

- ❍ Yes
- ❍ Maybe
- ❍ No

Q18. If yes, how much more would you be willing to pay for an offset that is generated domestically as compared to an offset generated elsewhere, assuming all other offset attributes are equal?

- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

Q19. Which of the following domestic offset project types would you prefer to support?

Please select a maximum of three choices.

- ❑ Renewable energy (e.g. wind, hydro, solar, geothermal)
- ❑ Household device distribution (e.g. clean cookstoves, efficient lighting, household biodigester, water purification, mini-grid)
- ❑ Forestry and land use (e.g. afforestation, reforestation, avoided deforestation, avoided forest degradation)
- ❑ Agriculture (e.g. reduced synthetic nitrogen fertilizers, reduced methane emissions in the dairy sector, efficient water pumping and irrigation)
- ❑ Energy efficiency and fuel switching (e.g. waste heat recovery, biomass, efficient transportation systems)
- ❑ Methane avoidance from waste management (e.g. landfill gas capture, manure management, wastewater treatment)
- ❑ Industrial processes (e.g. HFC destruction, N2O abatement)
- ❑ Other, please specify: _____
- ❑ No preference

(go to Q23)

Q20. Would you be willing to pay more for an offset that is generated within your supply chain as compared to an offset generated elsewhere?

- ❍ Yes
- ❍ Maybe
- ❍ No

Q21. If yes, how much more would you be willing to pay for an offset that is generated within your supply chain as compared to an offset generated elsewhere, assuming all other offset attributes are equal?

- ❍ 0.01 - 2
- ❍ 2.01 - 4
- ❍ 4.01 - 6
- ❍ 6.01 - 8
- ❍ 8.01 - 10
- ❍ 10.01-12
- ❍ 12.01-14
- ❍ 14.01-16
- ❍ 16.01-18
- ❍ 18.01-20
- ❍ >20, please specify _____

Q22. Which of the following offset project types would you prefer to support within your supply chain?

Please select a maximum of three choices.

- ❑ Renewable energy (e.g. wind, hydro, solar, geothermal)
- ❑ Household device distribution (e.g. clean cookstoves, efficient lighting, household biodigester, water purification, mini-grid)
- ❑ Forestry and land use (e.g. afforestation, reforestation, avoided deforestation, avoided forest degradation)
- ❑ Agriculture (e.g. reduced synthetic nitrogen fertilizers, reduced methane emissions in the dairy sector, efficient water pumping and irrigation)
- ❑ Energy efficiency and fuel switching (e.g. waste heat recovery, biomass, efficient transportation systems)
- ❑ Methane avoidance from waste management (e.g. landfill gas capture, manure management, wastewater treatment)
- ❑ Industrial processes (e.g. HFC destruction, N2O abatement)
- ❑ Other, please specify: _____
- ❑ No preference

Q23. Which of the following would incentivise your support for an emission reduction project?

Please select a maximum of three choices.

- ❑ Information about how the project can benefit your organisation's day-to-day operation
- ❑ Information about how the project can help you engage with your stakeholders
- ❑ Information about how the project contributes to national climate objectives and sustainable development goals
- ❑ Opportunity to differentiate your organisation from its competitors
- ❑ Opportunity to organise project visits
- ❑ Recognition of emission reductions by relevant authorities to allow them to contribute towards to your climate neutrality strategy and your country's national target
- ❑ Verification by an independent third party
- ❑ Recognition by a national authority or standard
- ❑ Recognition by an international authority or standard

Q24. Which of the following best describes your organisation type?

- ❍ International corporation
- ❍ National corporation
- ❍ Small to medium sized enterprise (SME) (<250 employees and <US$680 (or €500) million turnover)
- ❍ Governmental agency / public sector
- ❍ International development institution
- ❍ Non-profit organisation / NGO
- ❍ Other, please state: _____

Q25. What sector does your organisation operate in?

- ❍ Agriculture and forestry
- ❍ Manufacturing
- ❍ Paper and printing
- ❍ Food and drink
- ❍ Wholesale and retail
- ❍ Financial and insurance
- ❍ Information and communication
- ❍ Professional and administrative services
- ❍ Arts, entertainment and recreation
- ❍ Mining and quarrying
- ❍ Electricity / energy
- ❍ Construction
- ❍ Textile and leather
- ❍ Transportation and tourism
- ❍ Education
- ❍ Carbon offset retailer
- ❍ Other, please state: _____

Q26. In which country is your organisation incorporated or where is its head office located?

[Country drop-down list]

Q27. Does your company have a carbon management strategy?

- ❍ Yes
- ❍ No

Q28. Does your organisation purchase carbon offsets?

- ❍ Yes *(go to Q29)*
- ❍ No *(go to Q37)*

Q29. Please indicate how many offsets in tCO2 has your organisation contracted in 2015:

Q30.Please indicate the average price in US$ your organisation has paid per offset in 2015:

Q31. What do you offset?

Please select all that are applicable.

- ❑ A specific product
- ❑ A specific event or conference
- ❑ Scope 1 & 2 emissions: emissions from consumption of fuel, gas and electricity
- ❑ Scope 3 emissions: indirect emissions associated with waste generation, water use, employees' travel and supply chain
- ❑ Other, please state: _____

Q32. What is your main driver for offsetting your emissions?

Please rank a maximum of three choices, 1 as the most important driver.

_____ Reputation / brand image
_____ Market differentiation
_____ Pre-compliance
_____ Employees' engagement
_____ Internalising carbon cost
_____ Supply chain management
_____ Risk mitigation
_____ Feel responsible for our contribution to climate change
_____ Care about the environment and our society in general
_____ Other, please state:

Q33. When purchasing offsets, which of the following criteria do you consider the most important?

Please rank a maximum of three choices, 1 as the most important criteria.

_____ Carbon price
_____ Independent and recognised certification
_____ Vintage (the year the emission reduction took place)
_____ Co-benefits
_____ Relevance to business
_____ Ease of access
_____ Other, please specify:

Q34. Does voluntary carbon offsetting deliver tangible benefits to your organisation?

- ❍ Yes *(go to Q35)*
- ❍ Maybe *(go to Q36)*
- ❍ No *(go to Q36)*

Q35. If yes, please briefly describe these benefits and whether they are being measured.

(go to Q41)

Q36. If maybe or no, please provide a brief explanation regarding the benefits you are expecting but have not realised.

(go to Q41)

Q37. Has your organisation purchased offsets in the past?

- ❍ Yes
- ❍ No

Q38. What is the reason(s) your organisation does not purchase offsets or has stopped purchasing offsets?

Please select a maximum of three choices.

- ❑ We do not agree with the concept of offsetting for carbon abatement
- ❑ We are not interested in the market
- ❑ The market lacks credibility and transparency
- ❑ We are interested, but we do not know where to start (entry barrier)
- ❑ Lack of support from stakeholders, such as the senior management, shareholders and customers
- ❑ Too costly
- ❑ It is currently not on our list of priorities
- ❑ Other, please specify: _____

Q39. Does your organisation invest directly in GHG emission reduction projects such as tree planting, wetland restoration or off-grid renewable projects which are not third-party verified (thus not generating offsets) as a way to abate your emissions?

- ❍ Yes
- ❍ No

Q40. What would make you decide to engage in voluntary offsetting in the coming years?

Please select a maximum of three choices

- ❑ Increasing momentum globally for climate change mitigation actions
- ❑ Increased awareness of the contribution of offsetting to climate change mitigation
- ❑ A majority of organisations in your sector engage in offsetting programmes
- ❑ Voluntary carbon market becomes easier to understand
- ❑ Voluntary carbon market becomes more transparent
- ❑ The transaction costs of offsetting are lower
- ❑ You can find other types of projects to support than those currently available
- ❑ You can find projects in other locations of greater interest to your organisation
- ❑ Communication around offsetting projects and the role of carbon finance is improved
- ❑ Other, please specify: _____
- ❑ No preference

Q41. You've reached the end of this survey. Is there any topic that you expected to see in this survey and that you did not find? Are there features in the voluntary carbon market that you would like to see developed in the near future? Do you have a comment regarding this survey? If yes, please leave a message in the box below. If not, please click the next button to submit your response.

End of survey message

We would like to thank you for your participation and your time.

As mentioned, all responses are collected anonymously. Only the aggregated and/or average results generated from this study will be reported by Imperial College London. A report produced from this survey will be made available on the ICROA and UNFCCC websites, expected to be in the first half of 2017. In the meantime, if you are interested and would like to find out more about this study, please get in touch by emailing to e.tan-loh12@imperial.ac.uk.

For more information about the organisations undertaking or supporting this study, please visit the following websites:
Imperial College Research team: https://www.imperial.ac.uk/environmental-policy/
ICROA: https://icroa.wildapricot.org/
UNFCCC: http://newsroom.unfccc.int/

Appendix 7-2: MWU tests for comparing the attitudes of offset users and non-users

Respondent ID	Offset user	Responses								Ranking							
		Responsibility	Risk	Knowledge	Effectiveness	Other	Institution	Cobenefit	Cobenefitver	Responsibility	Risk	Knowledge	Effectiveness	Other	Institution	Cobenefit	Cobenefitver
1	1	1	1	1	1	2	1	1	3	40.0	28.5	8.0	14.5	44.5	12.0	32.0	84.5
2	2	3	4	2	2	2	3	3	2	93.5	89.5	32.0	52.5	44.5	65.0	90.0	66.0
4	1	1	3	3	2	3	1	1	1	40.0	82.0	64.5	52.5	81.5	12.0	32.0	26.5
5	1	1	1	1	1	2	1	1	1	40.0	28.5	8.0	14.5	44.5	12.0	32.0	26.5
6	2	1	5	3	3	3	3	5	1	40.0	95.0	64.5	81.5	81.5	65.0	96.0	26.5
7	1	2	2	3	3	1	2	1	2	85.5	67.0	64.5	81.5	8.5	38.5	32.0	66.0
8	1	3	1	1	1	2	1	2	5	93.5	28.5	8.0	14.5	44.5	12.0	74.5	95.5
9	2	4	1	3	4	4	5	1	1	96.0	28.5	64.5	91.5	93.5	95.5	32.0	26.5
10	1	1	3	3	1	3	4	3	3	40.0	82.0	64.5	14.5	81.5	85.0	90.0	84.5
11	2	1	1	3	4	2	2	2	1	40.0	28.5	64.5	91.5	44.5	38.5	74.5	26.5
12	2	2	5	4	4	2	2	1	1	85.5	95.0	88.5	91.5	44.5	38.5	32.0	26.5
13	2	1	1	3	2	1	1	2	1	40.0	28.5	64.5	52.5	8.5	12.0	74.5	26.5
14	2	1	1	2	1	2	1	1	3	40.0	28.5	32.0	14.5	44.5	12.0	32.0	84.5
15	2	2	2	3	1	3	4	1	1	85.5	67.0	64.5	14.5	81.5	85.0	32.0	26.5
16	2	1	3	3	3	3	4	3	1	40.0	82.0	64.5	81.5	81.5	85.0	90.0	26.5
17	1	1	4	1	1	1	2	1	1	40.0	89.5	8.0	14.5	8.5	38.5	32.0	26.5
18	1	1	3	2	1	3	3	5	1	40.0	82.0	32.0	14.5	81.5	65.0	96.0	26.5
19	1	1	1	3	2	2	1	1	1	40.0	28.5	64.5	52.5	44.5	12.0	32.0	26.5
20	2	1	2	3	1	1	2	2	1	40.0	67.0	64.5	14.5	8.5	38.5	74.5	26.5
21	1	1	1	1	1	2	5	1	4	40.0	28.5	8.0	14.5	44.5	95.5	32.0	91.5

22	1	1	3	1	1	4	2	1	4	40.0	82.0	8.0	14.5	93.5	38.5	32.0	91.5
23	2	1	1	4	2	2	3	3	1	40.0	28.5	88.5	52.5	44.5	65.0	90.0	26.5
25	1	1	1	2	2	2	1	1	1	40.0	28.5	32.0	52.5	44.5	12.0	32.0	26.5
26	1	2	1	3	2	3	3	1	1	85.5	28.5	64.5	52.5	81.5	65.0	32.0	26.5
27	1	1	1	3	2	1	2	3	2	40.0	28.5	64.5	52.5	8.5	38.5	90.0	66.0
28	1	1	1	2	2	2	2	1	2	40.0	28.5	32.0	52.5	44.5	38.5	32.0	66.0
29	1	1	1	3	1	1	1	1	1	40.0	28.5	64.5	14.5	8.5	12.0	32.0	26.5
30	1	2	4	3	2	3	4	1	2	85.5	89.5	64.5	52.5	81.5	85.0	32.0	66.0
31	1	1	1	1	1	3	1	3	1	40.0	28.5	8.0	14.5	81.5	12.0	90.0	26.5
32	1	1	2	2	2	1	2	2	2	40.0	67.0	32.0	52.5	8.5	38.5	74.5	66.0
33	1	1	1	3	1	2	4	1	1	40.0	28.5	64.5	14.5	44.5	85.0	32.0	26.5
34	1	1	1	2	2	3	1	1	2	40.0	28.5	32.0	52.5	81.5	12.0	32.0	66.0
35	2	1	2	1	1	2	4	1	2	40.0	67.0	8.0	14.5	44.5	85.0	32.0	66.0
36	2	1	2	3	2	2	2	1	2	40.0	67.0	64.5	52.5	44.5	38.5	32.0	66.0
37	1	2	4	4	3	2	4	2	2	85.5	89.5	88.5	81.5	44.5	85.0	74.5	66.0
38	1	1	1	2	4	1	2	1	1	40.0	28.5	32.0	91.5	8.5	38.5	32.0	26.5
39	2	1	4	1	2	3	3	1	1	40.0	89.5	8.0	52.5	81.5	65.0	32.0	26.5
40	1	1	2	2	1	2	3	2	2	40.0	67.0	32.0	14.5	44.5	65.0	74.5	66.0
41	2	1	2	3	2	2	3	1	1	40.0	67.0	64.5	52.5	44.5	65.0	32.0	26.5
42	1	1	1	3	2	2	3	1	2	40.0	28.5	64.5	52.5	44.5	65.0	32.0	66.0
43	2	1	1	4	2	1	2	1	5	40.0	28.5	88.5	52.5	8.5	38.5	32.0	95.5
44	1	1	1	2	2	3	4	1	2	40.0	28.5	32.0	52.5	81.5	85.0	32.0	66.0
45	2	1	1	2	1	2	3	1	2	40.0	28.5	32.0	14.5	44.5	65.0	32.0	66.0
46	2	1	3	2	2	1	2	2	4	40.0	82.0	32.0	52.5	8.5	38.5	74.5	91.5
47	2	1	1	1	4	2	4	1	4	40.0	28.5	8.0	91.5	44.5	85.0	32.0	91.5
48	1	1	1	2	2	2	2	1	2	40.0	28.5	32.0	52.5	44.5	38.5	32.0	66.0
49	2	1	1	2	4	4	5	1	1	40.0	28.5	32.0	91.5	93.5	95.5	32.0	26.5
50	2	1	1	3	2	1	1	1	1	40.0	28.5	64.5	52.5	8.5	12.0	32.0	26.5
51	2	1	1	2	2	3	2	2	1	40.0	28.5	32.0	52.5	81.5	38.5	74.5	26.5
52	1	1	1	4	1	2	4	1	1	40.0	28.5	88.5	14.5	44.5	85.0	32.0	26.5

53	2	2	1	1	1	2	1	1	1	85.5	28.5	8.0	14.5	44.5	12.0	32.0	26.5
54	2	1	1	2	3	1	1	1	1	40.0	28.5	32.0	81.5	8.5	12.0	32.0	26.5
55	1	1	1	2	2	1	1	2	1	40.0	28.5	32.0	52.5	8.5	12.0	74.5	26.5
56	2	1	1	3	1	2	3	1	1	40.0	28.5	64.5	14.5	44.5	65.0	32.0	26.5
57	1	1	1	3	2	2	4	1	2	40.0	28.5	64.5	52.5	44.5	85.0	32.0	66.0
58	2	1	3	1	1	2	2	1	2	40.0	82.0	8.0	14.5	44.5	38.5	32.0	66.0
59	1	2	5	2	2	2	1	1	1	85.5	95.0	32.0	52.5	44.5	12.0	32.0	26.5
60	2	1	2	4	2	2	3	1	3	40.0	67.0	88.5	52.5	44.5	65.0	32.0	84.5
61	1	1	1	3	2	1	3	1	1	40.0	28.5	64.5	52.5	8.5	65.0	32.0	26.5
62	2	1	1	2	2	4	1	1	1	40.0	28.5	32.0	52.5	93.5	12.0	32.0	26.5
63	1	1	2	2	2	3	2	1	1	40.0	67.0	32.0	52.5	81.5	38.5	32.0	26.5
64	1	1	1	4	2	4	4	1	1	40.0	28.5	88.5	52.5	93.5	85.0	32.0	26.5
65	1	1	2	2	1	2	3	1	1	40.0	67.0	32.0	14.5	44.5	65.0	32.0	26.5
66	1	1	1	2	2	1	2	2	1	40.0	28.5	32.0	52.5	8.5	38.5	74.5	26.5
68	2	1	2	4	2	2	2	1	2	40.0	67.0	88.5	52.5	44.5	38.5	32.0	66.0
69	1	2	1	3	1	2	1	1	1	85.5	28.5	64.5	14.5	44.5	12.0	32.0	26.5
70	2	2	3	3	3	3	4	3	2	85.5	82.0	64.5	81.5	81.5	85.0	90.0	66.0
71	1	3	1	4	3	3	2	2	1	93.5	28.5	88.5	81.5	81.5	38.5	74.5	26.5
72	1	1	1	2	2	2	5	3	3	40.0	28.5	32.0	52.5	44.5	95.5	90.0	84.5
73	2	1	2	4	2	2	2	1	3	40.0	67.0	88.5	52.5	44.5	38.5	32.0	84.5
74	2	2	1	1	1	2	3	2	3	85.5	28.5	8.0	14.5	44.5	65.0	74.5	84.5
75	1	1	2	2	2	2	2	2	1	40.0	67.0	32.0	52.5	44.5	38.5	74.5	26.5
76	1	1	1	2	4	2	4	2	1	40.0	28.5	32.0	91.5	44.5	85.0	74.5	26.5
77	2	1	3	4	2	2	2	2	2	40.0	82.0	88.5	52.5	44.5	38.5	74.5	66.0
78	1	1	1	2	4	2	2	1	1	40.0	28.5	32.0	91.5	44.5	38.5	32.0	26.5
80	2	3	2	5	3	2	3	1	1	93.5	67.0	97.0	81.5	44.5	65.0	32.0	26.5
81	2	1	1	1	1	1	1	1	5	40.0	28.5	8.0	14.5	8.5	12.0	32.0	95.5
82	2	1	1	3	2	2	2	1	1	40.0	28.5	64.5	52.5	44.5	38.5	32.0	26.5
83	2	1	1	3	4	3	4	2	3	40.0	28.5	64.5	91.5	81.5	85.0	74.5	84.5
84	1	1	5	2	1	2	1	1	2	40.0	95.0	32.0	14.5	44.5	12.0	32.0	66.0

85	1	1	1	3	1	2	2	1	2	40.0	28.5	64.5	14.5	44.5	38.5	32.0	66.0
86	2	1	1	2	2	2	1	1	2	40.0	28.5	32.0	52.5	44.5	12.0	32.0	66.0
87	2	1	1	1	2	2	3	1	2	40.0	28.5	8.0	52.5	44.5	65.0	32.0	66.0
88	2	1	1	4	2	2	1	2	3	40.0	28.5	88.5	52.5	44.5	12.0	74.5	84.5
89	2	1	1	4	2	2	3	2	1	40.0	28.5	88.5	52.5	44.5	65.0	74.5	26.5
90	1	1	2	3	2	3	3	1	1	40.0	67.0	64.5	52.5	81.5	65.0	32.0	26.5
91	2	1	1	2	1	2	2	1	1	40.0	28.5	32.0	14.5	44.5	38.5	32.0	26.5
93	2	1	2	2	2	2	2	2	1	40.0	67.0	32.0	52.5	44.5	38.5	74.5	26.5
94	1	1	2	2	2	2	3	1	1	40.0	67.0	32.0	52.5	44.5	65.0	32.0	26.5
95	2	1	1	4	4	2	3	1	1	40.0	28.5	88.5	91.5	44.5	65.0	32.0	26.5
96	2	1	1	3	2	2	2	3	1	40.0	28.5	64.5	52.5	44.5	38.5	90.0	26.5
97	2	1	4	4	3	2	4	2	2	40.0	89.5	88.5	81.5	44.5	85.0	74.5	66.0
98	2	1	1	3	2	2	2	2	3	40.0	28.5	64.5	52.5	44.5	38.5	74.5	84.5
100	2	5	5	2	5	5	4	5	5	97.0	95.0	32.0	97.0	97.0	85.0	96.0	95.5
101	2	1	2	2	2	2	1	1	1	40.0	67.0	32.0	52.5	44.5	12.0	32.0	26.5
102	2	1	2	3	2	2	3	1	2	40.0	67.0	64.5	52.5	44.5	65.0	32.0	66.0
103	1	2	2	4	3	4	3	1	2	85.5	67.0	88.5	81.5	93.5	65.0	32.0	66.0

Keys:

Offset user	Offset user = 1; non-user = 2
Responsibility	Organisations should voluntarily reduce their GHG emissions. Likert scale from 1 strongly agree to 5 strongly disagree with the statement.
Risk	Consider climate change as a risk to the organisation. Likert scale from 1 definitely yes to 5 definitely no.
Knowledge	Respondent's self-reported knowledge about the VCM. Likert scale from 1, know a great deal to 5, none at all.
Effectiveness	Carbon offsetting is an effective way to abate GHG emissions. Likert scale from 1 strongly agree to 5 strongly disagree with the statement.
Other	The Paris Agreement on climate change will increase other organisations' participation in voluntary carbon offsetting. Likert scale from 1 definitely yes to 5 definitely no.
Institution	The Paris Agreement on climate change will increase respondent's participation in voluntary carbon offsetting. Likert scale from 1 definitely yes to 5 definitely no.
Cobenefit	Respondent's view on the importance of offset co-benefits. Likert scale from 1, definitely yes to 5 definitely no.
Cobenefitver	Respondent's agreement with the statement that it is important for offset co-benefits to be independently verified. Likert scale from 1 strongly agree to 5 strongly disagree with the statement.

Null hypothesis, H_0: There is no significant difference in the attitude/perception of offset users and non-users.

Responsibility	R	n	U
User (1)	2305.5	47	1172.5
Non-user (2)	2447.5	50	1177.5
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	0.02		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Risk	R	n	U
User (1)	2216	47	1262
Non-user (2)	2537	50	1088
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-0.63		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Knowledge	R	n	U
User (1)	2106	47	1372
Non-user (2)	2647	50	978
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-1.42		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Effectiveness	R	n	U
User (1)	2054.5	47	1423.5
Non-user (2)	2698.5	50	926.5
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-1.79		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Other	R	n	U
User (1)	2321.5	47	1156.5
Non-user (2)	2431.5	50	1193.5
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	0.13		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Institutional	R	n	U
User (1)	2236	47	1242
Non-user (2)	2517	50	1108
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-0.48		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Cobenefit	R	n	U
User (1)	2182.5	47	1295.5
Non-user (2)	2570.5	50	1054.5
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-0.87		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

Cobenefitver	R	n	U
User (1)	2211	47	1267
Non-user (2)	2542	50	1083
U1+U2	2350		
n1*n2	2350		
mean	1175		
std dev	138.53		
Z statistic	-0.66		
Critical value	-1.96		
IZI is < c, so cannot reject H_0			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 7-3: Chi-square tests

Chi square tests are used to investigate the following hypotheses:

1) Having a carbon management plan and voluntary offsetting are independent of each other

Observed		Offset		
		Yes	No	Sum
Management	Yes	42	36	78
	No	5	14	19
	Sum	47	50	97

Probabilities	Management	Probability	Offset	Probability
	Yes	0.804	Yes	0.485
	No	0.196	No	0.515

Probability contingency table		Offset	
		Yes	No
Management	Yes	0.390	0.414
	No	0.095	0.101

Frequency contingency table (Expected)		Offset	
		Yes	No
Management	Yes	37.794	40.206
	No	9.206	9.794

(Observed-Expected)^2/Expected		Offset	
		Yes	No
Management	Yes	0.468	0.440
	No	1.922	1.806

Summary

Calculated χ^2	4.636
Uncertainty level	0.05
Degree of freedom	1
Critical value, c	3.841
p value	0.031
Reject H_0?	Yes, they are not independent

2) Knowledge about the VCM and belief in its effectiveness to abate GHG emissions are independent of each other

Observed		Effectiveness			
		Agree	Neutral	Disagree	Sum
Knowledge	Above moderate	41	1	6	48
	Moderate	25	4	3	32
	Below moderate	10	5	2	17
	Sum	76	10	11	97

Probabilities	Knowledge	Probability	Effectiveness	Probability
	Above moderate	0.495	Agree	0.784
	Moderate	0.330	Neutral	0.103
	Below moderate	0.175	Disagree	0.113

Probability contingency table		Effectiveness		
		Agree	Neutral	Disagree
Knowledge	Above moderate	0.388	0.051	0.056
	Moderate	0.258	0.034	0.037
	Below moderate	0.137	0.018	0.020

Frequency contingency table (Expected)		Effectiveness		
		Agree	Neutral	Disagree
Knowledge	Above moderate	37.608	4.948	5.443
	Moderate	25.072	3.299	3.629
	Below moderate	13.320	1.753	1.928

(Observed-Expected)^2/Expected		Effectiveness		
		Agree	Neutral	Disagree
Knowledge	Above moderate	0.306	3.151	0.057
	Moderate	0.000	0.149	0.109
	Below moderate	0.827	6.017	0.003

Key:

Knowledge: Respondent's self-reported knowledge about the VCM. Likert scale: 1 (a great deal) & 2 (a lot) -> **Above Moderate**, 3 (a moderate amount) -> **Moderate**, 4 (a little) & 5 (none at all) -> **Below moderate**

Effectiveness: Carbon offsetting is an effective way to abate GHG emissions. Likert scale: 1 (strongly agree) & 2 (somewhat agree) -> **Agree**, 3 (neither agree or disagree) -> N**eutral**, 4 (somewhat disagree) & 5 (strongly disagree) -> **Disagree**

Summary

Calculated χ^2	10.619
Uncertainty level	0.05
Degree of freedom	4
Critical value, c	9.488
p value	0.031
Reject H_0?	Yes, they are not independent

3) Expectations of others' and own participation are independent of each other

Observed		Institution			
		Yes	Maybe	No	Sum
Other	Yes	45	17	10	72
	Maybe	6	5	7	18
	No	2	1	4	7
	Sum	53	23	21	97

Probabilities	Other	Probability	Institution	Probability
	Yes	0.742	Yes	0.546
	Maybe	0.186	Maybe	0.237
	No	0.072	No	0.216

Probability contingency table		Institution		
		Yes	Maybe	No
Other	Yes	0.406	0.176	0.161
	Maybe	0.101	0.044	0.040
	No	0.039	0.017	0.016

Frequency contingency table (Expected)		Institution		
		Yes	Maybe	No
Other	Yes	39.340	17.072	15.588
	Maybe	9.835	4.268	3.897
	No	3.825	1.660	1.515

(Observed-Expected)^2/Expected		Institution		
		Yes	Maybe	No
Other	Yes	0.814	0.000	2.003
	Maybe	1.495	0.126	2.471
	No	0.871	0.262	4.073

Key:

Other The Paris Agreement on climate change will increase other organisations' participation in voluntary carbon offsetting. Likert scale: 1 (definitely yes) & 2 (probably yes) -> **Yes**, 3 (might or might not) -> **Maybe**, 4 (probably no) & 5 (definitely no) -> **No**

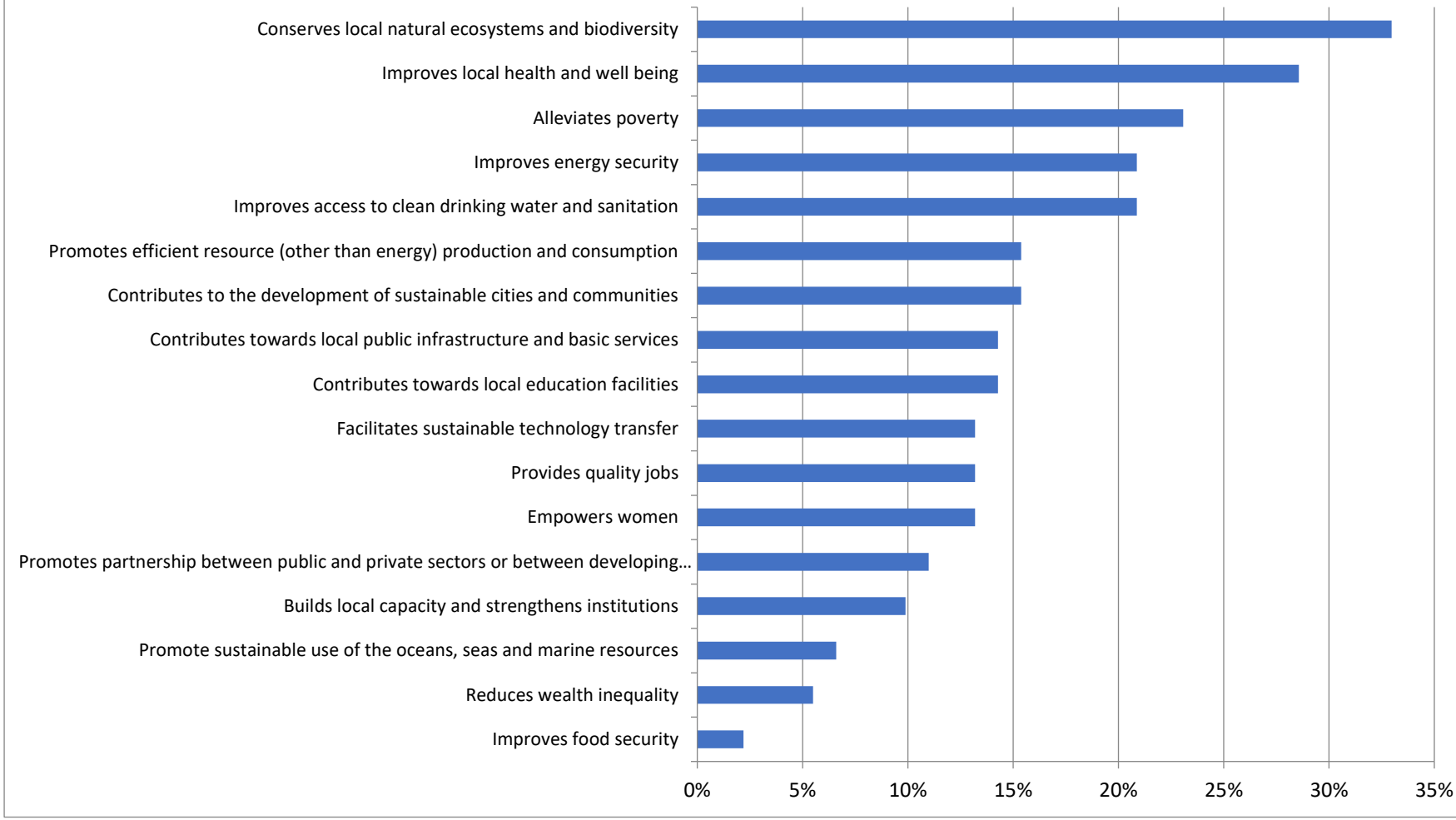
Institution The Paris Agreement on climate change will increase respondent's participation in voluntary carbon offsetting. Likert scale: 1 (definitely yes) & 2 (probably yes) -> **Yes**, 3 (might or might not) -> **Maybe**, 4 (probably no) & 5 (definitely no) -> **No**

Summary

Calculated χ^2	12.116
Uncertainty level	0.05
Degree of freedom	4
Critical value, c	9.488
p value	0.017
Reject H_0?	Yes, they are not independent

Appendix 7-4: Preferred offset co-benefits

If you are looking to purchase offsets, which of the following co-benefits would you prefer to support in a voluntary offset project? Please select a maximum of three choices.



Appendix 7-5: MWU test for comparing WTP of offset users and non-users for offset

MWU test for investigating if the WTP of offsets users and non-users for voluntary offset alone are significantly different. The null hypothesis states that they are not significantly different.

WTP		Ranking	
User	Non-user	User	Non-user
18.01	10.01	78	67.5
2.01	8.01	25	59.5
10.01	18.01	67.5	78
8.01	6.01	59.5	50
18.01	2.01	78	25
2.01	2.01	25	25
2.01	0.01	25	11.5
2.01	2.01	25	25
25	18.01	84	78
4.01	0.01	38.5	11.5
4.01	2.01	38.5	25
8.01	8.01	59.5	59.5
2.01	12.01	25	73.5
8.01	6.01	59.5	50
2.01	4.01	25	38.5
6.01	4.01	50	38.5
0.01	20.01	11.5	82
8.01	4.01	59.5	38.5
0.01	4.01	11.5	38.5
6.01	6.01	50	50
10.01	18.01	67.5	78
0.01	20.01	11.5	82
2.01	2.01	25	25
10.01	12.01	67.5	73.5
2.01	20.01	25	82
6.01	4.01	50	38.5
0.01	4.01	11.5	38.5
12.01	4.01	73.5	38.5
0	6.01	3	50
4.01	0	38.5	3
2.01	0.01	25	11.5
2.01	6.01	25	50
0.01	4.01	11.5	38.5
4.01	10.01	38.5	67.5
0.01	10.01	11.5	67.5
0.01	6.01	11.5	50
10.01	0	67.5	3

6.01	10.01	50	67.5
12.01	0.01	73.5	11.5
0	0	3	3
0.01	8.01	11.5	59.5
8.01	30	59.5	85
6.01		50	

	R	n	U
User	1707	43	1045.5
Non-user	1949	42	760.5
U1+U2	1806		
n1*n2	1806		
mean	903		
std dev	114		
Z statistic	-1.25		
Critical value	-1.96		
IZI is < c, so cannot reject null hypothesis			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 7-6: MWU test for comparing WTP for offset and offset with co-benefits

MWU test for investigating if the WTP for voluntary offset alone and voluntary offset with co-benefits are significantly different. The null hypothesis states that they are not significantly different.

WTP		Ranking	
Offset alone	Offset with co-benefits	Offset alone	Offset with co-benefits
10.01	10.01	110	110
18.01	40	148	167.5
2.01	6.01	33	74.5
10.01	18.01	110	148
8.01	12.01	92	125
8.01	12.01	92	125
18.01	18.01	148	148
18.01	18.01	148	148
6.01	16.01	74.5	139.5
2.01	4.01	33	55.5
2.01	4.01	33	55.5
0.01	4.01	13	55.5
2.01	8.01	33	92
2.01	2.01	33	33
2.01	4.01	33	55.5
2.01	6.01	33	74.5
25	20.01	163	158.5
4.01	14.01	55.5	134
18.01	40	148	167.5
4.01	8.01	55.5	92
8.01	10.01	92	110
2.01	2.01	33	33
8.01	10.01	92	110
2.01	6.01	33	74.5
6.01	8.01	74.5	92
0.01	4.01	13	55.5
8.01	12.01	92	125
0.01	4.01	13	55.5
0.01	2.01	13	33
2.01	6.01	33	74.5
6.01	10.01	74.5	110
10.01	30	110	165
8.01	10.01	92	110
0.01	6.01	13	74.5
12.01	16.01	125	139.5
2.01	6.01	33	74.5

6.01	14.01	74.5	134
10.01	16.01	110	139.5
4.01	16.01	55.5	139.5
4.01	8.01	55.5	92
20.01	20.01	158.5	158.5
2.01	4.01	33	55.5
4.01	10.01	55.5	110
4.01	12.01	55.5	125
6.01	10.01	74.5	110
6.01	14.01	74.5	134
18.01	18.01	148	148
20.01	20.01	158.5	158.5
0.01	0.01	13	13
2.01	10.01	33	110
12.01	20.01	125	158.5
12.01	18.01	125	148
20.01	10.01	158.5	110
0	20.01	3	158.5
4.01	10.01	55.5	110
4.01	12.01	55.5	125
2.01	4.01	33	55.5
2.01	2.01	33	33
0.01	2.01	13	33
4.01	8.01	55.5	92
4.01	14.01	55.5	134
0.01	2.01	13	33
0.01	0.01	13	13
4.01	6.01	55.5	74.5
10.01	14.01	110	134
6.01	8.01	74.5	92
6.01	8.01	74.5	92
0	0.01	3	13
0.01	2.01	13	33
6.01	18.01	74.5	148
12.01	12.01	125	125
0	2.01	3	33
4.01	18.01	55.5	148
10.01	18.01	110	148
0.01	2.01	13	33
10.01	14.01	110	134
6.01	8.01	74.5	92
8.01	12.01	92	125
10.01	14.01	110	134
0.01	2.01	13	33
0	0	3	3
8.01	10.01	92	110

30	30	165	165
6.01	8.01	74.5	92

	R	n	U
Offset alone	5808	84	4818
Offset with co-benefits	8388	84	2238
U1+U2	7056		
n1*n2	7056		
mean	3528		
std dev	315		
Z statistic	-4.09		
Critical value	-1.96		
IZI is > c, so can reject null hypothesis			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 7-7: MWU test for comparing WTP for offset with and without provision of co-benefit monetary values

MWU test for investigating if provision of co-benefit monetary values can significantly influence respondent's WTP for voluntary offset. The null hypothesis states that the WTP for offset with and without provision of co-benefit monetary values are not significantly different.

WTP		Ranking	
Quan	No quan	Quan	No quan
40	10.01	83.5	44
18.01	6.01	71.5	26
12.01	12.01	53	53
18.01	18.01	71.5	71.5
16.01	8.01	65.5	34
4.01	4.01	18.5	18.5
4.01	6.01	18.5	26
4.01	20.01	18.5	78
2.01	14.01	9.5	60
40	10.01	83.5	44
8.01	2.01	34	9.5
10.01	4.01	44	18.5
6.01	12.01	26	53
8.01	4.01	34	18.5
2.01	10.01	9.5	44
6.01	10.01	26	44
30	16.01	81.5	65.5
6.01	6.01	26	26
14.01	16.01	60	65.5
16.01	8.01	65.5	34
20.01	4.01	78	18.5
12.01	10.01	53	44
14.01	10.01	60	44
18.01	0.01	71.5	3
20.01	20.01	78	78
10.01	18.01	44	71.5
10.01	20.01	44	78
10.01	12.01	44	53
2.01	4.01	9.5	18.5
2.01	2.01	9.5	9.5
0.01	8.01	3	34
14.01	14.01	60	60
8.01	6.01	34	26
8.01	2.01	34	9.5
0.01	18.01	3	71.5
12.01	2.01	53	9.5

18.01	18.01	71.5	71.5
2.01	8.01	9.5	34
14.01	0	60	1
12.01	10.01	53	44
14.01	30	60	81.5
2.01	8.01	9.5	34

	R	n	U
Quan	1842	42	825
No quan	1728	42	939
U1+U2	1764		
n1*n2	1764		
mean	882		
std dev	112		
Z statistic	0.51		
Critical value	-1.96		
IZI is < c, so cannot reject null hypothesis			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 7-8: MWU test for comparing WTP of offset users and non-users for offset with co-benefits

MWU test for investigating if the WTP of offsets users and non-users for voluntary offset with co-benefits are significantly different. The null hypothesis states that they are not significantly different.

WTP		Ranking	
User	Non-user	User	Non-user
40	10.01	83.5	44
6.01	12.01	26	53
18.01	18.01	71.5	71.5
12.01	16.01	53	65.5
18.01	4.01	71.5	18.5
8.01	4.01	34	18.5
2.01	4.01	9.5	18.5
4.01	6.01	18.5	26
20.01	40	78	83.5
14.01	2.01	60	9.5
8.01	6.01	34	26
10.01	10.01	44	44
2.01	16.01	9.5	65.5
10.01	14.01	44	60
6.01	16.01	26	65.5
8.01	8.01	34	34
4.01	20.01	18.5	78
12.01	10.01	53	44
4.01	12.01	18.5	53
10.01	10.01	44	44
30	18.01	81.5	71.5
6.01	20.01	26	78
6.01	10.01	26	44
16.01	20.01	65.5	78
4.01	10.01	18.5	44
14.01	10.01	60	44
0.01	8.01	3	34
18.01	6.01	71.5	26
20.01	8.01	78	34
12.01	0.01	53	3
4.01	2.01	18.5	9.5
2.01	18.01	9.5	71.5
2.01	18.01	9.5	71.5
14.01	18.01	60	71.5
2.01	14.01	9.5	60
0.01	8.01	3	34
14.01	14.01	60	60

8.01	2.01	34	9.5
12.01	0	53	1
2.01	10.01	9.5	44
2.01	30	9.5	81.5
12.01		53	
8.01		34	

	R	n	U
User	1677	43	1032
Non-user	1893	41	731
U1+U2	1763		
n1*n2	1763		
mean	881.5		
std dev	112		
Z statistic	-1.35		
Critical value	-1.96		
IZI is < c, so cannot reject null hypothesis			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 7-9: MWU test for comparing offset users' WTP and actual price paid for voluntary offset

MWU test for investigating if the stated WTP of offset users for voluntary offset and offset with co-benefits are significantly different from the actual price they paid.

1) Null hypothesis, H_0: The stated WTP for offset alone is not significantly different from the actual price paid

	R	n	U
Paid 2015	711	27	396.5
WTP1	775	27	332.5
U1+U2	729		
n1*n2	729		
mean	364.5		
std dev	58		
Z statistic	-0.55		
Critical value	-1.96		
IZI is < c, so cannot reject null hypothesis			

2) Null hypothesis, H_0: The stated WTP for offset with co-benefits is not significantly different from the actual price paid

	R	n	U
Paid 2015	554	27	553
WTP2	931	27	176
U1+U2	729		
n1*n2	729		
mean	364.5		
std dev	58		
Z statistic	-3.26		
Critical value	-1.96		
IZI is < c, so cannot reject null hypothesis			

R = sum of ranking
n = number of observations
U = (n1*n2)+((0.5*n1)*(n1+1))-R1 or (n1*n2)+((0.5*n2)*(n2+1))-R2

Appendix 8-1: Full results of Survey 2 RPL model with interactions

	RPL with interactions
Mean	
Offset (ASC)	0.220 (2.602)
Social co-benefit	5.096 (1.559) ***
Economic co-benefit	2.270 (1.399)
Environmental co-benefit	2.281 (1.518)
Co-benefit verification	1.463 (1.545)
Price	-2.046 (0.183) ***
Standard deviation	
Offset (ASC)	2.453 (0.611) ***
Social co-benefit	-0.048 (1.359)
Economic co-benefit	-0.019 (0.604)
Environment co-benefit	-0.035 (0.508)
Co-benefit verification	1.647 (0.334) ***
Price	0.610 (0.148) ***
Interactions terms	
PROFIT*Offset	1.574 (2.280)
PROFIT*Social co-benefit	-3.195 (1.328) **
PROFIT*Economic co-benefit	-0.414 (1.184)
PROFIT*Environmental co-benefit	-1.754 (1.353)
PROFIT*Co-benefit verification	-1.091 (1.362)
PUBLIC*Offset	2.163 (2.533)
PUBLIC*Social co-benefit	-3.091 (1.432) **
PUBLIC*Economic co-benefit	-1.479 (1.328)
PUBLIC*Environmental co-benefit	-1.725 (1.449)
PUBLIC*Co-benefit verification	-0.665 (1.515)
ANNEXI_EU*Offset	0.237 (1.316)
ANNEXI_EU*Social co-benefit	-1.643 (0.714) **
ANNEXI_EU*Economic co-benefit	-1.255 (0.693) *

	RPL with interactions
ANNEXI_EU*Environmental co-benefit	0.902 (0.698)
ANNEXI_EU*Co-benefit verification	0.253 (0.771)
ANNEXI_NONEU*Offset	0.173 (1.519)
ANNEXI_NONEU*Social co-benefit	-2.008 (0.839) **
ANNEXI_NONEU*Economic co-benefit	-0.699 (0.809)
ANNEXI_NONEU*Environmental co-benefit	0.737 (0.825)
ANNEXI_NONEU*Co-benefit verification	1.082 (0.921)
ENERGY*Offset	-3.565 (1.500) **
ENERGY*Social co-benefit	-0.327 (0.768)
ENERGY*Economic co-benefit	2.789 (0.835) ***
ENERGY*Environmental co-benefit	0.724 (0.795)
ENERGY*Co-benefit verification	1.145 (0.941)
FINANCE*Offset	-0.063 (1.684)
FINANCE*Social co-benefit	0.270 (0.805)
FINANCE*Economic co-benefit	0.677 (0.844)
FINANCE*Environmental co-benefit	0.721 (0.776)
FINANCE*Co-benefit verification	0.248 (0.914)
TRANSPORT*Offset	0.419 (1.707)
TRANSPORT*Social co-benefit	-0.845 (0.843)
TRANSPORT*Economic co-benefit	1.165 (0.819)
TRANSPORT*Environmental co-benefit	0.249 (0.884)
TRANSPORT*Co-benefit verification	1.210 (0.928)
PROFESSIONAL*Offset	-3.079 (1.436) **
PROFESSIONAL*Social co-benefit	-0.114 (0.756)
PROFESSIONAL*Economic co-benefit	1.825 (0.750) **
PROFESSIONAL*Environmental co-benefit	0.006 (0.744)
PROFESSIONAL*Co-benefit verification	0.392 (0.910)

	RPL with interactions
INFORMATION*Offset	0.629 (2.001)
INFORMATION*Social co-benefit	-0.457 (0.982)
INFORMATION*Economic co-benefit	-0.231 (1.028)
INFORMATION*Environmental co-benefit	-0.089 (0.924)
INFORMATION*Co-benefit verification	0.210 (1.079)
USER*Offset	1.647 (0.988) *
USER*Social co-benefit	-0.217 (0.520)
USER*Economic co-benefit	-0.651 (0.514)
USER*Environmental co-benefit	-0.635 (0.527)
USER*Co-benefit verification	-1.131 (0.611) *
COBENEFIT*Social co-benefit	1.082 (0.749)
COBENEFIT*Economic co-benefit	-0.020 (0.781)
COBENEFIT*Environmental co-benefit	-0.141 (0.738)
COBENEFITVER*Co-benefit verification	1.573 (0.685) **
Model fit	
No. of observations	1,350
Log likelihood (null)	-494.376
Log likelihood (model)	-324.771
Pseudo R^2	0.343
Adjusted pseudo R^2	0.210

Appendix 8-2: Chi-square tests to compare the choice patterns of offset users and non-users

1) Chi-square test to examine if the proportions of offset users and non-users that received Block A and Block B are significantly different. The null hypotheses, H_0: the proportions of are equal.

Observed	Block A	Block B	Sum
Users	24	22	46
Non-users	20	26	46
Sum	44	48	92

Probabilities

Users	0.500
Non-users	0.500
Block A	0.478
Block B	0.522

Frequency contingency table (expected)	Block A	Block B
Users	22.000	24.000
Non-users	22.000	24.000

(Observed-Expected)^2/Expected	Block A	Block B
Users	0.182	0.167
Non-users	0.182	0.167

Summary

χ^2	0.697
d.f.	1
Critical value	3.841
p value	0.40
Reject H_0?	No

2) Chi-square test to examine if the Block A choice shares of offset users and non-users are significantly different. The null hypotheses, H_0: the choice shares are equal.

Observed	Alternative A	Alternative B	Opt out	Sum
Users	50	57	13	120
Non-users	36	49	15	100
Sum	86	106	28	220

Probabilities

Users	0.545
Non-users	0.455
Alternative A	0.391
Alternative B	0.482
Opt out	0.127

Frequency contingency table (expected)	Alternative A	Alternative B	Opt out
Users	46.909	57.818	15.273
Non-users	39.091	48.182	12.727

(Observed-Expected)^2/Expected	Alternative A	Alternative B	Opt out
Users	0.204	0.012	0.338
Non-users	0.244	0.014	0.406

Summary

χ^2	1.218
d.f.	2
Critical value	5.991
p value	0.54
Reject H_0?	No

3) Chi-square test to examine if the Block B choice shares of offset users and non-users are significantly different. The null hypotheses, H_0: the choice shares are equal.

Expected	Alternative A	Alternative B	Opt out	Sum
Users	38	53	19	110
Non-users	41	62	27	130
Sum	79	115	46	240

Probabilities

Users	0.458
Non-users	0.542
A	0.329
B	0.479
Opt out	0.192

Frequency contingency table (Expected)	Alternative A	Alternative B	Opt out
Users	36.208	52.708	21.083
Non-users	42.792	62.292	24.917

(Observed-Expected)^2/Expected	Alternative A	Alternative B	Opt out
Users	0.089	0.002	0.206
Non-users	0.075	0.001	0.174

Summary

χ^2	0.547
d.f.	2
Critical value	5.991
p value	0.76
Reject H_0?	No

Appendix 9-1: Chi-square test to compare offset users' profiles of Survey 1 and 2

The null hypotheses, H_0: the proportions of Survey 1 and 2 are equal.

1) Organisation type

Observed	Profit	Other	Total
Survey 1	50	5	55
Survey 2	38	8	46
Total	88	13	101

Probabilities

Survey 1	0.545
Survey 2	0.455
Profit	0.871
Other	0.129

Frequency contingency table (Expected)	Profit	Other
Survey 1	47.921	7.079
Survey 2	40.079	5.921

(Observed-Expected)^2/Expected	Profit	Other
Survey 1	0.090	0.611
Survey 2	0.108	0.730

Summary

χ^2	1.539
d.f.	2
Critical value	5.991
p value	0.21
Reject H_0?	No

2) Organisation location

Observed	AnnexIEU	AnnexI_non EU	Other	Total
Survey 1	38	12	5	55
Survey 2	31	10	5	46
Total	69	22	10	101

Probabilities

Survey 1	0.545
Survey 2	0.455
AnnexIEU	0.683
AnnexI_nonEU	0.218
Other	0.099

Frequency contingency table (Expected)	AnnexIEU	AnnexI_non EU	Other
Survey 1	37.574	11.980	5.446
Survey 2	31.426	10.020	4.554

(Observed-Expected)^2/Expected	AnnexIEU	AnnexI_non EU	Other
Survey 1	0.005	0.000	0.036
Survey 2	0.006	0.000	0.044

Summary

χ^2	0.091
d.f.	2
Critical value	5.991
Chi test	0.96
Reject H_0?	No

3) Organisation sector

Observed	Energy	Finance	Information	Transport	Professional	Other	Total
Survey 1	3	12	6	9	9	16	55
Survey 2	8	7	6	7	6	12	46
Total	11	19	12	16	15	28	101

Probabilities

Survey 1	0.545
Survey 2	0.455
Energy	0.109
Finance	0.188
Information	0.119
Transport	0.158
Professional	0.149
Other	0.277

Frequency contingency table (Expected)	Energy	Finance	Information	Transport	Professional	Other
Survey 1	5.990	10.347	6.535	8.713	8.168	15.248
Survey 2	5.010	8.653	5.465	7.287	6.832	12.752

(Observed-Expected)^2/Expected

Survey 1	1.493	0.264	0.044	0.009	0.085	0.037
Survey 2	1.785	0.316	0.052	0.011	0.101	0.044

Summary

χ^2	4.242
d.f.	5
Critical value	11.070
Chi test	0.52
Reject H_0?	No

Appendix 9-2: Chi-square tests to compare the choice patterns of offset users in Survey 1 and Survey 2

1) Chi-square test to examine if the proportions of offset users in Survey 1 and Survey 2 that received Block A and Block B are significantly different. The null hypotheses, H_0: the proportions of are equal.

Observed	Block A	Block B	Sum
Users	30	25	55
Non-users	24	22	46
Sum	54	47	101

Probabilities

Users	0.545
Non-users	0.455
Block A	0.535
Block B	0.465

Frequency contingency table (expected)	Block A	Block B
Users	29.406	25.594
Non-users	24.594	21.406

(Observed-Expected)^2/Expected	Block A	Block B
Users	0.012	0.014
Non-users	0.014	0.016

Summary

χ^2	0.057
d.f.	1
Critical value	3.841
p value	0.81
Reject H_0?	No

2) Chi-square test to examine if the Block A choice shares of offset users in Survey 1 and Survey 2 are significantly different. The null hypotheses, H_0: the choice shares are equal.

Observed	Alternative A	Alternative B	Opt out	Sum
Users	60	66	24	150
Non-users	50	57	13	120
Sum	110	123	37	270

Probabilities

Users	0.556
Non-users	0.444
Alternative A	0.407
Alternative B	0.456
Opt out	0.137

Frequency contingency table (expected)	Alternative A	Alternative B	Opt out
Users	61.111	68.333	20.556
Non-users	48.889	54.667	16.444

(Observed-Expected)^2/Expected	Alternative A	Alternative B	Opt out
Users	0.020	0.080	0.577
Non-users	0.025	0.100	0.721

Summary

χ^2	1.523
d.f.	2
Critical value	5.991
p value	0.47
Reject H_0?	No

3) Chi-square test to examine if the Block B choice shares of offset users in Survey 1 and Survey 2 are significantly different. The null hypotheses, H_0: the choice shares are equal.

Expected	Alternative A	Alternative B	Opt out	Sum
Users	38	54	33	125
Non-users	38	53	19	110
Sum	76	107	52	235

Probabilities

Users	0.532
Non-users	0.468
A	0.323
B	0.455
Opt out	0.221

Frequency contingency table (Expected)	Alternative A	Alternative B	Opt out
Users	40.426	56.915	27.660
Non-users	35.574	50.085	24.340

(Observed-Expected)^2/Expected	Alternative A	Alternative B	Opt out
Users	0.146	0.149	1.031
Non-users	0.165	0.170	1.172

Summary

χ^2	2.833
d.f.	2
Critical value	5.991
p value	0.24
Reject H_0?	No

Appendix 10-1: Project classification by different standards

VCS	GS	CDM
Energy (renewable/non-renewable) Energy distribution Energy demand Manufacturing industries Chemical industry Transport Mining/mineral production Metal production Fugitive emissions from fuels Fugitive emissions from industrial gases Waste handling and disposal Agriculture, Forestry, Land use Livestock and manure management	Biogas – cogeneration Biogas – electricity Biogas – heat Biomass Energy efficiency – domestic Energy efficiency – industrial Energy efficiency – public sector Geothermal Other PV Small hydro Solar thermal – heat Wind	Afforestation Biomass energy Cement CO2 usage Coal bed/mine methane EE households EE industry EE own generation EE service EE supply side Energy distribution Fossil fuel switch Fugitive Geothermal HFCs Hydro Landfill gas Methane avoidance Mixed renewables N2O PFCs and SF6 Reforestation Solar Tidal Transport Wind