Title Page

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Abstract

This research paper explores the current and future role of Corporate Social Responsibility (CSR) as a critical factor in the decision-making process for adopting cloud computing. Initially highlighting the issue of and abatement policies relating to global warming and specifically the damage caused by greenhouse gas emissions (GHG) created by human activity, such as electricity generation, the paper identifies the information and communications (ICT) technology sector as both a major contributor to CO2 emissions as well as a considerable enabler to future abatement. The popularisation of cloud computing as a model for ICT consumption is discussed and the paper examines, challenges and hones cloud computing's ability to reduce GHG emissions by comparing energy efficiency, infrastructure utilisation and 'clean' energy consumption between on premise and cloud data centres. Current cloud computing adoption drivers are researched and discussed to identify if CSR is prevalent. Using data drawn from ten credible secondary data surveys including the views of 5,888 ICT executives it is concluded that CSR is not yet a key driver despite cloud computing's substantiated ability to reduce emissions over on premise computing. This negative outcome is challenged via a series of primary data convenience interviews and survey conducted with 71 ICT executives to examine if CSR drivers are being masked behind the current predominant key driver of cost reduction. The idea is proven unfounded with CSR ranking as the least important driver despite the salient points of global warming, cloud computing's green credentials and specific related government policies being discussed during the sampling process. As such the research concludes that as the time between now and the identified ecological tipping point of 2050 shortens, CSR is well positioned to emerge as a key driver but only if the link between cloud computing's ability to reduce emissions and global warming / the tightening of government emission policy is made at both the individual and company level.

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Declaration of Authenticity

DECLARATIONS

I declare that the material contained in this project is the end result of my own work and that due acknowledgement has been given in the bibliography and references to ALL sources be they printed, electronic or personal.

And that:

The Word Count of this Project is 14,692.

SIGNED: Justin Sutton-Parker

DATE: 11th January 2016

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Glossary

BPAAS - Business process as a service is the outsourcing of business processes to cloud computing

CAGR - Compound annual growth rate measures growth across multiple years

CAPEX - Capital expenditure is funding used by an organisation or company to buy or upgrade physical assets

Clean / Green / Renewable Energy – Energy created from non-fossil derived renewable resources including solar, wind and hydroelectric

Cloud Computing - Cloud Computing is the consumption of Information Communication Technologies (ICT) as a utility service supplied by computing infrastructures located within the data centres of cloud computing service providers

CO2e - Carbon dioxide equivalent is a unit of measurement to convert all greenhouses gases to an equivalent amount of carbon dioxide in order to calculate carbon footprint

CSR - Corporate social responsibility is a practice undertaken by businesses or organisations to deliver sustainable economic, social and environmental benefits.

CUE - Carbon Usage Effectiveness is a sustainability measurement that reports carbon emissions per kilowatt hour intensity for data centres

Data Sovereignty - Data sovereignty is the practice of applying country law to the storage of digital information

Fossil Fuel - Energy created from non-renewal fossil derived sources such as coal, oil and gas

Gigaton - the equivalent of 1 billion tons

GHG - Greenhouse gases are referred to as such due to their ability to increase global temperatures by limiting Earth's eco-system's ability to manage levels of infrared radiation levels. They include Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Ozone (O_3) and Chlorofluorocarbons (CFCs), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6)

GWh - Gigawatt hours is a unit of energy measurement equal to 1,000,000 kilo watt hours or 1,000 megawatt hours (see Kwh)

IAAS - Infrastructure as a service is the consumption of computing resources via cloud computing across the internet and / or secure private leased lines / encrypted public network connections

ICT - Information and communications technology is the encompassing or unified term for computing and unified communications technology used for the creation, manipulation, storage and transfer of digital information (see also UC&C)

ISO5001 – A certificate / accreditation awarded for meeting the International Organisation for Standardisation requirements relating to energy management systems

KPI - Key performance indicators are metrics applied in business to individuals and business units / departments to evaluate success against key factors or initiatives deemed vital to the overall success of the organisation.

kWh - Kilowatt hours is a unit of energy measurement equal to the constant supply of 1kW of power for one hour

LAN - Local area networks is a cable or wireless network connecting locally positioned computing systems and resources.

MWh - Megawatt hours is a unit of energy measurement equal to 1,000 kilo watt hours (see kWh)

OPEX - Operating expenditure is the cost attributed to a business or organisation carrying out normal business operations.

On Premise Computing - ICT infrastructure resources situated within premises owned by the consuming company

PAAS - Platform as a service is a cloud computing service that enables consumers to develop, test and operate applications

PPA - Power purchase agreements is a contract between a supplier of energy (power) and the consumer

PUE - Power usage effectiveness is an equation used to calculating a data centre's energy efficiency

REC - Renewable energy certificates are energy commodities measured in units of 1 MWh that can be traded to enable the owner to report that renewable energy has been purchased.

SAAS – Software as a service is the consumption of software capabilities or resources on a flexible utility basis via cloud computing

TBL – Triple bottom line is a non-traditional accounting approach that looks beyond standard economic accounting procedures where profit and loss are used to calculate the 'bottom line'. Instead two further performance elements associated to social (people) and environmental (planet) are introduced to compliment the financial (profit) results.

TWh - Terawatt hours is a unit of energy measurement equal to 1000,000,000 kilo watt hours (see Kwh)

Service Provider - A business supplying cloud computing services to customers delivered via the internet and / or secure private leased lines / encrypted public network connections

UC&C – Unified communication and collaboration is the integration of communications and collaborative computing solutions to increase productivity

1. Introduction

1.1 What is Cloud Computing?

Cloud Computing is the consumption of Information Communication Technologies (ICT) as a utility service supplied by computing infrastructures located within the data centres of cloud computing service providers such as Amazon Web Services (AWS), Rackspace, Microsoft and Google amongst many others. Consumers access cloud computing via public networks such as internet technologies or secure private leased lines / encrypted public network connections. Located away from the consumer's premises, cloud computing services operate on a shared infrastructure known as public cloud, a dedicated infrastructure known as private cloud or a mixture of both known as hybrid. Popular cloud computing services include infrastructure (compute, networking and storage) as a service (IAAS), unified communications and collaboration (UC&C), business process (BPAAS), platform (PAAS) and software as a service (SAAS).

1.2 Cloud Computing Adoption in the United Kingdom

Prior to the advent of the cloud computing era in 2010 (McAfee, 2010), over 90% of business ICT infrastructure was located within the consuming organisation's data centre (Duncan, 2015) and accessed by local area networks (LAN). This is referred to as 'traditional' or 'on premise' computing. Over the last five years there has been a shift towards companies incorporating 'off premise' cloud computing as part of ICT strategy and adoption is forecasted to reach 40% by 2020 (Lamy, 2015). Growing popularity in cloud computing is ratified by AWS's recent announcement that their cloud service business had grown 49% in 2015 to $5bn turnover (Forbes, 2015) (Harding, 2015). Equally Microsoft's public cloud PaaS business grew 128% reaching $6.3bn (Foley, 2015). As such, IDC reports (Fernandez et al, 2015) that global cloud service provider spending on server, storage and networking infrastructure required to deliver cloud services increased to $26.4bn in 2014 in response to rising demand. This figure represents 28.1% of the worldwide total ICT infrastructure spend and is forecasted to reach $41bn or 44% share by 2018 (Yezhkova et al, 2015). In 2014, the total European cloud services industry was valued at $42bn with a 27% compound annual growth rate (CAGR) forecasted to 2017 (Arend & Carter, 2014). The United Kingdom (UK) represents between 23% (Mohr, 2015) and 25% (Fellows, 2014) of this market as highlighted by the UK Government backed figure (HM Government, 2014) of $10bn (TechMarketView, 2010) for 2014. It is therefore reasonable to state that cloud computing adoption in UK is high and experiencing a 27% CAGR across a five year period rising from $10bn in 2014 to a projected $33bn in 2018.

1.3 What is Driving Cloud Computing Adoption?

Grant cites that the most successful method to overcome key weaknesses in business is to outsource (Grant, 2008). Cloud computing enables organisations to do exactly this by effectively outsourcing a portion, or sometimes all, of their ICT functions. Service providers market the benefits (Rackspace, 2015) (Salesforce, 2015) (SkyScape, 2015.1) associated with this transfer of function by detailing the positive effects delivered to the consumers' Triple Bottom Line (Elkington, 1999). These effects include:

- 'Profit' retention and cash flow fluidity enabled by switching from high capital expenditure (CAPEX) related to on premise ICT purchase to predictable operational utility style expenditure (OPEX) delivered by pay as you consume scalable cloud computing (Gerwitz, 2014)
- 'People' productivity increases delivered by enhanced workforce mobility enabling flexi-time and home working (Masanet et al, 2013) via 'access anywhere' browser based applications (Microsoft, 2015)
- 'Planet' focused benefits related to zero carbon computing (Google, 2015) (Skyscape, 2015.2) (Salesforce, 2014) achieved by ultra-efficient and clean energy (Greenpeace, 2014) service provider data centres

Whilst service providers evangelise the three aspects of the triple bottom line, market data examined within this paper indicates that consumers are currently focused more on profit and people as key drivers for adopting cloud computing than planet (King, et al, 2011) (Hill, 2011) (Interxion, 2011) (Bell, 2014) (Ffoulkes, 2015) (Gehringer, 2014) (Skok, 2014) (Oxford Economics, 2014) (CIF, 2015) (Rightscale, 2015). With a groundswell of information verifying the ecological benefits delivered by cloud computing examined in this research, questioning whether consumers are simply unaware or perhaps indifferent to the 'planet' effect is key to understanding the position of Corporate and Social Responsibility (CSR) as a driver for the adoption of cloud computing.

1.4 Should UK Cloud Computing Consumers be interested in CSR?

In 1972 the United Nations highlighted that 'acid' or polluted rain (United Nations, 1972) had begun to damage Earth's environment (Granat, 1972). The source of the increased atmospheric pollution was identified as heat and toxins from gas emissions created by electricity generation, factories and vehicles. Subsequent studies have built upon this subject of anthropogenic interference determining the Industrial Revolution as the starting point for the significant change in atmospheric pollution (Houghton, 1990). If left unabated scientists have determined that the year 2050 will be a tipping point when anthropogenic harm to the ecosystem will become irreversible (Bernstein et al, 2007). Already proven related environmental crisis such as the depletion of the ozone layer (Crutzen, 1995) and global warming (Houghton, 1990) have caused nations to appreciate the reality of this issue and to create international conventions (UNEP, 1985) (United Nations, 1992) (UNEP, 1987) (United Nations, 1998) outlining counter measures to reverse the damage caused by emissions. Arguably the most significant of these agreements is the Kyoto Protocol (United Nations, 1998), an international treaty created to formulise greenhouse gas (GHG) (Houghton, 1990) emission reduction targets for thirty nine developed countries. Using 1990 as a baseline, targets range from as high as 110% reduction for Iceland and 92% for the majority of Europe (United Nations, 1998). By 2012 all included nations were expected to have reached at least 5% below 1990 levels. To ensure that the UK complied, the UK Government passed the Climate Change Act (HM Government, 2008). Focusing upon lowering UK GHG emissions to 80% below baseline by 2050, the legislation included Carbon Budgets (CCC, 2015). Aptly named after the gas carbon dioxide (CO_2), determined as responsible for over 80% of all harmful UK GHG emissions (Webb et al, 2014), the budgets forecast and measure progress across four 5 year 'carbon accounting' periods from 2008 to 2027. The latter period, if current successful reductions of 28% continue (HM Government, 2011), will see the UK reach a 50% reduction to 1,950 million tonnes carbon dioxide equivalent ($MtCO_2e$) emissions (HM Government, 2011).

Unsurprisingly, considering the Industrial Revolution is cited as the catalyst for climate change, reducing UK industry CO_2 emissions is determined as key to this success. In 2011 the UK government produced a Carbon Plan that outlined industry 'Sectoral' plans (HM Government, 2011) for low carbon initiatives in key sectors of Domestic Buildings, Transport, Industry, Power Generation, and Agriculture & Forestry. The document states that during the next decade the UK will install proven technologies to aid reduction of GHG emissions (HM Government, 2011). Whilst much of these technologies relate to renewable energy sources, such as wind farms, ICT is highlighted as a key enabler. This idea is examined in depth in the SMARTer 2020 (GeSI, 2012) report concluding that ICT innovation in industry could be capable of reducing emissions by 16.5% by 2020. The European Environment Agency (Dejean, 2014) and Greenpeace (Myslewski, 2010) concur suggesting the way in which the IT services are consumed moving forward will play a pivotal role in whether or not the UK (and Europe) meets Kyoto reduction targets.

Whether the source of emission reduction is ICT, sustainable technologies or more likely a mix of the two, the threat of climate change is real and the UK Government is determined to encourage industry to act immediately. In 2013 HM Government introduced a mandatory requirement for all London Stock Exchange (LSE) listed companies to report GHG emissions with a view to improvement. Enforced by the spectre of unlimited fines for failure to comply (Gov.uk, 2015) and in a pilot phase to include a further large section of limited companies (HM Government, 2013) the policy implies that CSR ought to be of interest to UK companies and organisations. As cloud computing service providers suggest they can deliver near carbon zero computing capabilities then CSR should be of interest to consumers of cloud computing if only as a 'quick win' in the goal of policy compliance or more importantly in the longer term issue of addressing the Planet part of the triple bottom line.

1.5 Aims & Objectives

Having identified that businesses need to address future emission reduction from both a governmental and planetary perspective and that the adoption of cloud computing may be a catalyst to enable this goal, it is the intention of this research paper to explore the current and future role of Corporate Social Responsibility (CSR) as a critical factor in the decision-making process for adopting cloud computing.

In order to achieve this aim the objectives are:

1. To explore current key drivers for cloud computing adoption
2. To examine on premise data centre efficiencies
3. To identify cloud computing capabilities to lower emissions
4. To identify Government Policies enforcing emission reduction
5. To gather perspectives from CIO/IT Executives in relation to CSR and cloud
6. To derive conclusions and make recommendations for potential future CSR drivers

2. Literature Review

The literature review will address the first four Aims and Objectives topics in order to enable the subsequent discussion, results and conclusions sections to address points five and six.

2.1 Exploring Current Key Drivers for Cloud Computing Adoption

Early cloud computing adoption survey's (King, et al, 2011) (Hill, 2011) (Interxion, 2011) indicate the key drivers for cloud computing adoption were fore mostly to reduce ICT costs followed by gaining flexibility and scalability to grow or minimise resources to meet user demand (Figure 1). Further drivers included business continuity, speed of implementation / accelerated time to market, fundamental changes in business models, management transactional insight and the ability to comply with industry regulatory changes. None of these drivers suggest any sustainable ICT agenda and the closest inference to a CSR driver is the inclusion of regulatory compliance. However in this context this aspect relates to then current obligations (Buchanan, 2011) including data protection (HM Government, 1998), encryption (US Congress, 1996), security (ISO, 2013) and auditing (AICPA, 1992) as opposed to the latterly introduced 2013 regulations amendment (DEFRA, 2013) to the Companies Act 2006 (Strategic Report and Directors' Reports) (HM Government, 2006) requiring companies to report greenhouse gas emissions.

Post 2013, whilst the key drivers grew in number (Figure 2) to include areas such as a shift from 'CAPEX to OPEX' (Gerwitz, 2014) as financial accounting benefits were realised by early adopters, and 'Data

Insight' as the social media market and possibilities for cloud evolved, cost reduction remains, on average, the top priority across seven leading cloud adoption survey's. KPMG's survey (Bell, 2014) of five hundred CxO level executives managing ICT programs within $100m+ turnover organisations across a dozen industry verticals returned a response of 49% stating cost as the main reason for adopting cloud. Similarly 451 surveyed (Ffoulkes, 2015) one hundred and sixty three ICT professionals from the same sized organisations returning a highest score of 29% focused on cost. Equinix's (Gehringer, 2014) six hundred and fifty nine IT professional surveyed concurred, with reduced costs returning 69% of responses, followed by agility and a new variance of end user experience scoring 48% and ranking in joint third place. LinkedIn's (Skok, 2014) one thousand three hundred and fifty eight respondents consisting of IT professionals from end user organisations and IT vendors reported agility as superseding cost reduction and defined CAPEX to OPEX driver as more relevant to companies with five thousand plus employees perhaps explaining why this particular driver only appears in the enterprise focused surveys. Oxford Economics (Oxford Economics, 2014) survey of two hundred senior IT executives used a modified approach and examined drivers as ranked in order of related expected business outcomes revealing that whilst cost saving scored highly at 56% it was placed behind (in descending order) productivity, innovation, speed of process, strategic partnering value and transformation of the ICT into a profit centre. CIF's (CIF, 2015) focus on small to medium businesses and the public sector included two hundred and fifty senior ICT decision makers resulting in cost again attaining the top score with 59% whilst Rightscale's (Rightscale, 2015) nine hundred and thirty person survey took a wider cross section to include SMB (defined as below 1000 employees) and Enterprise (1000+ employees) and delivered 34% in favour of cost reduction as the key driver; again the highest response.

Interestingly six of the seven surveying organisations (LinkedIn being the exception) used an open ended question methodology and not a multiple choice option to collect the data. Using this approach the survey's all documented unprompted responses and notably none of the four thousand and sixty respondents offered a CSR related response. Even in Frost and Sullivan's report (Stadtmueller, 2015) that examines 'secret drivers' that may be less obvious, no reference to CSR was made. However this evident lack of data linking CSR to drivers directly related to cloud computing adoption does not rule out the idea that IT executives are concerned about sustainable ICT practices commonly termed as 'Green IT' (O'Neill, 2010). In fact, CSC's (CSC, 2014) 2014 survey of five hundred and ninety CIOs revealed that 64% of respondents confirmed cloud computing as a critical priority and more importantly 49% also confirmed that adopting sustainable ICT practices was a priority. The report does not relate the two responses to one another suggesting that the gap between CSR becoming a key driver is in the education of CIOs that cloud computing is a greener option. Equally personal performance measures drive behaviour and it is feasible that the expectation a business places upon a CIO will create a reactively defined key driver list related to a move to cloud computing thus masking unexpected or unreported benefits such as CSR. Ernst and Young's (Osborne, 2014) recent study of three hundred and one worldwide CIOs revealed that IT executives are measured on six key performance indicators (KPI), including IT performance, leadership skills, budget efficiency, business transformation, corporate efficiency, and strategic mind-set. With no measure related to the CSR goals of the organisation it is perhaps not surprising that again CSR is not defined as a key driver for cloud adoption. As such the notion of awareness and KPIs masking the responses will be tested in the discussion section of this paper.

2.2 Examining 'on premise' data centre efficiencies

To avoid the predicted 2050 ecological tipping point (Bernstein et al, 2007) humankind is required to reduce GHG emissions to a safe level of approximately 20GtCO2e per year (Stern, 2008). Currently, if left unchecked, levels of GHG will reach over twice this recommendation at 53GtCO2e per year by 2020 (Enkvist et al, 2007). As the creation and consumption of electricity represents over 60% of all CO2 emissions (USEIA, 2002), a gas responsible for as much as 84% of total GHG emissions (USDoS, 2014), it is sensible to examine areas of high electricity consumption to seek emission reductions (HM Goverment, 2011). The ICT sector is responsible for 1.5% of total worldwide energy consumption (Koomey, 2011) and produces 2% of global carbon emissions (Mingay, 2007). With ICT emissions predicted to increase from 0.53GtCO2e in 2002 to 1.43GtC02e in 2020 (Neves, 2008) and ranking as the world's 12th largest electricity consumer (DCD Intelligence, 2013) the ICT sector has been highlighted (Climate Group, 2008) as an industry capable of generating significant 'abatements' of perhaps minus 7.8 Gt per year by 2020 (Enkvist et al, 2007) through enablement, dematerialisation and improved efficiency. Data centres in particular consume up to thirty times more electricity per square foot than office space (Greenburg et al, 2006) and constituted 14% of the global ICT carbon footprint in 2007 producing 0.116GtCO2e (Climate Group, 2008). By 2020 the figure will rise to 18%, doubling emissions to 0.257GtCO2e (Climate Group, 2008). Housing as many as between 15-30% of servers powered on but not computing (Koomey, 2011) and with almost half (Stansberry, 2013) operating at temperatures of up to 15°F below the recommended ASHRAE limits (Rudgyard, 2014) the majority of on premise data centres are deemed as energy inefficient (Digital Realty Trust, 2013). To address this, best practice frameworks for data centre efficiency have been adopted in both the United States and Europe. In 2007 the USA Environmental Protection Agency (USEPA, 2007) reacted to a federal data centre report (Brown et al, 2007) and set a mandatory 20% carbon foot print reduction target for federal data centres. Similarly the European Commission created a Code of Conduct on Data Centres Energy Efficiency (European Commission, 2008) designed to slow and hopefully reverse what is termed as an ecological impact and threat to European energy security as European Union data centre energy consumption rises from 56Twh in 2007 to a projected 104Twh in 2020 (European Commission, 2008).

To assist in calculating a data centre's energy efficiency the Green Grid, an association of IT professionals dedicated to improving the energy efficiency of data centres, created a measurement called Power Usage Effectiveness (PUE) (Green Grid, 2007). The calculation takes the Total Facility Power measurement (used for IT equipment power, cooling, distribution losses and relevant miscellany including lighting) and divides the reading by the IT Equipment Power (power used for the energy load associated to compute, storage and networking infrastructure plus supporting devices) to determine electrical efficiency. A result of 1.0 suggests the data centre is 100% energy efficient. As an example a typical 5,000sq foot data centre (Emerson, 2008) consuming a total facility power of 27,048kwh with 14,784kwh attributed to IT Equipment Power will return a PUE of 1.83. This suggests that the power grid is having to over supply 83% extra electricity to power the data centre's compute, storage and networking capability. PUE has now been accepted as an ICT industry standard (Ashrae, 2014) for calculating data centre electrical efficiency having been adopted by both the U.S. Department of Energy's Federal Energy Management Program (Mahdavi, 2014) (Bruschi et al, 2011) and the European Commission (Cader, 2008). Studies are revealing that PUE ratings for on premise data centres range between 2.9 (Digital Realty Trust, 2013) and 1.7 (Stansberry, 2014) suggesting that these data centres 'waste' between 70% and 190% of energy consumed due to inefficient operations. Whilst specific case studies have suggested that changes to infrastructure layout and cooling equipment (Bruschi et al, 2011) (Brill and Strong, 2013) can deliver a PUE rating as low as 1.38 in existing on premise data centres (Mahdavi, 2014) Stanberry's (2014) report indicates that ICT professionals responsible for on premise data centres that have improved to 1.7 PUE are becoming more reluctant to further increase best practice procedures as the investment costs at this point begin to outweigh the energy costs.

Bouley's (Bouley, 2010) work introduces location and energy source as a key factor when calculating the carbon dioxide emissions coefficient (carbon footprint) of data centres could be of benefit to offsetting the ecological impact of electrical inefficiencies in newly built data centres or for existing on premise data centres as clean energy becomes more widely available. In this instance, location causes variations in the carbon footprint due to geographical factors such as climate and available energy sources. As an example HP's new Wynyard data centre utilises already cold North Sea air for natural cooling. Based in Billingham England where the temperature only rises above 24C for 20 hours a year the data centre's cold location has reduced energy consumption by 25,000mWh resulting in a PUE of 1.2 and a reduction of CO_2 emissions by 12,500 tonnes (Datacentre Knowledge, 2015). Similarly location and energy source plays a key role for Hydro66 new data centre (Hydro66, 2015). Located at the head of a river in Boden Sweden, the data centre is 100% powered by hydro electric energy, a sustainable fuel source that has a carbon emission factor (CEF) of between 5 and 10gCO_2eq/kWh compared to that of a fossil based energy supply registering between 870 and 1,000gCO_2e/kWh (POST, 2006) (WNA, 2011) (EDF, 2015). Whilst these new data centres are benefitting from geographical advantage having been built in sustainable locations, legacy on premise data centres are tied to their current position and currently utilise less than 14% (Sverdlik, 2015) clean energy. To further expand upon the significance of incorporating sustainable fuel consumption Green Grid has since introduced a Carbon Usage Effectiveness CUE (Azevedo, 2010) sustainability measurement that reports carbon per kilowatt hour intensity for data centres. Taking into account the sustainability criteria of the energy source, a total carbon efficiency can be deduced in conjunction with PUE using the equation CUE = (CO_2 emitted in kgCO_2eq / unit of energy in kwh) x PUE. To highlight the significance of this a 6000sqft on premise data centre with a PUE of 1.7 and relying on 100% fossil fuel derived electricity would produce (11,826,000kWh x 870 gCO_2e/kWh) 10,288tCO_2e in emissions whilst a similar on premise data centre incorporating the reported 14% clean energy source would produce (86% of power x 870 gCO_2e/kWh + 14% of power x 5 gCO_2e/kWh) 8,856tCO_2e. The difference being the equivalent removing 300 cars annually from the road per data centre (USEPA, 2014).

It is clear that on premise data centres suffer poor electrical efficiency and currently lack a significant uptake in clean energy sources. Reservations to improve the PUE beyond 1.7 will impact slow emissions reductions unless clean energy is adopted to overcome this barrier to reduce the overall CUE. This draws the argument full circle to cost implications. Whilst production of renewable energy sources outstripped fossil fuels for the first time in 2015 (Randall, 2015) price per kWh remains prohibitive with renewable energy costing in many instances twice as must as fossil based energy (Renewable Energy Sources, 2015).

2.3 Identifying cloud computing capabilities to lower emissions

Koomey (2011) cited an average PUE of 2.0 to project future data centre electricity consumption to compensate for anticipated data centre efficiency improvements. The figure has been proven as reasonably accurate sitting between the recent 2.9 (Digital Realty Trust, 2013) and the 1.7 (Stanberry, 2014) figures. In the same report Koomey noted that this figure will need to be examined in future modelling as cloud computing was growing in popularity and highly efficient and hyper utilised cloud data centres may be able to reach a PUE rating of 1.1 causing his average prediction to drop sharply.

There are now over 8 million data centres in the world, filling 1.6 billion square feet (Villars, 2015) and consuming annually almost 400Twh of electricity (Mills, 2013). It is estimated that over 30% of total data centre infrastructure (Yezhkova et al, 2015) and compute power (Gartner, 2014) now resides within cloud service provider data centres. As early as 2010 Greenpeace (Greenpeace, 2010) recognised that this significant shift to cloud computing may play a part in reducing the overall ICT carbon emissions as hyper-scale service providers worked hard to reduce energy consumption as a cost saving measure in what would become a price driven market (Mahaney, 2015). Early estimations suggested that as much as 38% energy consumption reductions could be attained by workloads moving to cloud computing and creating never previously feasible scales of efficiency (Fichadia et al, 2011). The global cloud computing market is dominated by six leading service providers (Gill et al, 2015). These are Amazon Web Services (AWS) with a market share of 28% followed by Microsoft 10%, IBM 7%, Google 5%, Salesforce 4% and Rackspace 3% (Synergy Research Group, 2015). The six companies represent 57% of the entire cloud computing market and could therefore potentially represent and effect 17% of the total 0.210GTco2e data centre emissions projected for 2015 (GeSI, 2012) dependent upon how 'green' these providers are.

2.3.1 Amazon Web Services

AWS has ten times more compute capacity than the total sum of the next fourteen closest rivals (Gill eta al, 2015). Greenpeace stated in 2010 that the company has no agenda other than to buy electricity from the cheapest source (Greenpeace, 2010) and later in 2011 defined the provider as not offering any publicly announced environmental goals, instead continuing to locate data centres in areas that rely heavily on coal and nuclear fuels (Greenpeace 2011). Three years later (Greenpeace, 2014) AWS was under fire again being described as being powered by only 2% renewable energy, falling behind competitors dedicated to a green internet and the least transparent of all service providers. AWS subsequently responded positively to the criticism announcing a long term commitments to 100% renewable energy usage, kick started by its building of two Amazon Wind Farms in Indiana and North Carolina plus an Amazon Solar Farm in Virginia that will collectively start generating approximately

1,340,000mWh in 2016 (AWS, 2015). Additionally AWS has since joined the American Council on Renewable Energy and the U.S. Partnership for Renewable Energy Finance to assist in the adoption of sustainable energy sources for the cloud service provider community. Jeff Barr, AWS's Chief Evangelist, also blogged (Barr, 2015) that having read the Greenpeace reports AWS needed to make clear that even before the planned sustainability changes Amazon Web Services users still enjoy a total reduction of 88% carbon emissions over using traditional on premise, made possible by a combination of extensive server virtualisation and utilisation and a PUE of 1.2.

2.3.2 Microsoft

Microsoft has committed to carbon neutrality (Drake, 2015) and publishes data centre PUE figures of between 1.12 and 1.2 (Microsoft, June 2015). Relying on predominantly coal and nuclear fuel in 2010 (Greenpeace, 2010) the cloud service provider has moved towards creating a renewable energy approach with projects including a bio mas powered data centre in Wyoming (Verge, 2014), increased hydroelectric power use in Oregon (Greenpeace, 2011) and Washington (Lamb, 2009) plus an investment in wind power for its Dublin data centre (Datacenter Dynamics, 2011). The company drew initial criticism for building a new data centres in coal-heavy Virginia suggesting the policy as flawed (Greenpeace, 2011) although subsequent 2015 data (Greenpeace) reports that Microsoft now uses 39% renewable energy. This shift towards 'clean energy' ranks Microsoft as the number two top technology green energy user by the US Environmental Protection Agency (USEPA, 2015). Similarly to AWS, it is reported by Accenture and WSP Energy that moving workloads to the Microsoft cloud from on premise data centres can deliver as much as 90% carbon emission savings (Abood et al, 2011).

2.3.3 IBM

IBM's cloud company Softlayer constitutes twenty four of IBM's total one hundred and twenty data centres worldwide. The company publishes a PUE of 1.7 suggesting that the rating is not as favourable as comparable cloud computing data centres due to the ten to thirty year age of much of the estate. IBM has registered 45 data centres into the European Code of Conduct and to date has reduced total energy consumption by 28,000mWh through efficiency measures including raising running temperatures by 2c to 24c (IBM, 2015). In 2011 Softlayer's Texas data centres switched partially to renewable energy abating 12 million pounds of CO_2 annually (Softlayer, 2011). By 2014 these operations became 100% wind powered (IBM, 2014) ranking Softlayer 12th in the USEPA Top 30 (USEPA, 2015) using 60,403,000kWh green energy per year.

2.3.4 Google

Google takes a relatively unique approach to sustainability citing Kirchhoff's circuit laws (Kirchhoff, 1845) that determine no electron can be identified as being from a particular source. In short the company is saying that it is difficult to prove if sustainable electricity is actually the electricity being received from the grid and consumed by the datacentre. It also states that creating a renewable energy source such as solar adjacent to a data centre to overcome this doubt is questionable as neither wind nor solar could generate enough power to keep the data centre running 24/7. Google states openly that if they did do this then it would simply be for company's image to appear to be 'greener' (Google, 2013). Google's approach confirms that it has a policy to ensure that any renewable energy purchases or investments must be additional to the entire energy market. The company simplifies this by explaining that if they consumed the total capacity of an existing wind farm it would simply drive other user consumers towards coal or nuclear based energy. Instead Google buys power purchase agreements (PPA) from wind farms in Iowa, Oklahoma, Texas and Sweden (Greenpeace, 2014) and then sells it back into the grid at wholesale prices. In this manner Google is not consuming green energy directly but is ensuring that sustainable energy sources are available to standard consumers at standard prices. During the process Google accrues the renewable energy certificates (RECs) associated with the consumption of the electricity. These RECs are then applied to the corresponding local Google data centre rendering a carbon neutral rating (Google, 2011). Google suggests that its approach offers green energy suppliers long term stability by committing in some instances to a 20 year term and believes that the cloud service provider is contributing more to emission reductions than if it moved to driving renewable energy directly into its data centres (Google, 2013/2). Greenpeace (Greenpeace, 2014) cites Google as a leader in transparency and attributes 48% of energy consumed as derived from a sustainable source green, higher that Google's published 35% (Google, 2015). In relation to data centre efficiency Google is committed to the reduction of PUE (Google, 2011/3) achieving reductions of 0.9 via airflow optimisation. Koomey (2011) states that despite Google's large scale operations, the efficiency of the Google data centres result in a total energy consumption of less than 1% of worldwide data centres and as such Google has received ISO 50001 accreditation across six data centres to date (Kava, 2013). Google also produces evidence that moving to the cloud will reduce carbon emissions (Google, 2011/2). This is demonstrated by highlighting that, as an example, a small business will require resilience built into any server infrastructure resulting in the necessity for a minimum of two servers to operate. In this example a PUE rating for the small business is approximated to be 2.5 delivering an annual power per user of 175 kWh. As Google's Gmail data centre PUE rating is 1.16 and includes resilience then the total yearly electricity consumption per user reduces to less than 2.2 kWh delivering a 100kg of CO_2 emission reduction per user. To ratify this Google compared its Gmail cloud offering to EPA emission figures (Google, 2011/2) for on premise email servers highlighting that as much as 80% emissions savings can be made by moving workloads to the cloud.

2.3.5 Salesforce

From making a commitment in 2013 (Saleforce, 2013) to move to 100% renewable energy consumption (Greenpeace, 2014), Salesforce has to date achieved 34% adoption with 19% purchased from the grid and 15% accrued in RECS (Salesforce, 2014). Data centres produced 32,227MtCO_2e in 2014 up from 19,058 in 2013. The company attributes this to revenue growth of 30% and the need to create data centres in high demand locations that supply coal-intensive energy. Reparation has been made to counter this figure with its London datacentre now 100% powered by renewable energy (Greenpeace, 2015) and the company indicates that the grams CO_2e per transaction (0.7) has remained static due to the increase in data centre efficiencies and renewable energy (Salesforce, 2014). Salesforce reports that each workload or transaction carried out on its cloud platform is 95% more carbon efficient than when executed on traditional on premise (Krall, 2011). This figure was calculated using a model developed by WSP in line with Gesi methodology (GeSI, 2010) enabling the cloud service provider is to quantify energy use and carbon emissions to a per-user/transaction level. Included as a key factor was the PUE of Salesforce data centres at 1.43 delivered by the multitenant nature of the cloud producing 90% server utilisation (Salesforce, 2014). Salesforce concludes that across its 92,000 users it has driven down emissions of 1,000,000 tonnes of Co2e in 2014 by moving workloads into the cloud.

2.3.6 Rackspace

Rackspace was an early adopter of energy commitments (Engates, 2008) joining Green Grid in 2008 and publishing a global energy policy (Roenigk, 2012) stating an intention to pursue energy efficiency via the Open Compute Project (Open Compute, 2015) and a move towards renewable energy. In 2013 the company consumed 46,461,000kWh of renewable energy avoiding 72,269 pounds of CO2 (Sterling Planet, 2013) raising this to 76,788,691kwh in 2014, placed the service provider tenth in the EPA green power Top Tech list (USEPA, 2015). Recently Rackspace announced that its new UK data centre is powered by 100% renewable energy (Rackspace, 2015/2). The cloud service provider continues to rely overall on 75% coal, gas and nuclear energy (Greenpeace, 2015) with a total energy consumption of 295,341,119kwh (USEPA, 2015). GHG emissions are not publicly available despite Rackspace's dedicated CSR website (Rackspace, 2015/3) stating otherwise drawing criticism (Greenpeace, 2015) that the company needs to be more detailed and open with reporting. Rackspace does suggest that the new London data centre will deliver a PUE of 1.15 having been designed to meet all ASHRAE calculations and will reduce energy consumption by 80% (Rackspace, 2015/2). Rackspace publishes benefits of the cloud focusing on agility and cost without reference to any environmental benefits (Rackspace, 2015).

Beyond the leading six cloud service providers and the reports already referenced above further opinion reported by ICT analysts, manufacturers and organisations echoes the evidence that cloud computing can reduce carbon emissions when workloads are removed from energy inefficient, underutilised on premise data centres. Some studies rely upon and repeat the data published by the service providers to identify the savings (Kepes, 2011) and others incorporate the data as part of wider independent figures to produce examples that deliver 95% reduction in emissions when adopting cloud computing (Thomond, 2013). Other notable studies utilise common theme GHG data from Government resources such as the EPA and efficiency modelling from Green grid. These include CDP's results of 50% or 85.7m tonnes of carbon reduction (Dickinson, 2011), Berkley's study (Masanet, 2013) focusing on cloud based software application suggesting an 87% reduction in emissions, Skyscape's focus on the UK Government and determining the savings in a per server basis stating reductions achievable of reducing from 46kg of CO_2 per year 2kg of CO_2 for a cloud server, and NRD's studies (Delforge, 2012) (Kennedy, 2012) reporting carbon reduction prospects of 98% when moving to cloud. This final approach is interesting as the report breaks out reduction savings as a rising scale from on premise un-virtualised, to virtualised environments all the way through to a highly utilised and green data centre offering public cloud.

In summary it is evident that through a combination of increased utilisation of hardware infrastructure via virtualisation and scale, green energy sources and more efficient energy consumption practices cloud computing is reported to deliver between 38% and 98% carbon emission reductions compared to on premise data centres. Accounting for a third of all data centre capacity and growing at 27% CAGR, cloud computing has an opportunity to significantly impact the GHG emissions attributed to the ICT industry.

2.4 Identifying Government Policies enforcing emission reduction

The UK Government's Climate Change Act (HM Government, 2008) determines that the UK's commitment to carbon emissions reduction of at least 80% by 2050 in line with the Kyoto Protocol (United Nations, 1998) is now a binding law. Emissions are measured in MtCO2e and a yearly GHG emission report is produced by National Atmospheric Emissions Inventory (Webb, 2014) under IPCC revised guidelines (Gytarsky, 2006). This report is subsequently submitted by DECC to the United Nations Framework Convention on Climate Change (United Nations, 1992) at the close of each carbon budget (HM Government, 2011). The first submission covered the period 1990 to 2012 and the second report will be available post 2017 when the second carbon budget (2013-17) concludes. The first UK carbon budget expectation of 23% reduction has been exceeded at minus 26% (HM Government, 2011). For the second carbon budget a further reduction of 2,782 MtCO2e is required to reach the target of 29% total reduction to date. In order to create awareness and to drive energy efficiency in business (DEFRA, 2013) the UK Government amended the Companies Act (HM Government, 2013) stating that all companies operating in the UK and listed on the London Stock Exchange, a European Economic Area market or having equity trading on the New York Stock Exchange or NASDAQ must report CO2 emissions (DEFRA, 2013). This change in law is estimated to include up to 20,000 businesses (Carbon Action, 2015) and failure to comply under 414A of the act (Legislation.gov, 2013) will result in the company director/s being convicted on indictment to a fine that prior to 2015 was maximised at £5000 but is now unlimited (Linklaters, 2015). As an additional measure companies reporting above 6,000mWh of electricity use are ordered to buy carbon compliance credits at £16.40 per CO2 tonne over use as part of further DECC legislation (Carbon Trust, 2015). The idea being that companies will strive to use less energy to reduce the compliancy penalty credits. These recent legislations could be considered as a future driver for adopting cloud as companies seek additional and diverse ways to offset or reduce carbon emissions and are discussed later in this paper.

2.5 Literature Review Summary

Whilst it is clear that CSR is not currently evident as a key driver for the adoption of cloud computing there is evidence that sustainable ICT practices are being prioritised (CSC, 2014). Cloud computing is identified as a more efficient computing model compared to energy inefficient on premise data centres, scoring a 23% PUE improvement (Figure 3) and utilising 16% more clean energy across the six main service providers (Greenpeace, 2015). Reportedly capable of reductions of up to 98% CO2 emissions by workload it is feasible that cloud computing adoption may assist companies to comply with new government policies that affect over a quarter of businesses located or trading in the UK (Rhodes, 2015). Therefore it is not unreasonable to state that CSR could become a future key driver; a subject that is tested and explored in the discussion and results section of this paper.

3. Methodology

3.1 Designing a Structure to Answer the Question

As the philosophy below indicates, I already held a belief that efficient cloud computing models could help abate climate change. In order to build the grounded theory (Glaser and Strauss, 1967) I identified four key elements that when researched and linked would produce objective results and conclusion. The elements were:

1. Consumers: Drivers for adopting cloud computing
2. Climate Change: ICT energy consumption and related GHG emissions
3. Government: Policies and measures related to GHG emissions
4. ICT: Cloud computing adoption and On Premise vs. Cloud data centre electricity efficiencies

The following methodology describes how I approached working with these elements to reach my goal.

3.2 Philosophy, Approach and Paradigm

Before designing the research methodology I noted that I had a hypothesis in mind and therefore a predisposed axiology that may cause bias; particularly as my personal value system (Heron, 1996) compelled me to engender beneficial conclusion (Tashakkoria and Teddlie, 1998) to my specialist field of cloud computing. As such the research philosophy is epistemological positivism, selected to deliver a value free conclusion (Remenyi et al, 1988). The research is both deductive (Robson, 2002) to test the theory and inductive to build on theoretical gaps (Collis and Hussey, 2003). Prior knowledge in the subject suggested any emergent CSR drivers may resonate best with larger organisations due to the scale of benefit that could be delivered. These organisations would most likely have a complex status quo and would be more receptive to a rational approach proffering a practical conclusion that would not require significant change. As such the functionalist paradigm seemed most appropriate to reflect this positioning (Burrel and Morgan, 1979).

3.3 Research Design

3.3.1 Purpose & Strategies

The purpose of the research question is exploratory (Lewis et al, 2007) to illustrate current cloud computing drivers and casting ‘new light’ (Robson, 2002) on the possible relevance of emerging CSR benefits as future drivers (Goulding, 2002). This is achieved using grounded theory strategy building upon secondary data drawn from existing literature and fresh primary data created by interviews and a survey. As such a mixed methods approach is used, including both quantitative and qualitative data.

3.3.1.1 Grounded Theory Strategy

Secondary Data

The first research step was to explore if CSR based cloud computing drivers exist. Focusing on the longitudinal time line of 2011 and 2015 (post advent of cloud computing) quantitative secondary data from nineteen cloud adoption driver surveys was identified. Nine were excluded as they drew from data within the ten core independent surveys (see References) finally included within this research. For the pre 2014 period judged as 'early adoption drivers' three surveys were reviewed from service provider Interxion (2011), analyst KPMG (Hill, 2011), and cloud software company VMware (King, 2011). The results include responses from a total of 1828 international ICT executives from companies with 250+ employees. For the 2014 and 2015 period judged as 'current adoption drivers' seven surveys were reviewed (Bell, 2014) (Ffoulkes, 2015) (Gehringer, 2014) (Skok, 2014) (Oxford Economics, 2014) (CIF, 2015) (Rightscale, 2015) including a total of 4060 responses from ICT executives working for international organisations including SME, $100m+ turnover and public sector. Twenty two different drivers were cited across all ten surveys. All data was freely available from the internet and only output from industry recognised organisations was included to retain reliability and validity.

Due to the outcome of the survey data confirming CSR drivers did not historically or currently exist the next logical step was to seek new substantive insights suggesting how CSR could be positioned as a key future driver. To achieve this, descriptive and explanatory studies identifying and explaining the relationships between the variable elements of climate change, government policy and cloud computing energy efficiencies was introduced. This research quantified four key findings that enabled both the subsequent interview and survey research and the results discussion:

- UK specific cloud adoption growth curve
- Climate change milestones
- UK GHG emission targets and penalties
- GHG emission reductions achievable via cloud computing over on premise computing

The cloud computing descriptive study illustrates adoption is in high growth and therefore capable of significant theoretical impact. Secondary data was sourced from multiple recognised industry analyst sources to ensure reliability and objectivity and validated by Rory Duncan, 451 EMEA Research Director, IDC's Associate VP European IoT Practice Leader Lionel Lamy and Hewlett-Packard's VP of Service Providers Robert Wigger.

The climate change and related policy descriptive studies illustrate that electricity consumption is a significant contributor to GHG emissions and that international and local bodies are exercising mandatory and penal measures to reduce emissions. UK specific data is included for the longitudinal time horizon of 2008 to 2027 to coincide with the introduction of the UK Government's Climate Change Act and carbon budget timeline. The findings are used in the interview and results sections to substantiate external validity of new CSR drivers by making them relevant to the twenty thousand companies affected in the UK. All secondary data was freely available via publications and the internet and required no external access assistance. As this research field was inductive I gained assurance that the findings would prove reliable under scrutiny (Raimond, 1993) from environmentalist Jarvis Smith (Jarvis Smith, 2015).

Descriptive study of ICT data centre energy consumption is used to illustrate that ICT is responsible for a significant percentage of global electricity consumption (and therefore CO2 emissions) and that cloud computing is a more energy efficient model when compared to on premise computing. Validating both points enables explanatory comment in the results and interview sections as to how cloud computing creates a unique CSR driver by reducing emissions and assisting in meeting policy requirements if adopted. To ensure positivism is retained secondary quantitative comparison data of similar sized data centres for both on premise and cloud is referenced. To exercise a measure of control (Adams and Schvaneveldt, 1991) the industry standard for judgement of data centre energy efficiency (PUE) and CUE was applied to both variants. All data for ICT electricity consumption and emissions is freely available via the internet, publications and journals.

Primary Data

Having validated that cloud computing offers CSR benefits and therefore possible future drivers the next logical step was to seek point in time feedback as to the importance of these findings from a similar sample audience as used in secondary data driver surveys. This final primary data qualitative research was accomplished through convenience sampling, semi-structured interviews and an online SurveyMonkey survey conducted during the time horizon of November and December 2015. 71 UK CIO and IT Executives working in the UK were identified and either interviewed by phone / in person or by survey using the questions highlighted in the discussion section. Access to the sample set was via existing professional contacts. This process enabled an objective conclusion to be made as to whether or not CSR was masked as a current CSR driver or could become a future key driver in the adoption of cloud computing. In order to protect personal data all interviewees and survey respondents identity was not revealed and whilst each responded to an invite to participate survey responses were made anonymously.

3.4 Methodology Summary

The philosophy and strategies incorporated in the methodology are designed to capture sufficient data from the four defined elements to yield findings that support logical steps towards a triangulated results discussion and pragmatic conclusion. Throughout measures are used to counter value bias, sensationalism, and social phenomena/feelings in the ultimate goal of exploring the theory that CSR has a role to play as a driver for the adoption of cloud computing.

4. Discussion and Results

Despite the research confirming that cloud computing is rapidly growing in popularity and has a genuine capability to reduce GHG emissions it is evident that corporate and social responsibility is not currently cited openly as a key adoption driver. Of the twenty two 2011 to 2015 current cloud computing key drivers reported within the ten independent adoption surveys (Figures 1 and 2), none are CSR related. As the 2014-15 ranking chart shows (Figure 2), of the polled 4060 respondents the majority of adopters (48%) are driven by cost savings, followed closely by the need for scalability and performance. This outcome suggests that it would be simple to summarise that CSR drivers for cloud computing do not exist currently and therefore focus should shift to the conclusion and examination of possible future drivers. However examining the coding amongst the many and varied reports both read (see bibliography) and referenced suggests strongly that a CSR demand already does exist in ICT as a whole and that the issue lies more in awareness of the link between cloud computing and CSR. Clearly cloud computing is already recognised as meeting the ‘Profit’ aspect of the triple bottom line and plays well to achieving several of the CIO key performance indicators, identified in Osbourne’s (2014) survey, such as budget efficiency, IT performance and business transformation. This is not surprising as business has forever been ubiquitous with profit and as Coolidge highlights as early as 1932, companies must ‘profit or perish’ (Coolidge, 1971). However it is feasible that this traditional or legacy recognition of profit associated drivers could be masking underlying CSR drivers. As an example Murphy (2014) states that there are eight key drivers for voluntary CSR, the first being to reduce cost by focusing on more efficient resources. The key driver surveys and rapid adoption statistics confirm this is exactly what cloud computing is currently achieving and suggests that the ICT community is in the first stage of general transition. CSC’s (2014) survey of five hundred and ninety CIOs adds weight to the notion that there is already a wide ranging need for CSR in ICT, confirming that 49% of respondents stated the adoption of sustainable ICT solutions was already a priority. Equally in all of the Greenpeace reports (2010, 11, 14 & 15) there is clear evidence that CSR driven computing demand exists in that cloud computing companies are already driving towards improved CUE via the use of green energy to make themselves more attractive to business consumers looking for a greener option. In order to test the theory that cloud computing adoption CSR drivers do currently exist but are simply not being recognised and proclaimed this research includes the results from a set semi-structured, convenience sampling interviews and an online survey involving over 70 ICT executives, the outcome of which is discussed below. In order to achieve this it was necessary to further distil two of the research areas as per below. The reasoning was firstly to validate credibility in relation to the GHG reductions claimed by cloud computing, and secondly to judge whether the UK government policy for business emissions reporting was generalised enough to have significance impact.

4.1 Setting a Credible Cloud Computing GHG Reduction Figure

The research clearly indicates that there is a GHG emission benefit to be reaped from cloud computing over on premise computing. Arguably the range of reduction attained is so wide that credibility is threatened. Imagine if a bank manager suggested you could earn between 24% and 95% interest on an investment. Whilst the idea of the 24% is vastly appealing the fact that the 'professional' setting the expectation has no firm opinion on the final result may lead you to question the viability. The same can be said for cloud computing. Based upon the research it is reasonable to state that moving from on premise to cloud computing can certainly reduce ICT carbon footprint by between 24% when comparing like for like PUE, in the region of 40% (Fichadia et al, 2011) when a significant clean energy consumption is evident and as high as 90 to 95% in specific workload scenarios (Abood et al, 2011) (Salesforce, 2015). To set a credible point of reference this section seeks to discuss the findings in order to determine an 'average' substantiated percentage GHG reduction figure that withstands scrutiny when challenged.

Of the three figures derived from the literature review the 24% reduction is the least contentious, being the lowest, and perhaps the most instantly credible, as the outcome is purely focused upon like for like energy efficiency. As an example, the average PUE for cloud computing service providers for 2014 was 1.31 (Figure 3) whilst for on premise data centres it was 1.7 (Stansberry, 2014). Gartner (2015) describes an enterprise class data centre as being between 3,000 to 15,000 square feet suggesting a midpoint size of 6000sqft. Emerson (2008) states that a typical on premise enterprise 5000sqft data centre consumes a total of 27,048kWh of daily energy. This equates to 225W draw per square foot. Therefore, using the Gartner average sizing in combination with Emerson's findings, a 6000sqft on premise enterprise data centre with a PUE of 1.7 consumes 11,826,000kWh of energy annually whilst the service provider equivalent with a PUE of 1.31 consumes 9,110,400kWh. When converted to CO2 equivalent the cloud enabled emission reduction is 24% or the equivalent to removing 342 cars annually from the road per data centre (USEPA, 2014).

The 40% carbon emission reduction figure is derived from carbon emissions being further reduced by increases in consumption of clean energy versus fossil generated electricity to improve carbon usage effectiveness (CUE). In reality, an on premise data centre too could adopt the same level of clean energy as cloud data centre thus the equation for CUE (Azevedo et al, 2010) is rebalanced and the outcome again reverts to relying on PUE rating. The credibility factor in this instance is that whilst clean energy adoption is in the early phases for on premise data centres at 14% (Sverdlik, 2015), uptake is already twice that figure at 30% within cloud service providers (Greenpeace, 2015). As an example Microsoft's cloud data centres were defined as now consuming almost ten percent above average using 39% clean energy (Greenpeace, 2015) drawn from both hydroelectric and wind generated sources. Wind and hydro energy generation produces 11gCO2e/kWh compared to coal at 870gCO2e/kWh (EDF, 2015). Therefore in this example Microsoft's cloud data centre would exceed the 40% independently suggested figure by producing up to 53% less emissions (4,873tCo2e) versus a coal powered on premise data centre emitting 10,288tCO2e. The difference between the computing models in this instance equates to removing 1152 cars annually from the road per data centre (USEPA, 2014).

The 90% example (Abood et al, 2011) does not support generalisability and is therefore perhaps the least credible to be used for a wider audience to promote CSR drivers for cloud adoption. The reasoning for this is that the high percentage reduction in emissions is the result of a very specific scenario whereby many underutilised, on premise email servers across a large number of small businesses are being consolidated to a highly utilised, multi-tenant cloud environment. Using dynamic provisioning the compute energy load is flattened to avoid over provisioning and thus requiring a far lower energy draw per user. Whilst these scenarios do exist an increasing variety of workloads are moving to the cloud as adoption matures (Duncan, 2015) and this figure does not give a truly holistic view. The danger here would perhaps be to sensationalise the emission savings attributed to cloud computing only to deliver lower outcomes in reality causing reduced belief in the driver. Microsoft itself demonstrates in the Abood (2011) case study examining a 50,000 user company the realistic reduction was 32% and in line with initial expectations within the project team of between 30 and 60%.

In summary, to ensure credibility it is reasonable to state that as a general guide, moving to cloud computing can result in over 50% carbon emissions reductions dependant on the cloud provider's clean energy credentials.

4.2 Removing Ambivalence and Generalising the importance of CSR

It is reasonable to state that whether or not CSR is or could become a key future driver for cloud computing adoption relies on the attitude or values of the deciding ICT executive. In short, if an individual does not believe the science behind climate change, or does not have an ecological standpoint then this may lead the adopter to judge the 50% GHG reduction benefits of cloud computing as irrelevant despite the substantiated credibility. The research highlights that over forty years of scientific work confirms the planet is warming due to anthropogenic interference, mostly driven by GHG emissions. The most impactful point is the prediction that 2050 is the pivotal date when Earth's eco system will be irreversibly damaged unless climate change is abated. It is hopeful that existing or created awareness of this fact has strength enough to resonate with the majority of ICT executives with or without an ecological conscious; even if the only appeal is to leave a stable planet for current or future offspring. For the remainder who continue with ambivalence it is suggested that the UK government's new GHG emission reporting law will obligate companies to instigate companywide CSR emissions policies that effectively remove the individual control point. However the measure of how generalised the approach is relies on the size of the market affected. As previously stated, currently the UK policy for mandatory emissions reporting and enforcement of uncapped fines for failure to comply applies to at very least all companies listed on the LSE. There are 2,400 listed businesses (LSE, 2015), representing 34% of the 7,000 UK businesses classified as 'Large Enterprise Businesses' (Rhodes, 2015); a sector that generates 54% of all business turnover in the UK. It is therefore reasonable to state that almost one fifth of all business turnover in the UK is affected by the new policy rules. In this instance one in five ICT decision makers could be overruled or positively influenced by the changes in policy and the subsequent centralisation of CSR activities related to ICT. It is therefore judged worthwhile to include this notable point within the interviews.

4.3 Semi-Structured Interview and Online Survey Results

The following set of questions were created using the salient results of this research to examine the level of awareness of a) climate change, b) humankind's role played in this change, c) cloud computing's capability to lower emissions, and d) the goals and regulations that are beginning to appear in the UK specifically. The interviews and survey conclude with the respondent being offered the opportunity to rank cloud computing drivers based upon the information delivered in the questions. The sample audience included a total of 71 (30 interviews and 41 surveys) all of whom are ICT executives responsible for computing strategies in the UK. Job roles range from CEO, CTO, and CIO to IT Directors and Managers. Only three interviewees declined to answer the final 10 key cloud adoption driver questions based on interview time constraints.

4.3.1 Question 1

Are you aware that scientists predict the year 2050 as being the pivot point when Earth's eco system will be irreversibly damaged if global warming is not abated?

65% stated that they were not aware of this deadline date. Common expansions included that interviewees understood climate change was an issue through the recent increase in media commentary but were unware that a deadline as such had been predicted. Six people asked for an explanation and indicated that the reasoning appeared logical. 35% stated that they were aware of the date mainly due to recent media coverage. Eight responses stated that they understood this due to discussions during CSR policy meetings conducted with their employer in relation to their data centre ISO accreditations. The overwhelming outcome suggested that all interviewees were unsurprisingly aware of global warming but over two thirds simply had no idea that the issue was so far advanced. Where time allowed during interviews I introduced the fact that ICT was responsible for 2% of global electrical consumption and viewed by Gesi (2012) and international governments as a rich source for enabling GHG reductions. The majority responded that they did indeed carry out PUE reduction activity in relation to lowering electricity consumption but the cost associated with the activity was beginning to outweigh any return on investment experienced across previous years and that the activity had perhaps reached its apex. This response substantiated finding from Stanberry's (2014) report. The lack of awareness of the pivotal date confirms that the majority of this sample audience do not appreciate the severity of global warming. This is reflected in the response stating that PUE reduction investment was no longer viewed as cost effective whereby long term CSR improvements are sacrificed for short term focus on profit growth / retention. The positive aspect of the two thirds negative responses is that should awareness grow then a future willingness to assist in abatement may also increase giving life to future CSR adoption drivers.

4.3.2 Question 2

Are you aware that global warming is caused predominantly by greenhouse gas emissions created by human activity?

96% responded that they were aware. Those pressed to give examples during interviews stated vehicle exhaust fumes as the most likely culprit for change alongside major manufacturing in countries such as China and the USA and deforestation. Only one respondent stated that they had never really given it any thought what was causing the issue. The responses confirm that almost all respondents are aware of climate change but the link between electricity consumption as being a major contributor is not yet truly resonating. In this sense the response suggests that the PUE reduction striven for in question 1 responses is more attributed to lowering operation cost than meeting emission reduction targets. One respondent even stated that it is cheaper to allow a server to 'run hot' and eventually burn out than it is to support the cost of cooling systems. The reflection in this suggests that ICT executive KPIs are not specific in relation to CSR activity and cost or profit focus currently supersedes all.

4.3.3 Question 3

Are you aware that the UK Government has set a reduction target of 29% for GHG emissions to the year 2018?

This response was almost split down the middle with 52% stating yes, and 48% stating no they were not aware. Of the 37 responders stating they were aware I asked six whether they were specifically aware of the 29% goal or had responded having understood that government had put in place measures to significantly reduce carbon emissions. All six replied that they had heard the figure was between a quarter and a third but didn't know the exact measure nor when the measurement date was taken from. All confirmed that they presumed it was a reduction on future carbon emission increases. The responses suggest a lack of understanding that the emissions are a reduction to below a historical base year rather than slowing future growth. The underlying theme within the conversations suggested that the ICT executives felt that advances in the electricity efficiency of new servers coupled with virtualisation would be enough to slow increases by a sufficient percentage. By re-stating the reduction was a return to lower than 1990 levels by 29% resulted in one response of 'that's absurd' and many more who found the idea quite surprising. When discussed further with four of the interviewees they concluded that the rapid digitalisation of the world and its need for increased compute and storage capacity would far outstrip any expected GHG reduction gains within the ICT arena and that a slowing of a future electrical consumption increase is of paramount importance whilst a reversal is simply impossible to comprehend. The silver lining in this series of responses is that with credibility given to the 50% reduction of emissions attributed to cloud computing may be received warmly by an audience under pressure to lower PUE and emissions by means beyond on premise computing.

4.3.4 Question 4

Are you aware that the UK Government requires all LSE listed companies to report GHG emissions and imposes unlimited fines for noncompliance?

54% stated that they had no idea that this was in place. 46% confirmed that they were aware. Twelve respondents went into further detail stating that the reason they were aware of this was due to them holding a company directorship and having to complete reports highlighting the ICT data centre emission outputs. I asked whether or not PUE was vital to this calculation and all confirmed that it was at the centre of the workings and that they do focus on PUE. When quizzed as to whether green energy could play a part all replied that the cost was prohibitive and simply reversed any gains made through PUE lowering. Again in this example the overwhelming focus to reduce PUE was cost not environment driven and the notion that clean energy is available but too highly priced is substantiated.

4.3.5 Question 5

Does your company have a Corporate and Social Responsibility program that includes aspects of Ecological or Green benefits such as the reduction of harmful emissions?

76% confirmed that the company did have a CSR policy in place whilst 23% stated that their company did not (the responses included one ‘no answer’). Eight respondents stated that the CSR policy was specifically attributed to recycling of IT products to lower carbon footprint and the reduction of electricity consumption across the business including datacentre usage and office space consumption including afterhours lighting. Thirteen were asked if emissions reductions were included in their CIO KPIs and all stated that they were not but building a sustainable supply chain was. The positivity within this comment is that these interviewees would be open to the idea of a cloud computing provider assisting with this aspect of business as a future supplier. The outcome also substantiates the suggestion that the link between cloud computing and CSR has not yet been made by the majority of adopting organisations.

4.3.6 Question 6

Are you aware that cloud computing can reduce information and communication technology data centre greenhouse gas emissions by over 50%?

55% stated that they were aware whilst 41% stated they were not aware. Three respondents chose not to answer yes or no as they were aware that general utilisation of infrastructure and lowering of PUE and CUE was appropriate to both on premise and traditional therefore they were sceptical that this was a cloud focused achievement. Where time permitted I asked nine of the respondents if they believed the figure and all stated that they had seen such a variety of figures they tended to disbelieve the data and just accepted there must be a gain of some form. This attitude adds validity to the prospect that there is a credibility issue in relation to cloud computing’s capability to reduce GHG emissions. Twenty of those whom confirmed cloud did reduce emissions understood that it was through the ability to maximise utilisation through multi-tenancy within cloud data centres. Positively twenty two of the negative responders stated that now they were aware they would try to make the link between GHG emission calculations and future adoption plans to assist the overall company CSR activities under the heading of strategic leadership as this would help with CIO KPIs. The significant percentage of negative responses underlines the significant lack of awareness in relation to cloud computing’s capabilities to reduce GHG. With such a wide scope of limited education this could lead to opportunity for future awareness and the computing model being presented as a genuine GHG reduction option.

4.3.7 Question 7

Does your organisation's ICT capability or strategy include an element of cloud computing?

100% of the sample responded positively to this. This further endorses the adoption of cloud computing figures stated in this research paper. I further questioned twenty six of the interviewees and all stated that they felt cloud computing had reached sufficient enough maturity since 2010 that the risk of failure during adoption was now less than the positive outcomes it could deliver for the business. The same people stated that in fact maturity and stability had reached such a stage that outcomes such as time to market gains were beginning to outweigh cost savings as the businesses looked for new ways to innovate and gain competitive advantage. The response positively highlights that cloud computing is accepted as a viable model. Whilst the high CAGR continues to be predicted it is feasible that increased adoption will naturally act to lower ICT total GHG equivalent emissions as an inevitable and unintentional by-product of the market trend.

4.3.8 Question 8

Looking forward, of the 10 key cloud adoption drivers below which are more important to you? Rank in order of importance. 1 being most important, 10 being least important.

A. Cost Savings
B. Scalability
C. Faster time to Market
D. Higher Availability
E. Ease of Use
F. Move from CAPEX to OPEX
G. Flexibility of Delivery
H. GHG emissions reduction / CSR benefit
I. Geographic Reach
J. Better Enable Mobile Workforce

The intention of this question was to allow the climate change issues, policies and GHG reduction gains of cloud computing to be forefront of the consumers mind when ranking future drivers. The key wording was 'looking forward' suggesting that perhaps with enlightenment comes a change of mind. Despite the pre amble of questions 1 through to 7 CSR again scored very poorly. Faster Time to Market, Cost Savings and Scalability/Agility were judged as the most important drivers scoring an average of 7 each (Figure 4). High Availability, Move from CAPEX to OPEX and Flexibility of Delivery attained fourth position gaining an average of score of 6. Ease of Use and Better Enable Mobile Workforce took equal seventh place whilst Geographical Reach took 9th place with 3.43 average score whilst GHG emissions reduction and CSR benefit attained lowest positioned driver in 10th position.

I asked the thirty interviewees why the CSR driver had scored so low. The overwhelming response was due to the fact that their job role included performance metrics that were highly focused upon three key areas:

1. Delivering ICT capability within budget
2. Ensuring that ICT capability and capacity stays ahead of demand and remains at all times available.
3. Newly required functionality is made available in the fastest method to ensure a competitive edge is maintained as the business develops.

All of these areas reflected the cloud driver and KPI surveys included in this research. As such the CSR benefit delivered by cloud computing was viewed as a very welcome side effect but did not currently rank as a key driver and was unlikely to become so unless the company as a whole introduced it as a vital key performance indicator for the ICT function in the business.

In summary it is clear that the tested sub theory of current masked cloud computing CSR drivers is not correct and there is no interwoven code hidden in the surveys. Awareness of climate change and cloud computing GHG capabilities are definitely an issue with limited current understanding but it appears that even after a short education the main drivers for cloud computing adoption return to cost, scalability and time to market or 'Profit' ahead of 'Planet'. However the hope delivered by this primary data is for CSR to become a future driver as the gap between 'current' and the 'future' horizon of 2050 shortens. With an audience split down the middle on appreciating the specifics and severity of climate change and unaware of cloud computing's ability to deliver GHG reduction the emphasis for the success of future CSR adoption drivers rests with evangelism within the ICT sector and importantly a focus on the 76% of companies who have a current CSR policy in place. In a top down approach these organisations ought to be educated and encouraged to introduce CSR specific KPI that would enable ICT executives to include cloud computing as a vital ingredient within their drive for efficiency in all forms; a theme discussed further in the conclusion.

5. Conclusion

This research paper clearly identifies that there is an urgent ecological need to address exponential increases in harmful GHG emissions. International recognition of this fact is highlighted by conventions and protocols (UNEP, 1985 and 1987) (United Nations, 1992 and 1998) collectively binding 39 developed countries to immediate action. A line in the sand of 2050 (Bernstein et al, 2007) has been drawn by credible scientists declaring that if humankind doesn't act swiftly to abate climate change the Earth's atmospheric ecosystem will begin to collapse in less than 35 years. Locally, governments have accepted this ever shortening time horizon and set targets to reduce GHG emissions (European Commission, 2008) (HM Government, 2008) (USEP, 2007). Specifically in the United Kingdom targets have been set to reverse emissions to 80% below 1990 base levels (HM Government, 2011) by the deadline date and are being enforced by new reporting and fining laws to combat noncompliance (DEFRA, 2013) (HM Government, 2013). Whilst low carbon futures for buildings, power generation, transport, agriculture and industry as a whole are subject to focus in the UK, leading ICT and ecology experts including Mingay

(2007), Koomey (2011), Greenpeace (2010, 2011, 2013, 2014 and 2015) and GeSI (2010 and 2012), have identified ICT as both culpable for 2% of global GHG emissions and capable as an enabler of delivering annual emissions reductions as high as 9.1 GtCO2e by 2020 equating to a staggering 16.5% of all UK emissions (GeSI, 2012). Currently ICT consumption is proven by the reports cited in this paper (Lamy, 2015) (Fernandez et al, 2015) (Yezhkova et al, 2015) (Arend & Carter, 2014) (Mohr, 2015) (Fellows, 2014) (Duncan, 2015) to be experiencing rapid transition. ICT is shifting from a predominantly on premise data centre computing consumption model of pre 2010 (MCafee, 2010) to a predicted 40% cloud computing consumption model by 2020 (Lamy, 2015). Cloud computing has been examined in both the literature review and results discussion and credibly suggested to be capable of delivering in the region of 50% GHG reductions when compared to on premise data centres and therefore a rich source for potential ICT emission reductions. As such, having substantiated that an extreme ecological situation exists, that the problem of emission reduction targets is real, and that an implication to generalised business has been created, the notion of cloud computing acting as a needs payoff that will deliver true CSR and Planet benefits could be a reality. As stated the intention of this research paper was to explore this theory and determine the current and future role of CSR as a critical factor in the decision-making process for adopting cloud computing. To reach this goal specific aims and objectives were identified and are concluded as follows.

5.1 To explore current drivers for cloud computing adoption

The ten secondary data surveys (King, et al, 2011) (Hill, 2011) (Interxion, 2011) (Bell, 2014) (Ffoulkes, 2015) (Gehringer, 2014) (Skok, 2014) (Oxford Economics, 2014) (CIF, 2015) (Rightscale, 2015) reporting the cloud computing drivers of 5,888 ICT executives during the period 2011 to 2015 inclusive revealed that of all twenty two drivers cited none were CSR based. Instead profit retention related drivers were prominent throughout as shown in Figures 1 and 2. This negative outcome was challenged in line with the grounded theory approach of this paper by the more recent primary data interviews to determine if the CSR drivers were masked behind CSR efficiency concepts (Murphy, 2015) or as secret drivers examined by Frost and Sullivan (Stadtmueller, 2015). The challenge proved unfounded and the primary data surveys simply mirrored the secondary data confirming that profit rather than planet is currently driving cloud computing adoption as drivers including Faster Time to Market, Cost Savings and Scalability/Agility topped the responses (Figure 4).

5.2 To examine on premise data centre efficiencies

By utilising the industry accepted measurements of PUE (Green Grid, 2007) and CUE (Azevedo, 2010) it is clear from the literature reviewed that on premise data centres suffer from power usage inefficiency resulting in higher GHG emissions than cloud computing data centres. Ranging from a reported average of 2.9 (Digital Realty Trust, 2013) to 1.7 (Stansberry, 2014) PUE rating, on premise data centres are not reaching the levels of efficiency reported by hyper utilised cloud data centres averaging 1.31 PUE (Figure

3). The main factors causing this poor result are underutilisation of infrastructure with as much a 30% of servers non-operational but still powered on (Koomey, 2011), operating at up to 15°F below recommended cooling temperatures (Rudgyard, 2014) and a low uptake of clean energy (Sverdlik, 2015). In the highlighted example of a 1.7 PUE coal powered on premise data centre compared to a cloud data centre with a PUE of 1.31 and consuming 39% clean energy the difference between the two would be the equivalent of removing 1152 cars annually from the road (USEPA, 2014). Both the secondary (Stansberry, 2014) and primary data confirmed PUE reduction for on premise data centres is on the agenda of ICT executives although both sources stated that progress is slowing as cost of investment in this area begins to outstrip savings delivered by increased efficiency. The obvious conclusion in response to this challenge is to look towards cloud computing as the bridge to achieve a lowered hybrid PUE related to overall compute load by combining on premise computing and cloud computing models to meet demand. In this example both cost (already proven as a key driver) and emissions are reduced thus attaining both efficiency and profit retention goals.

5.3 To identify cloud computing capabilities to lower emissions

The research clearly identifies that cloud computing has the capability of reducing annual carbon GHG emissions ranging from 24% to 95% (Abood et al, 2011) (Salesforce, 2015). To ensure credibility the results and discussion section questioned the validity of the projection, instead distilling the figure to a more substantiated 50% reduction in comparison to current on premise data centre emissions. Evidently excelling in the areas where on premise data centres are determined as failing the reviewed literature revealed that via hyper utilisation, a focus on alternative or limited cooling methods and green energy consumption, cloud computing is outperforming on premise data centre computing in terms of accelerating emission reductions. To add weight to the planetary benefits being delivered, leading ecology campaigner Greenpeace is referenced as supporting cloud computing having produced extensive reports with evocative titles such as 'Make IT Green, Cloud Computing and It's Contribution to Climate Change,' (2010) 'Clicking Clean, How Companies are Creating the Green Internet' (2014). Each report (Greenpeace, 2010, 2011, 2013, 2014 and 2015) shows the ever increasing 'Clean Energy Index' scores for cloud service providers highlighting the increased uptake of clean energy powering cloud data centres; now reaching an average of 30%. The primary data survey confirmed that over half of the seventy one respondents confirmed they were aware that cloud computing was capable of such reductions. Whilst the awareness of this factor does not appear within the secondary data examined the outcome is promising with relation to future CSR drivers in the fact that one half of ICT executives are arguably yet to appreciate cloud computing's CSR credentials. With a shortening of time between now and 2050 increased proof and awareness of this fact could increase the adoption of cloud based on CSR drivers.

5.4 To identify Government Policies enforcing emission reduction

It is identified that the UK Government's Climate Change Act (HM Government, 2008) has officially determined the country's top level commitment to an 80% GHG emissions reduction by 2050. The research further highlights that subsequent Carbon Budgets (HM Government, 2011) define how this target will be achieved, citing industry as a focus area. Subsequent amendments to the Companies Act (HM Government, 2013) now determine that all LSE listed companies must report GHG emissions (DEFRA, 2013). The policy implementation certainly affects at least 2,400 businesses (LSE, 2015) with a further 20,000 businesses, currently subject to voluntary reporting, being possibly brought into scope in the coming years (Carbon Action, 2015). Importantly the law is not impotent in this aspect. Penalty for failure to comply with reporting is exercised via clause 414A of the act (Legislation.gov, 2013) resulting in the company director/s being convicted on indictment to an unlimited fine (Linklaters, 2015). The conclusion to this finding is that UK law exists as a compelling reason to examine GHG emissions and incorporate the concept into wider CSR policies in order to attain reporting thresholds. Companies need to increase awareness of the laws amongst staff if they are to achieve benefits from areas previously not investigated. As an example the primary data survey revealed that over half of the ICT executives were unaware of the law changes. Now, armed with the cloud computing emissions capabilities data it is not unreasonable to state that these ICT leaders could score highly against the identified key KPI of strategic mind set (Osborne, 2014) by discussing this CSR angle with the company directors.

5.5 To gather perspectives from CIO/IT Executives in relation to CSR and cloud

The secondary data research reveals that 64% of CIOs surveyed (CSC, 2014) confirmed cloud computing as a critical priority whilst the primary survey (2015) confirm that 100% of respondents had already adopted cloud computing in some form. Interestingly 49% of the CSC (2014) audience confirmed that sustainable ICT practices were a priority whilst 76% of the primary data audience confirmed their company had a CSR policy concerning GHG emissions already in place. The reason why this is interesting is despite both cloud and CSR being recognised as important, within both the secondary and primary responses, there is a lack of relation between cloud computing and CSR being complimentary. The primary data interviews showed that there is a limited awareness of the severity of climate change with two thirds not being aware of the 2050 crisis date suggesting an urgency has not yet resonated loudly enough to make the link. Equally results reveal that, as previously highlighted, only half of the respondents understood the GHG reduction capabilities of cloud whilst again over half had no knowledge of the government policies that would add leverage to the case in favour of CSR and cloud. Ultimately when faced with the question mirroring the ten cloud adoption surveys, the primary data interviews revealed the same perspective as to whether or not CSR yet relates to cloud as a driver and the outcome was clear; it currently doesn't.

5.6 Recommendations

It is concluded that whilst CSR is not currently a key driver in the decision making process for the adopting cloud computing there is strong evidence to suggest it may become key in the future. As indicated there is a definite Situation, Problem, and Implication associated with a limited and shortening time frame to act that requires an urgent 'Needs Pay Off'. Cloud computing with its clearly defined capability to reduce ICT GHG emissions by 50% should be in the driving seat to assume this role. However for CSR to become a key driver the following recommendations should be considered.

5.6.1 Corporate CSR Policy

Corporate CSR policies should be included in CIO / ICT Executive KPIs with agreed and specific GHG reductions targeted. By incentivising monetarily the ICT staff to drive CSR initiatives as part of their everyday role GHG reduction will become a focus area and the triangulation between ICT, CSR and ultimately cloud computing will be made and strengthened.

5.6.2 Evangelism from Suppliers and Government

Whilst there is clear evidence that cloud computing suppliers are incorporating green messaging as unique selling points as highlighted in the literature review and that Government and ecological organisations appreciate the capabilities of cloud computing, more needs to be done to carry the message to consumers. It was surprising to discover that half of the primary data interviewees who live and breathe ICT were unaware that cloud computing could reduce GHG emissions. More joint studies in conjunction with recognised industry consultancies including real life case studies should be produced with urgency and communicated across social media platforms as well as industry events and similar media channels.

5.6.3 Green Energy Initiatives

The primary data suggested that the reasoning behind a lack of green energy adoption was due to prohibitive prices when compared to coal generated energy. Government subsidies or initiatives such as those instigated by Google's sell back approach should be examined with a view to supporting energy companies willing to supply green energy at cost to enable on premise data centres to gain some ground on cloud computing data centres or equally to enable cloud computing suppliers to increase the already climbing 30% average in clean energy adoption.

5.6.4 Government Fines Exercised

A threat is sometimes only perceived to be real if exercised. I spent time trying to locate evidence that any company had been fined for noncompliance of GHG emissions reporting and failed. Whilst I am sure the Government is in a good grace period and allowing businesses to begin to create the correct practices to enable accurate reporting it is recommended that within the next two years the fining system should be exercised and the results announced publicly to act as dire warning to companies that they do need to comply or suffer financial penalty and brand damage.

5.6.5 Expansion of Government Policy

The proposed expansion of the government policy for mandatory GHG emissions currently focused upon LSE organisations need to be widened to include the 20,000 or more companies currently subject to voluntarily reporting. Increasing the emphasis by tenfold will act as leverage for companies to seek more innovative ways of GHG reduction and push them towards sources of CSR benefit such as cloud computing.

5.6.6 Cross border data agreements for Clean Energy Cloud Providers

Currently rules are being passed to ensure that data is stored within geographical boundaries to retain data sovereignty (Athow, 2015). Whilst embryonic and yet to be seen, this action could cause international cloud service providers currently operating in countries where cooling is natural such as Sweden and Iceland to suffer from a diminishing market as consumers seek local providers to meet data sovereignty and retention laws. A clause addressing this could be written into any emerging laws that rewards over and above cross border data storage capabilities to service providers proving to be carbon neutral. This emphasis would drive clean fuel adoption in a race to compete.

5.7 Limitations

Whilst I believe the approach of this research captures substantiating evidence that CSR is not current a driver for cloud adoption but could become so in the future I recognise the following limitations to my work and suggest these should be addressed should further research be undertaken in this field.

5.7.1 Clean Energy

More data is required to outline the current trends associated with price, availability and adoption within legacy on premise data centres of clean energy. I believe that in the not too distant future the government plans to make clean energy more accessible will benefit on premise data centre CUE ratings.

5.7.2 CEO Survey / Interview

I would have liked to have presented the findings of this paper to the CEOs of listed LSE companies to appreciate their level of concern in relation to CSR as an overall driver and the theory that cloud computing offers an outlet. However time constraints relating to the completion deadline of this paper negated the opportunity to do so.

5.7.3 On Premise Data Centre Infrastructure refresh

Evolutions in computing infrastructure need to be thoroughly investigated. As the dates for cloud computing evolution show, the equipment in cloud data centres is relatively new in comparison to some legacy on premise data centres that may have been in place for many years. As these older data centres refresh to new infrastructure then I believe ultimately PUE will reduce with time as utilisation increases and compute load decreases with improvement in technology. These future results will offer a clear data set to define the true impact of cloud computing over the next decade.

5.7.4 Data Growth

It is reasonable to state that the reported exponential data generation increases (Hilbert et al, 2011) will happen whether created or stored on premise or not and obviously choosing the compute model that creates the least GHG emissions is sensible. However I believe that to truly understand the impact of ICT GHG reductions to the planet then data and compute growth figures need to be correlated with emissions reduction data. This aspect was beyond the scope of this report but should be consider for future work.

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Appendices

Figure 1 – Cloud Adoption Drivers 2011 (King, et al, 2011) (Hill, 2011) (Interxion, 2011)

Cloud Adoption Drivers 2011	Interexion	KPMG	Vmware	Total %
Cost Savings	69	50	56	58
Scalability	38	0	75	38
Faster time to Market	0	36	75	37
Business Continuity and Disaster Recovery	30	0	40	23
Better Leverage of Data to Provide insight	0	32	32	21
Flexibility	52	0	0	17
Higher Availability / Service Dependency	0	0	50	17
Faster Access to Infrastructure	0	0	50	17
IT Staff Efficiency / Skills / Ease of Use	0	0	46	15
Improve Alignment with Customers / Partners	0	40	0	13
New Business Model	0	33	0	11
Speed of Implementation	19	0	0	6
Policy Decision	0	0	17	6

Figure 2 – Cloud Adoption Drivers 2014 and 2015 (Bell, 2014) (Ffoulkes, 2015) (Gehringer, 2014) (Skok, 2014) (Oxford Economics, 2014) (CIF, 2015) (Rightscale, 2015)

Cloud Adoption Drivers 2014-2015	451	CIF	Equinix	KPMG	Linked in	Oxford Economics	Rightscale	Total %
Cost Savings	29	56	69	49	45	55	34	48
Scalability	12	66	0	0	40	0	53	24
Increase Performance	5	0	47	0	0	70	33	22
Improve Alignment with Customers / Partners	0	0	48	37	0	70	0	22
Innovation / Competitive Advantage	0	0	0	32	35	80	0	21
Better Enable Workforce / Increase Productivity	5	0	0	42	0	80	0	18
New Business or Service Model	7	47	41	30	0	0	0	18
Agility	21	0	53	0	50	0	0	18
Faster time to Market	0	42	0	28	0	0	46	17
Higher Availability / Service Dependency	9	56	0	0	0	0	48	16
Move from Capex to Opex	0	45	0	0	27	0	28	14
IT Staff Efficiency / Skills / Ease of Use	17	38	0	0	0	0	33	13
Flexibility of Delivery	5	68	0	0	0	0	0	10
Policy Decision	5	46	22	0	0	0	0	10
Security	26	0	45	0	0	0	0	10
Geographic Reach	0	0	0	28	0	0	37	9
Transform IT to a Profit Centre	0	0	0	0	0	65	0	9
Disaster Recovery & Backup	5	0	48	0	0	0	0	8
Faster Access to Infrastructure	0	0	0	0	0	0	52	7
Business Continuity	5	0	0	0	0	0	34	6
Better Leverage of Data to Provide insight	0	0	0	35	0	0	0	5
Temporary Project	0	26	0	0	0	0	0	4

Figure 3 – Cloud Computing Service Provider PUE 2014 (Greenpeace, 2015)

Cloud Computing Provider	2014 PUE
AWS	1.20
Microsoft	1.20
IBM	1.70
Google	1.16
SalesForce.com	1.43
Rackspace	1.15
Average Cloud Service Provider	1.31

Figure 4 – Primary Data Interview and Survey Cloud Adoption Driver Combined Results

	1	2	3	4	5	6	7	8	9	10	Total	Score
Cost Savings	27.27% 18	7.58% 5	10.61% 7	10.61% 7	9.09% 6	12.12% 8	7.58% 5	4.55% 3	6.06% 4	4.55% 3	66	6.76
Scalability	7.35% 5	23.53% 16	16.18% 11	10.29% 7	16.18% 11	5.88% 4	7.35% 5	7.35% 5	4.41% 3	1.47% 1	68	6.75
Faster Time to Market	19.12% 13	19.12% 13	16.18% 11	11.76% 8	2.94% 2	10.29% 7	8.82% 6	5.88% 4	4.41% 3	1.47% 1	68	7.07
Higher Availability	3.03% 2	9.09% 6	15.15% 10	9.09% 6	13.64% 9	15.15% 10	18.18% 12	10.61% 7	4.55% 3	1.52% 1	66	5.70
Ease of Use	3.13% 2	6.25% 4	7.81% 5	12.50% 8	14.06% 9	10.94% 7	18.75% 12	17.19% 11	6.25% 4	3.13% 2	64	5.19
Move from CAPEX to OPEX	11.59% 8	8.70% 6	5.80% 4	11.59% 8	18.84% 13	11.59% 8	8.70% 6	10.14% 7	1.45% 1	11.59% 8	69	5.72
Flexibility of Delivery	17.65% 12	13.24% 9	8.82% 6	10.29% 7	13.24% 9	11.76% 8	2.94% 2	13.24% 9	5.88% 4	2.94% 2	68	6.43
Greenhouse gas emissions reduction / CSR benefit	5.71% 4	1.43% 1	1.43% 1	5.71% 4	0.00% 0	10.00% 7	17.14% 12	8.57% 6	22.86% 16	27.14% 19	70	3.39
Global Reach	0.00% 0	4.35% 3	8.70% 6	5.80% 4	4.35% 3	5.80% 4	5.80% 4	13.04% 9	24.64% 17	27.54% 19	69	3.43
Better Enable Mobile Workforce	5.63% 4	7.04% 5	9.86% 7	12.68% 9	12.68% 9	5.63% 4	7.04% 5	9.86% 7	16.90% 12	12.68% 9	71	4.96