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ICT adoption in road freight transport in Nigeria – A case study of the petroleum downstream sector

Abiye Tob-Ogu^{a,*}, Niraj Kumar^b, John Cullen^a

^a Sheffield University Management School, University of Sheffield, Sheffield, S10 1DF, United Kingdom

^b University of Liverpool Management School, University of Liverpool, Liverpool L69 7ZH, United Kingdom



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ABSTRACT

This paper advances the ICT adoption discourse to explore ICT mechanism use, adaptation and contextual influences on management strategies in Africa. A polar-type multiple case studies approach is used to guide empirical data collection across 10 individual cases. 21 interviews were conducted with top executives and these were corroborated with over 30 h of non-participant observations and archival documentation from these cases. Using a tripartite coding frame, thematic and content analyses were performed to identify patterns and themes in the collected data. Findings of this study evidence ICT use at firm level with significant links to local contextual factors. Additionally, whilst affirming relationships between size and adoption, the findings also suggest an inverted parallel between both variables. The paper contributes by empirically highlighting the influence of contextual factors on ICT use in road freight transportation as well as highlighting the potential for ICT developers and OEMs to acquire innovative input from local adaptation practices within the industry.

1. Introduction

Information and communications technology (ICT) has been identified as a critical enabler of sustainable development (Kayisire and Wei, 2016). Mobile phones, internet of things (IoT), big data, radio frequency identification (RFID) and geographic information systems (GIS) are some examples of ICT tools that have been deployed to support sustainable development across a variety of contexts (Kyem, 2012; Korja et al., 2014; Wang et al., 2015). The application of ICT tools to promote sustainable travel is documented within the literature. For example, authors have identified time saving efficiencies from the application of ICT (barcoding, decision support systems) to haulier operations, improving the overall experience of the service providers and users (Sternberg et al., 2014). Other studies have linked competitiveness (Davies et al., 2007), safety (Harris et al., 2015; Wang et al., 2015), and wellbeing (Button et al., 2001) to the use of ICT tools like GIS navigation and on-board computers (OBCs) to support transportation. However, the evidence for this link between ICT and sustainable transport in Africa is absent, despite the importance of transportation as a key UN sustainable development indicator as well as the high socio-economic costs associated with transportation in Africa (UN, 2016).

Africa accounts for a disproportionately high percentage of externalities from road transport incidents with Nigeria identified as recording the second highest fatality figures in the world (UN Economic

and Social Council, 2009; International Transport Forum, 2016). By exploring the evidence for ICT adoption in road freight transport within Africa, this paper seeks to improve insight on how adoption of ICT is taking place in road freight transport operations as well as the key contextual factors that are influencing the adoption from a management perspective (Gallego et al., 2015; Osabutey et al., 2014; Wang et al., 2015).

Accordingly, this paper reports on ICT use by firms in the road freight transport sector of one of Africa's largest petroleum industries; the Nigerian downstream petroleum industry. It highlights evidence for ICT use, adoption, perceived socio-economic benefits and specific contextual factors that influence management. Our discussion is aligned with the technology adoption and freight transport literature to demonstrate how our findings inform policy as well as ICT developers and original equipment manufacturers (OEMs) in promoting sustainable transport within the continent.

The rest of this paper is structured as follows; in section 2, we review the literature and present the theoretical underpinning of the research; in section 3, we explain our research methodology and report our findings in section 4. Finally, in sections 5 and 6 we discuss the implications of the findings and advance some conclusions from our study.

* Corresponding author.

E-mail address: a.tob-ogu@sheffield.ac.uk (A. Tob-Ogu).

2. Literature review

ICT has been identified as promoting growth in developing and developed nations and several studies have explored ICT use in various contexts (Siegel, 1997; Kyem, 2012; Asongu and Le Roux, 2017). The use of the term ICT is expansive within the literature, incorporating mobile phones, decision support applications, IoT applications and technology hardware into the scope (Harris et al., 2015; Jean, 2007; Kayisire and Wei, 2016; Wang et al., 2015). In this study, we determined ICT as a multi-tier concept, incorporating hardware, software and information constructs of connectivity tool configurations that enable a variety of relationships, processes and networks. The emphasis is on information acquisition, processing, exchange and remote access capabilities that match the user's requirements. In the succeeding sections, we review the material on ICT adoption from a general perspective on developing countries as well as Africa. Subsequently, we explore the literature on road freight transport in Africa and identify the potential of ICT use to support road freight transport in African contexts before concluding with a theoretical framework and some key research questions.

2.1. ICT adoption and adaptation in developing countries

Adoption refers to the replicative uptake, incorporation or use of ICT for private, public or individual purposes whilst adaptation refers to the adjustment of ICT for uses other than the replicated use (Biagini et al., 2014). The literature uses the term interchangeably, however Biagini et al.'s (2014) paper offers a better understanding of adaptation as involving some modification of technology to suit the localised context requirements.

In exploring the influence of ICT adoption in developing countries, Gallego et al. (2015) studied 3759 Columbian manufacturing firms and established factors like human capital, size, innovation and international competitiveness as key drivers of ICT adoption. Other studies have advanced cultural, economic and infrastructural factors as influencing adoption at developing country levels (Erumban and De Jong, 2006; Kayisire and Wei, 2016; Roztock and Weistroffer, 2016). The literature highlights differences in adoption drivers in different contexts. For example Erumban and De Jong (2006) found that cultural practices are key drivers of ICT adoption, whilst Caselli and Coleman (2001) attribute ICT adoption to market structures. Additionally, we know that adoption rates differ between countries, with a number of comparative studies highlighting differences in adoption rates at country levels, using factors like income per capita, legal quality, and infrastructure being advanced as construct measures of ICT adoption (Chinn and Fairlie, 2010; Weber and Kauffman, 2011).

At firm level, team-working and quality structures in firms have been highlighted as some unique factors that drive ICT adoption (Bayo-Moriones and Lera-López, 2007). Other authors have linked ICT adoption to increased capital productivity (Bharadwaj, 2000), operations efficiencies (Kohli and Devaraj, 2003; Melville et al., 2004) and national competitiveness (Gallego et al., 2015). These studies underline the importance of firm level investigations as instructive for understanding the role that businesses play in advancing sustainable development within developing regions like sub-Saharan Africa. Since most technology adoptions are driven by the actions of firms within a country, studies have highlighted industry level decomposition approaches as critical for understanding sustainable development challenges (Kveiborg and Fosgerau, 2007). The focus on a specific industry is also influenced by our understanding of industry specific factors responsible for technology adoption (Kayisire and Wei, 2016).

2.2. ICT adoption and adaptation in Africa

The literature on ICT adoption in Africa is continuing to emerge. Recent studies have identified adoption drivers like policy,

competitiveness, innovation and government spending as critical to ICT adoption in Kenya and Ghana (Koria et al., 2014; Osabutey et al., 2014), however the literature highlights gaps in terms of how policy in Africa is helping to scale up technological capacity and adoption at firm level (Amankwah-Amoah and Sarpong, 2016). More recently, Danquah and Amankwah-Amoah (2017) established positive correlations between human capital and technology adoption in sub-Saharan African (SSA) countries, extending the discourse on links between socio-demographic factors and technology adoption (See also Asongu and Le Roux, 2017). It is worth noting that whilst some other studies have reported on ICT adoption in African countries, their data sets have adopted regional aggregation models and as such these studies may not have reflected some unique nuances of the African countries they relate to (Erumban and De Jong, 2006; Kayisire and Wei, 2016). As such, these aggregated models are likely to omit context specific factors that are important for understanding African contexts.

Closely linked is the issue of ICT adaptation that may be better investigated by localising research? Whereas the literature has largely focused on adoption, i.e. the replicative uptake of ICT by African firms, it also highlights some inherent risks that accompany such adoptive transfers and replication that often lead to performance failures (Dadzie, 1990; Erumban and De Jong, 2006; Kayisire and Wei, 2016). This perhaps supports the arguments for adaptation, whereby local firms are going beyond replicative models to modify technology use to support specific requirements that are unique to their environments. Examples of these adaptations include the use of drones to deliver medical aid supplies to remote communities in Rwanda and the MellowCabs electric vehicles phenomenon in South Africa that are free for users but supported by revenue from advertising on ICT enabled platforms on the cab. The adaptation phenomena and its link to firm performance vis-à-vis drivers, processes and outcomes are increasingly areas of research interest (Weber and Kauffman, 2011; Biagini et al., 2014), yet we note that very few empirical studies have focused on African contexts, despite opportunities for learning and innovation by ICT developers and OEMs.

From a firm perspective, we view ICT as not only a critical resource but also suggest that its application and performance is best understood by identifying contractual factors that drive modification to suit firm objectives beyond the original intentions of the technology innovators (Jean, 2007). Our study contributes to the literature by extending insight on ICT adoption in Africa by adopting an industry decomposition approach to explore ICT adoption for sustainability performance from a strategic management perspective. We advance on the findings from previous studies to highlight the impact of contextual factors on management's adoption of ICT, linking sustainability and strategy in road freight operations (Erumban and De Jong, 2006; Aleke et al., 2011; Chinn and Fairlie, 2010; Gallego et al., 2015; Osabutey et al., 2014; Kayisire and Wei, 2016).

2.3. Road freight transport

Africa has the highest risks of road transport fatality with over 26% of road accidents occurring in Africa (UN Economic and Social Council, 2009; World Health Organisation, 2015). Porter (2014) highlights the unique nature of many African contexts where the consumption of human and freight mobility services occur simultaneously. Whilst the co-consumption of freight and people transport increases latent risks of fatalities within road freight in Africa, the risk is also significant in industry sectors like the petroleum products transport industry where co-consumption is very rare.

Most African economies rely heavily on petroleum products for industrial and domestic purposes fuelling high local demands for transportation. These transport operations often come with significant human, social, environmental and economic costs (UN Economic and Social Council, 2009). For example, in Nigeria and Ghana, there have been series of fuel tanker related deaths between 2008 and 2015. In the

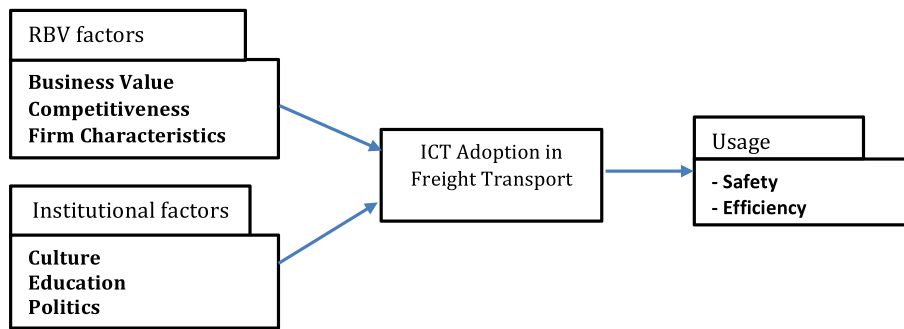


Fig. 1. Theoretical Framework.

instance of Ghana, 21 lives were reportedly lost to an explosion that occurred after a fuel tanker overturned and members of the public tried to scoop some of its products in Techiman, Ghana (Iddrisu, 2008). In Nigeria, the occurrences are even more frequent, with multiple casualties from over 331 incidents recorded in 2015 alone (Federal Road Safety Corps, 2015). Whilst road transport accidents in Nigeria have reduced marginally over the last four years, improved data and communication have been identified as critical to improving performance in road freight transport (Federal Road Safety Corps, 2015; WHO, 2015). In spite of these distressing observations, our search of the extant literature did not disclose any study that has investigated the application of ICT to road freight transport operations in Africa. This study seeks to bridge this gap by extending the discourse on ICT adoption in Africa to an under-researched sector where ICT has been identified as potentially significant for improving the sector's sustainability performance.

Consequently, our investigation focuses on the use of ICT in the road transport operations of the Nigerian petroleum downstream sector and our reasons for this are stated below:

- Although important for sustainable development (McKinnon, 2007; Alises et al., 2014), transportation in Africa remains under researched. The Nigerian petroleum downstream sector meets the criteria of a local African industry that is transport intensive and has significant socio-economic implications for the country.
- Although the literature identifies increased ICT penetration in Nigeria (Chiemeke and Longe, 2007) our knowledge of how and why these technologies are being utilised to address transport as a sustainable development goal is limited. The downstream sector's road freight operations provide a suitable context for exploring this phenomenon.

2.4. Theoretical framework

ICT has been recognised as an intervention mechanism for improving road freight transport safety (Sternberg et al., 2014; Wang et al., 2015). In terms of ICT adoption for freight transport, Wang et al. (2015) and Evangelista et al. (2013) have investigated ICT use in the road transport industry, establishing environmental and efficiency benefits from ICT deployment in logistics. However, there is no empirical study that reports on ICT adoption in freight transport performance within Africa despite its potential to make significant contribution to improving the quality of freight transport operations in Africa.

As management theorists, we identify the resource based view (RBV) and institutional theory integration as most suitable for theorising on ICT adoption in road freight transport within Nigeria. Progressing on the factors identified by previous studies, we conceptualise that institutional and firm level forces that combine to impact on management strategies influence ICT adoption. RBV advances firm strategies as centred on resource accumulation and coordination for sustainable competitive advantage (Grant, 1991; Wernerfelt, 1984). Perhaps, Barney's (1991) valuable, rarity, inimitable and non-substitutability (VRIN) resource characterisation remains the most widely

accepted RBV application. We identify ICT mechanisms as valuable resources that can improve freight transport efficiency and safety (Palsson and Kovacs, 2014; Sternberg et al., 2014; Wang et al., 2015).

Institutionalism on the other hand is more externally focused and advances firms' actions like ICT adoption as influenced by mimetic, normative and coercive forces (Dimaggio and Powell, 1983). Espousing external pressures on the firm, institutionalism links firms' strategies to environmental forces that impact on the firm (Tate, 2014). However, institutionalism on its own also ignores the capacity of a firm's management to evolve strategies innovatively and this has been highlighted as a limitation (Palsson and Kovacs, 2014). Although early drivers of ICT adoption in Africa may have been driven by mimetic considerations, examples of innovative use for healthcare, mobility and financing indicates some modification by local businesses who are able to adapt ICT resource uniquely. In the absence of evidence to support specific institutional forces instigating this adaption process, we suppose that it is due to the management's ability to reconfigure existing resource for competitive advantage.

As illustrated in Fig. 1 below, we reflect extant findings and assume that this relationship is moderated by other institutional factors like culture, politics, education and economic development, all of which are beyond the control of the firm as postulated by institutionalism (Dimaggio and Powell, 1983; Tate, 2014).

As illustrated by Fig. 1, our investigation acknowledges that environmental factors like competition, culture, education and value influence ICT adoption by firms. As such our theory framework highlights that a unilateral theory approach may fall short of explaining some of these factors. Accordingly, the combination of RBV and institutional theories provide a more robust framework for explaining ICT adoption in road freight within the specified industry. We consider this particularly instructive as it affords theoretical validation for extending the findings from this study. In this case, key assumptions on competitive pressures from both internal and external factors are accommodated in the theoretical framework model.

To this end, the research questions we seek to explore are as follows:

1. What are the common ICT instrumentations being used in the Nigerian Petroleum Downstream Transport Sector?
2. How are these instrumentations being used? Is there evidence of technological adaptation?

Addressing these research questions will support a systematic identification of ICT mechanisms employed as well as provide substantive evidence to evaluate adaptation and contribute to the academic literature discourse on ICT and technology transfer.

3. Methodology

The exploratory nature of our inquiry was supported by qualitative case study strategies that enabled us to address research phenomena that is considered to be effectively emergent as opposed to mature (Lee et al., 2007; Voss et al., 2002). Accordingly, our strategy involved a

Table 1
– Case^a and participant profiles.

Case 1	Fluid plc		
Instrumentation	Details	Participant Portfolios	Recorded ^b
Interviews	3 Semi-structured interviews with open-ended questions	Logistics Manager	Yes
		Fleet Manager	Yes
		Transport Executive	No
Observations	Head office	NA	No
Public archival documentation	CSR Report, 2012–2015 accounts and reports	NA	No
Case 2	ABS Nigeria		
Instrumentation	Details	Participant Portfolios	Recorded
Interviews	4 semi-structured interviews with open-ended questions	Plant Manager	Yes
		Lubricants Manager	Yes
		Distribution Manager	Yes
		Fleet Payments Manager	No
Observations	2 operational premises, branded assets travel	NA	No
Public archival documentation	2 CSR reports (2013–2014) Annual reports (2012–2014)	NA	No
Case 3	Vertex limited		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	5 Semi-structured interviews with open-ended questions	Distribution Supervisor	Yes
		Archiving Manager	Yes
		Shipping Operations Coordinator	Yes
		IT manager	No
		Logistics manager	No
Observations	3 major operational premises, branded truck travels	NA	No
Public archival documentation	Annual report and accounts (2013–2014)	NA	No
Case4	TServe limited		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	1 Semi-structured interview with open-ended questions	Head of Operations	Yes
Observations	Operations office	NA	No
Public archival documentation	Web archive	NA	No
Case 5	Phalco		
Instrumentation	Details	Participant Portfolios	Recorded
Interviews	2 Semi-structured interviews with open-ended questions	Community and HSE Manager	No
		Transport Executive	No
Observations	–	NA	No
Public archival documentation	Web archive	NA	No
Case 6	Skin limited		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	1 Semi-structured interview with open-ended questions	Head of Operations	Yes
Observations	–	NA	No
Public archival documentation	Web archive	NA	No
Case 7	Mash		
Instrumentation	Details	Participant Portfolios	Recorded
Interviews	2 Semi-structured interviews with open-ended questions	Line Manager (Distribution)	No
		Head of operations	No
Observations	–	NA	No
Public archival documentation	Web archive	NA	No
Case 8	Honey Plc		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	1 semi-structured interview with open-ended questions	Managing Director	No
Observations	–	NA	No
Public archival documentation	–	NA	No
Case 9	Radar Plc		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	1 Semi-structured interview with open-ended questions	Regional Manager	No
Observations	–	NA	No
Public archival documentation	–	NA	No
Case 10	PAF		
Instrumentation	Details	Participant portfolios	Recorded
Interviews	1 Semi-structured interview with open-ended questions	Area Coordinator	Yes
Observations	Regional operational bays and coordinating office	NA	No
Public archival documentation	Web archives	NA	No

^a All cases have been anonymised.

^b Indicates that interviews were audio recorded in addition to interview notes taken during course of the interview.

multiple case approach, selected by a polar strategy that ensured representation of the different types of firms in the industry. We employed a combination of purposive and snowballing techniques to aid case selection and theoretical saturation (Eisenhardt and Graebner,

2007; Jugdev and LaFramboise, 2010). Polar strategies allow for an accommodation of varieties within the research population, increasing the representation of the findings. Compared to homogenous strategies, polar cases tend to support a more realistic perspective of the industry

set as it accounts for the variety of case types within the industry (Eisenhardt and Graebner, 2007).

3.1. Multiple case studies

Multiple case study strategies are commonly used in strategy and operations based research (Eisenhardt and Graebner, 2007; Huq et al., 2016; Jarvensivu and Tornroos, 2010; Wang et al., 2015). Supporting in-depth investigations across several cases or units, multiple case studies allow for better persuasion and support research rigour, strengthening the link between data, findings and research implications. Compared to single case studies, multiple case studies have been demonstrated as reducing researcher bias, enhancing validity and improving theory development (Eisenhardt and Graebner, 2007; Jarvensivu and Tornroos, 2010; Yin, 2003). Furthermore, multiple case studies support the systematic examination of complex real issues, cross-validation and flexibility in case study research. Our case population included multinational and local firms of different sizes; one public agency, three small, three medium and three large companies, all with significant transport operations in the Nigerian petroleum downstream industry.

3.2. Study context

As previously stated, our empirical study is focused on the road transport sector of the Nigerian petroleum downstream industry. Besides the growing population and corresponding demand for fossil fuel in Nigeria, the literature has also established links between road freight transport and socio-economic development (Ehinomen and Adeleke, 2012; Kveiborg and Fosgerau, 2007; Leonardi and Baumgartner, 2004; McKinnon, 2007). With intensive road freight transport operations, the industry is plagued by significant operational, social and environmental challenges like diversion, poor infrastructure, accidents, fatalities, theft and environmental spills. Nigeria was listed as one of the new emerging economy blocs, i.e. the MINT bloc, comprising of Mexico, Indonesia, Nigeria and Turkey and whilst these countries were tipped to experience significant growth in the guise of the BRICS countries, Nigeria as a unique context, remains faced with unique infrastructural and operations challenges, particularly in road freight transport (Ehinomen and Adeleke, 2012; Ubogu et al., 2011). Operational problems like methodological inefficiencies, corruption of processes and environmental degradation continue to affect the distribution of petroleum products across the country with very extreme outcomes in some instances. With ICT's designation as an enabler of operational efficiencies and sustainable solutions, the sector provided a dynamic and relevant setting for exploring ICT deployment and adaptation in Africa.

3.3. Data collection

Data collection was initiated through the formulation and development of a research protocol that was pilot tested (Yin, 2003). Feedback from the pilot testing was used to improve the scope and detail of the eventual protocol. Semi-structured interviews, non-participant observations and archival documents were used to collect data, enhancing the rigour and reliability of the data collection process (Barratt et al., 2011; Eisenhardt, 1989). A total of 21 semi-structured interviews, each averaging 50 min, were conducted with key industry executives holding logistics, plant, IT and operations management portfolios (see Table 1). Initial collection was leveraged on existing industry contacts through which we identified and contacted suitable management executives for interviews. One interview was conducted with a government agency representative and the remaining 20 interviews were held with management executives of petroleum distribution and retailing companies. After 17 interviews, the team discussed the data saturation and perceptible confidence in the data quality, agreeing to its sufficiency. A

target for 3 additional interviews were set after which a saturation review would eventually lead to the ending the collection process (Bryman and Bell, 2015; Philbin et al., 2009). For most of interviews, the participant gave their consent to record the interviews. However, in some cases where the participant did not give consent, we took interview notes to reflect the views of the participants in response to the questions asked.

Over 30 h of non-participant observations were carried out across 3 main geographic regions within Nigeria (North-Central, South-West and South-South regions). This included scheduled and non-scheduled visits, on-road observations and site visits to loading and administrative centres of 7 companies. Archival data consisted of soft and hard copy documentary evidence such as web page information, end of year reports and other publications.

4. Analysis and findings

4.1. Analysis

Data analysis overlapped significantly with the data collection phase and followed a thematic analysis of the data. Pre-transcription analysis of the interview data influenced follow-up questions in many instances and judgement calls were made regarding the appropriation of observation and documentary evidence for inclusion in the transcription and post-transcription phases of analysis process. All the recordings and interview notes were transcribed for analysis and coded using Nvivo¹¹ software. Analysis was conducted at both within case and cross case levels.

Provisional coding based on the literature was used to generate 1st stage coding themes, which were then reviewed and modified with input from each team member over the 2nd and 3rd coding stages (Miles et al., 2014). Coding focused on extracting both provisional and 'in vivo' themes that reflected the realities of the data as captured. At the first level, over 57 descriptive codes were extracted from the interview and archival data (see Appendix A2). Following this stage, it was agreed that there were many overlapping themes that could be better presented under aggregated themes and this reduction was achieved during the 2nd stage coding, where a total of 8 main themes were identified.

Observation data by way of notes, memos and pictures were infused into the data pool at this stage. Contradictions between different data sources were noted for further review and observation data was often ranked in prominence over interview and archival data. This practice helped to reduce participant bias that may be obtainable in interviews and archival data whilst at the same time strengthening the reliability of our findings. In the final stage, a content analysis of the coded themes was conducted to distinguish 'in vivo' themes. Each of the eight themes was subjected to further reviews and examined using a matrix structure to identify patterns and relationships that were then classed into unique themes for reporting. The cross-case matrix supported comparisons and contrasts with adjustments for factors relating to ownership structures, operations scope and firm size (Miles et al., 2014). As a measure of rigour, results were jointly reviewed and discussed by all members of the research team. Deviations and ambiguities were resolved at this stage with final themes reported after consensus across the team (Barratt et al., 2011; Huq et al., 2016).

4.2. Findings

Following the analysis of the 21 interviews, review of archival documents and 30 h of observation data across 10 individual cases, we have summarised relevant findings below.

4.2.1. ICT use

We found evidence to support the use of ICT mechanisms to support road freight transport operations in the Nigerian petroleum

downstream industry. Table 3 presents the distribution of ICT instrumentation being used within the industry as established from the data.

Our findings support the extensive use of ICT to support road freight operations in the industry although the penetration seemed to differ amongst the different categories of firms. For example, larger firms (ABS, Vertex and Fluid plc.) were more likely to have a greater range of ICT tools compared to small and medium firms and our analysis of the ICT range revealed the use of ERP systems to support their transport and logistics operations. In contrast, none of the smaller firms that were sampled (Honey, Radar and Water Energy) had any ERP software to support their operations. Although size did not seem to factor in terms of ICT acceptance within the industry, size seemed to be an important factor in determining ICT penetration within firms.

In terms of the evidence for how ICT was being used to support sustainable transport, three main themes emerged from the data; monitoring, accountability and visibility. Monitoring refers to the use of ICT to gain oversight and control over their freight transport processes and the actors. Accountability captured the use of ICT to support administrative audits and records, whilst visibility denotes the use of ICT to access real time data of the transportation process. We present these in more detail below:

4.2.1.1. Monitoring. Control was a recurring issue for many of the executives we discussed this with and they often cited examples of staff deviating from instructions that often led to socio-economic loss. By using ICT, management believed that they were influencing staff behaviour decisions and reducing the negative socio-economic consequence of errant actors. For example, the Distribution Manager of ABS Limited explained that:

“Drivers we know can be dishonest, they don't tell the truth, some of them are not properly trained, they don't know how to do the right thing and these things are there to monitor them. Because if someone knows that he is being monitored, someone knows that if he stops where he is not supposed to stop, if he is packed on the express, if he is over speeding, someone is checking and is going to sanction him at the end of the day, then it will reduce and mitigate such occurrence.”

By adopting ICT to monitor and control actor behaviour, management were not only reducing the opportunity for economic loss but also reducing the incidents of product sabotage, road accidents and fatalities that often result from unauthorised parking and over-speeding. As reported in Table 3, the larger firms tended to have bespoke replicated ICT (hard and software) tools for monitoring including on-board computers (OBCs) and radio frequency identification devices (RFIDs) both of which can be cost intensive. On the other hand, we observed that SMEs were mostly making do with mobile telephones to monitor road transport operations. The smaller firms had evolved methods to successfully modify the use of mobile phones beyond communications to control the behaviour of actors. Beyond the diverse range of software and hardware mechanisms, we construe the modification of mobile phone use as evidence of localised adaptation by the smaller firms who perhaps lack the capital for bespoke ICT investment.

4.2.1.2. Accountability. Principally administrative, this was closely tied to functional stewardship and evaluation of tasks. ICT hardware included laptop computers, mobile phone records, electronic testers which were used to identify and store information records. These audit and record mechanisms helped address some concerns about corruption, which is a big social issue in Nigeria. For example, some managers reported that the use of special computing records had improved their ability to reconcile sales and distribution metrics, such that incidents of fraud from falsified deliveries had been effectively reduced, improving economic performance and long-term sustainability of the business. Accountability through communication technology underpinned business success and performance as captured by the excerpt below.

“Well communications is crucial in this business. Sales, deliveries can be dependent on communication and records. E.g. PAF requires proof of delivery, they require different documentations and all the rest, without these communication devices, we cannot meet up”.

– Operations Head (Mash)

4.2.1.3. Visibility. The use of ICT mechanisms to improve real time oversight and understanding of processes in their road transport operations. ICT mechanisms helped managers see through previous ‘blindspots’ within their transportation operations. For example, ICT tools like AQUILA and Optitune gave executives the ability to relay real time information to customers about the status of their deliveries. They saw this as offering competitive advantage since their customers considered them more reliable. Also ICT mechanisms including enterprise resource planning (ERP) platforms like ORACLE, SAP and GAL (a locally produced and bespoke software application used by one of the companies) were in use and supported integration and visibility of freight operations in many large and medium organizations. We also found that open software like Google maps application was also used to support hardware visibility functions like truck tracking.

Perhaps one of the most critical sustainable outcomes from the use of ICT to support visibility relates to safety. Prior to this application, poor emergency response to incidents often led to avoidable losses sometimes with managers oblivious to the incident for hours or days. As captured by the excerpt below, ICT was helping to address this problem by supporting transport process visibility and improving response times to incidents. We have reported this as a safety outcome in Table 3.

“We also have radio systems for communicating. We know the implication of having spills because if there is an explosion, people could lose their lives... and we are very mindful. In event of an accident, the drivers get in touch with the haulier, the office, fire-fighters to ensure that these things do not go out of hand...it (ICT) does make things a lot easier for us.”

Logistics Manager – Fluid Plc

Post-incident response remains an area of concern for the operators in the industry, however all the managers were of the opinion that ICT use is helping companies curb the negative aftermaths of these incidents. Our observation data correlated this, as we were able to verify emergency response records and also visit some control rooms in some of the firms visited.

4.2.2. Rationale and adaptation

In order to identify strategic management rationales for ICT use, we used a perceptive outcome and rationale matrix approach to analyse the data and establish rationales for ICT use within the industry (Tables 2 and 3). We identified three underlying rationales for adoption; *competitiveness*, *safety* and *audit*. Some were identified as *a priori* reasons for adoption or adaptation where modification as evidenced.

4.2.2.1. Competitiveness. Our data analysis indicates that managers perceived ICT as supporting improved customer and order preferences that promoted their business' competitive advantage. Many executives who were interviewed associated ICT use with efficiencies that improved speed and accuracy of their transport operations. This was despite a ‘reliability premium’ that many customers valued and sought after in their dealings with these companies. ICT mechanisms offered their customers increased visibility over the transaction process and this helped to improve their trust in the order process, positively impacting sales. For example, executives from ABS Limited and Vertex Limited believed that their awareness of their ICT infrastructure was a main reason why customers preferred to do business with them. We noted that this view was shared by all the executives interviewed as they determined the ICT as a threshold requirement for operation in the current industry environment.

As shown in Fig. 2, our analysis identified ICT/competitive strategy subsets including process/inventory efficiencies, training, routing

Table 2
Cross case matrix analysis.

Case	Size			Operations scope		ICT evidence		Ownership		
	Large (over 500 employees)	Medium (100–500 employees)	Small (below 100 employees)	Distribtn	Other/retail	Adoptn	Adaptn	Govt.	Local	MNC
ABS limited	✓			✓	✓	✓				✓
Fluid Plc	✓			✓	✓	✓	✓			✓
Vertex Plc	✓			✓	✓	✓	✓			
Mash		✓		✓	✓	✓	✓		✓	
Phalco		✓		✓	✓	✓	✓		✓	
PAF						✓	✓	✓		
Skin		✓		✓		✓			✓	
Honey			✓	✓	✓	✓	✓		✓	
Radar			✓	✓	✓	✓	✓		✓	
Water energy			✓	✓	✓	✓	✓		✓	

optimisation and accident prevention (brand). ICT applications like EBT, SM Web and Optitune were useful for reducing inventory theft, improving route optimisation decisions and reducing energy use in the transportation process. Additionally, we also found that ICT was being used to execute staff training and community services that helped to improve the security and branding of the firms, which were connected to profitability in some cases.

4.2.2.1.1. Safety. Safety was a very important consideration within the industry. Since customer decisions were presented as rarely determined by safety performance, safety was more of a duty outcome rather than a competitive one. ICT mechanisms were perceived as critical for improving a firm's safety performance and this informed adoption in many instances. Some executives reported over 40% reduction in accidents and damage over a three-year period and this was attributed to the deployment of ICT in their road freight transport operations (ABS Limited). ICT tools were used to support both preventive and responsive safety strategies; OBCs and computers assisted driver training, prevented over-speeding, detours and supported routing decisions whilst mobile phones and GPS devices enabled speedy response strategies in cases of emergencies and incidents (see Fig. 3). Reductions in incidents and incident management are perhaps the most important outcome from the use of ICT in the industry. This was a significant outcome and in spite of the poor road infrastructure challenge that plagues the country.

As illustrated above ICT use also supported inventory control. As a safety issue, this was designed to support the automated activation of product spill safety controls in the event of an incident. Prior to ICT use,

this contributed to fatalities caused by spills and fires. Conversely, we found that the use of ICT for safety was more likely to occur in larger firms than in the smaller firms. Additionally, we observed that some mobile phone usage also created additional safety risks that were not being controlled by management. For example, drivers were likely to be distracted by using mobile phones to communicate whilst driving, raising questions about its suitability as a safety enabling tool.

4.2.2.1.2. Regulation. In addition to the competitive and safety rationales, ICT was used to support process audits and transparency driven by regulatory pressures. With very high rates of petroleum product diversion, it had been extremely difficult to trace products and their delivery. This regularly created scarcity and caused hardship for consumers. Although we found no links between firm profitability and scarcity, we established that compliance with regulatory requirements was influencing management's use of ICT in their road freight operations.

Although some firm executives highlighted losses from product diversion, we observed that it was mostly compliance with regulatory requirements that influenced adoption for audit and verification as was illustrated by the compulsory participation in the government backed ICT programme for distribution – AQUILA. The RFID based programme was administered by the Petroleum agency (PAF) and was used to reduce product diversions problems like theft and irregular deliveries (Fig. 4). Since the national government subsidises petroleum products sale, the initiative was designed to aid delivery verification records as opposed to supporting the competitiveness of the participating firms:

“What we do is to make sure that the products actually reach their

Table 3
Case analysis and rationale.

Case (firm)	ICT use	ICT component		Perceived outcome		Rationale
		Software	Hardware	Comp. Adv.	Other	Themes
ABS limited	✓	SM Web, SAP, Optitune, MS Office, EQ	OBCs, Printers, Computer Servers, Phones	Yes	Safety, accessibility	Efficiency, accident prevention, travel emissions control, Community training
Fluid Plc	✓	ERP, SAP,	Computers, Tracking device, Phones	Neutral	Threshold, safety	Efficiency, accident prevention
Vertex Plc	✓	SAP, EBT, ORACLE, GIS programmes, QR Coding, MS Office, AQUILA	Radios, Computers, phones, OBCs, GPS trackers, intercom	Yes	Reliability, accessibility, safety	Efficiency, communication, community training
Mash	✓	Google maps,	Mobile phones, computers, printers	Yes	Safety, accessibility	Visibility, efficiency, sales
Phalco	✓	ERP, Google maps, AQUILA	Computers, phones,	Yes	Safety, image, reliability	Accident prevention, efficiency
PAF	✓		Computers, GPS trackers, Barcodes, RFID devices	N/A	Regulatory	Audit and records
Skin	✓	GAL software	Phones, Tracking devices,	Yes	Accessibility	Efficiency, audit, learning
Honey	✓	MS Office	Computers, phones	Yes	Loss prevention	Visibility, communication
Radar	✓	MS Office, WhatsApp	Computers, phones	No	Threshold	Inventory management, visibility
Water energy	✓	MS Office	Phones, trackers, computers	Neutral	Threshold	Inventory management

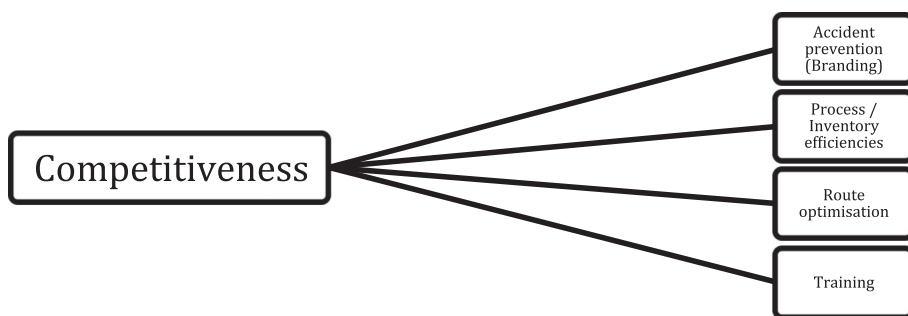


Fig. 2. Competitive factors influencing ICT adoption.

destinations. This is because my organisation pays claims called bridging allowances for the people transporting products over a particular distance. In order to make sure that people do not 'beat us to it' we monitor them to ensure that they actually take the products to destinations that they are claiming that they are going to...people divert products. They can tell you that they are going to Kaduna but we find out that this wasn't the case, they may sell the product in Lagos or take the products to Ibadan but yet they would want to claim the transportation allowance to Kaduna.”

- PAF Coordinator (West)

The use of ICT reduced the opportunity for product diversion, which we noted was a fairly unique problem in the Nigerian downstream industry and a significant challenge for the national agency. ICT use was helping to reduce incidents of scarcity and increase product accessibility for consumers in remote areas, where the problem was most prevalent. Although the AQUILA programme was still at an intermediate phase, the plan is to ensure that all product delivery trucks were fitted with RFID devices in order to comply with improving regulation.

5. Discussion

In this study, we sought to explore ICT adoption and adaptation complexities within Africa and our findings support our assumptions regarding ICT use and adaptation in road freight transport operations within the Nigerian petroleum downstream sector. With respect to instrumentations, we identified a range of ICT mechanisms used in road freight operations within the Nigerian petroleum downstream industry. Our findings reveal an expansive use of ICT for addressing firm objectives that go beyond economic rationales. Usages include social and environmental purposes and this tallies with the position of Weber and Kauffman (2011), who argue that social and 'other' factors contribute to ICT adoption in many countries.

The results validate the framework and evidence ICT adaption at firm level. For example, the use of mobile phones to monitor and track behaviour highlights localisation and adaptation of conventional technology to meet specific business challenges. For example, mobile phone or RFID usage in the industry is driven by concerns about relatively high corruption tendencies that trouble management and government. We contend that such adaptation is driven by the specifics of their business operating contexts and this is a vital link in the adaptation

discourse. This link between adoption, adaptation and business contexts has not been previously determined and this represents a novel outcome of this study. Perhaps this result necessitates future comparative studies across different developing country contexts to improve our understanding of how specific contextual factors influence technology adoption and adaptation.

Similarly, our findings support previous results regarding the role of size on ICT adoption (Evangelista et al., 2013; Jean, 2007; Melville et al., 2004). The findings suggest that larger firms, multinational or local are more likely to adopt ICT compared to smaller firms, however we observe that the evidence for adaptation is converse. Small and medium enterprises were more likely to adapt their ICT mechanisms to successfully support objectives other than those intended by the OEMs. Like Melville et al. (2004) we further observe that adaptation strategies may produce inherent risks that expose the adapting firms to negative consequences because of perceived pressure to improve performance through ICT. For example, we have highlighted the contrasts in objectives and the resulting illegalities relating to mobile phone use by drivers whilst conveying products. Despite the benefits of the adaptation in this case, the findings demonstrate some inherent risk with equally vital implications for management. For example, a road safety report highlights that mobile phone usage accounts for as high as 3% of the reported accidents on Nigerian roads (Federal Road Safety Corps, 2015).

Policy wise, there is evidence to support government action to promote ICT use within road transport operations in the industry, however there are a number of critical issues that need addressing. Firstly, although the AQUILA programme of the PAF agency supports ICT diffusion, it fails to support efficiency at firm level and as a result firm participation on the programme is still borne out of unenthusiastic compliance rather than value perceptions. Secondly, consideration should be given to expanding the range of ICT mechanisms supported by policy. For example, the PAF programme; AQUILA is entirely based on RFID technology that is administered by the agency's centralised monitoring units. This limits options available to firms who may have different ICT adoption priorities that are not covered by the narrow policy programme. A more robust framework that supports a varied range of safe ICT mechanisms may improve diffusion.

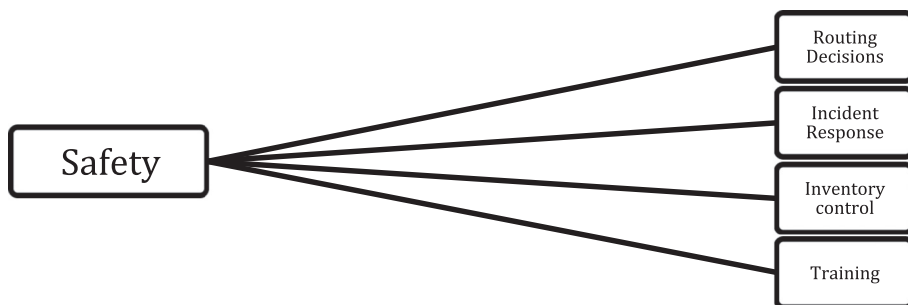


Fig. 3. Safety factors influencing ICT adoption.

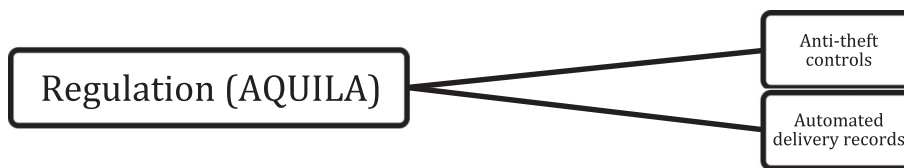


Fig. 4. Regulatory factors influencing ICT adoption.

6. Conclusions and future research directions

6.1. Conclusion

The discourse around ICT adoption and adaptation in Africa continues to garner interest amongst academics. Whereas scholars have explored some adoption interests, the literature is still thin in this area and the nuances of ICT adaptation have been rarely discussed (Aleke et al., 2011; Osabutey et al., 2014). This is particularly true of the road freight transport sector that generates significant benefits and costs. This research explores the nature of ICT use in the Nigerian petroleum downstream industry, highlighting examples of adaptation as well as rationales for adaptation. Our study finds that ICT adoption is positively impacting road freight transport in the industry, supporting safety, audit, visibility and accountability in operations.

By way of originality, our findings provide empirical links between ICT adoption, adaptation and contexts, establishing that beyond the adoption discourse, contexts influence the way in which conventional ICT mechanisms become localised to meet firm and contextual objectives. This finding aligns with the knowledge and transfer arguments advanced in the extant literature, underlining the inherent risks of blanket technology appropriation to developing and developed countries (Dadzie, 1990, Kyem, 2012).

Additionally, this study affirms the role of size and ownership as critical to ICT adoption (Erumban and De Jong, 2006; Osabutey et al., 2014). In particular, we observe that the relationship between size and adoption is potentially converse to the relationship between size and adaptation, whereas smaller firms are more likely to adapt their limited technology beyond the intentions of OEMs. Future studies may expand on this finding to investigate the complexities that drive this anti-technical correlation between size and ICT adaptation.

The contributions of this study create implications for practice and academia. Primarily, this paper contributes to the literature on technology adoption in Africa by way of establishing empirical evidence to

support prevailing assumptions regarding the influence of contexts on ICT adoption. Furthermore, our empirics provide insight into an industry sector that has not been the subject of investigation in this area, addressing some real issues on the scope and effect of ICT adoption.

Likewise, the paper highlights the role of contextual factors on ICT adoption and adaptation. We believe that there are learning and parallel transfer opportunities for users and OEMs in this regard. OEMs can explore avenues for innovation by drawing on some adaptation models to improve their offering to different market regions. Particularly, the findings suggest that innovative adaptation is occurring more in SMEs than in the larger firms and OEMs can explore collaborative opportunities for learning and technology innovations with SMEs. Our paper also highlights some important considerations for policy makers with regards to ICT diffusion in developing countries, where there needs to be a better balance between ICT as a value tool as opposed to being a tool for control.

6.2. Future research directions

This study provides unique insights into a contemporary area of research relevance in the area of technology transfer and use in Africa; however, we identify with the opportunity for future research to build on our findings to explore performance management issues. Specifically, future studies can expand on testing the dynamics of control and strategy in the technology adoption and adaptation field. Similarly, comparative studies that adopt case study methodologies can be undertaken to explore the adaptation dynamics in similar industries within different developing and developed contexts. In this regard, there is the potential to unearth subtle dynamics that drive adaptation with moderations for industry and product or service dissimilarities. Of equal interest is the need to further explore and test size factors and their effects on ICT adaptation or sub-variables that impact the technology adaptation process.

Appendix A

A.1. Interview protocol

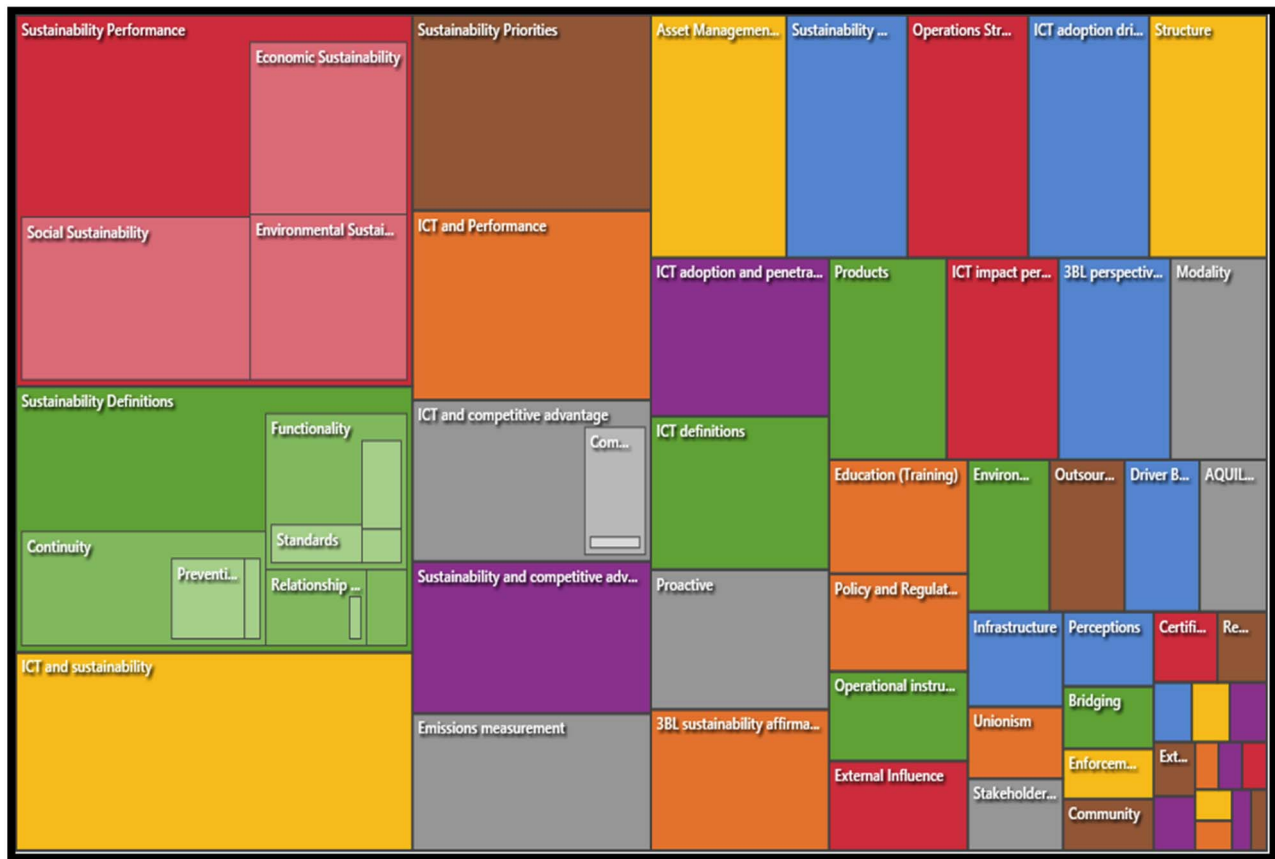
This interview is part of a research that seeks to understand particular challenges in ICT adoption within road freight operations in the oil and gas industry.

1. Please describe your role and responsibility within your organisation?
2. Can you please provide some detailed information on the range and volume of products that your organisation distributes on a daily, weekly and monthly basis?
3. Are your operations organised nationally, regionally or locally (State or Local government levels)?
4. Can you please describe in (as much detail as possible) the processes of distributing and marketing your petroleum products via road networks?
We are interested in the process between the requisition and loading of the products from the depots through to the offloading of the products into the fuel station storage tanks for dispensing
5. Can you describe your distribution and marketing structure/strategy? i.e. does your organisation own and control all the assets used in the distribution of your products via road or do you have sub-contracting and 3rd party logistics partners in place?
6. People use the term sustainability commonly; please can you tell me what the term “sustainability” means to you?
7. How important would you say the issue of sustainability is to your operations as a petroleum products distribution and marketing firm?
8. In what ways would you say your operational structure/strategy influence your objective to keep your operations sustainable?
9. In your opinion, do you think that sustainability is important to all organizations in your industry and what are the possible reasons for your answer?
10. Sustainability is commonly viewed from 3 different perspectives, namely the Social, Economic and Environmental perspectives; do you agree that these perspectives apply to your operations as a petroleum products distribution and marketing firm?

11. Bearing in mind the different perspectives to sustainability, can you give some examples of
- i. *How your organisation sets its social sustainability objectives, preferably with examples?*
 - ii. *How your organisation sets its economic sustainability objectives, preferably with examples?*
 - iii. *How your organisation sets its environmental sustainability objectives, preferably with examples?*
12. Would you say the processes you have in place are socially, economically and environmentally sustainable, i.e. are your operations meeting the sustainability objectives?
13. Do you think that the level of sustainability being achieved in your distribution and marketing process gives you any advantage over your competitors?
14. Can you please give some reasons for your answer to question 13?
15. Let me draw your attention to the Okobie incident in 2012 where lives were lost as a result of an overturned fuel delivery tanker whose contents were being siphoned by members of the public;
- i. *Are there any procedures, measures or methods proactively put in place to prevent or mitigate such occurrences?*
 - ii. *Do you employ information and communications technology tools like computers, computer applications and other devices to enable these procedures and measures?*
 - iii. *Can you describe the extent to which you think ICT tools are important to your objective of preventing or mitigating such occurrences?*
 - iv. *Are you compelled by law to have these procedures, measures or methods in place or are they resultant from internally initiatives?*
 - v. *Do currently measure and keep records of the emissions from your road transport distribution processes? And how do you achieve this?*
 - vi. *Do you feel the use of ICT has positively impacted your operations in this area of preventing negative occurrences like the Okobie incident?*
16. Do social and environmental issues like noise levels, carbon emissions, air pollution, and accidents come within the scope of negative issues that you seek to prevent or mitigate?
17. How do you balance the challenge of being socially and environmentally sustainable with being economically sustainable?
18. If you were evaluating your organisation's approach to sustainability, would you describe it as very competent, competent or not competent (*where competence means that you have a very strategic and efficient plan in place*)
19. Back to the idea of ICT, I understand that your operations are very complex and involve a lot of coordination to deliver your operational objectives on a daily basis.
- i. Do you use ICT devices and systems to aid the delivery of these objectives?
 - ii. How important is the use of ICT, in terms of your ability to meet your objectives? Would you say you couldn't meet your operational objectives without the aid of ICT tools, devices, applications etc.?
 - iii. Can you give examples of ICT devices, software and applications that you use to achieve your operations objectives?
20. Does the objective of being sustainable contribute to your decision to adopt ICT devices, tools, software and applications in your product distribution processes?
21. Bearing in mind that you also have other means of transporting products, e.g. water and pipelines,
- i. How important would you say ICT is to your distribution of products via road?
 - ii. In what ways do you deploy ICT to aid the actual process of distributing your petroleum products
 - iii. Does the use of ICT any advantage over your competitors with regards to the distribution of petroleum products via road or would you consider it a basic threshold requirement of the industry sector? i.e. all the firms have it and it doesn't create any significant profitability advantage.
 - iv. Can you share any ideas of how you think the use of ICT (as part of the product distribution process) can give your organisation an advantage or better advantage over the competition?
22. Does your organisation share information about the sustainability of your operations? If it does share with the public, where can such information be found?
23. Are there any issues which we haven't highlighted but you think are important to discussing sustainability in your road freight operations?

A.2. Level 1 codes and themes

Code/Theme Density (Transcription)



List of Codes and Themes/Referenced Meanings

Code	Theme
1	3BL Sustainability - Acknowledgement of 3BL
2	3BL feasibility - Belief in its being achievable
3	Asset Management Strategy - Plan for and use of firm assets
4	Community - Locals in areas of operations
5	Emissions measurement - Calculation or metrics for emissions
6	ICT adoption - Uptake/use of ICT in operations
7	ICT adoption drivers - Factors that influence ICT use
8	ICT competitive advantage - Competitive factors or results from ICT use
9	ICT penetration - Extent of ICT use in operations
10	ICT for sustainability - Use of ICT for sustainability performance
11	ICT and firm performance - Use of ICT for general firm operations. Linked to penetration, adoption and adaptation
12	ICT definitions - How managers/respondents define ICT and its scope
13	ICT adaptation - Use of ICT in ways other than OEM prescription.
14	ICT impact perceptions - How respondents view ICT use and its benefits/costs
15	Incidents - Reference to notable externality examples
16	Outsourcing practices - Delegation of freight or ICT operations to external firms
17	Policy & regulations - Range of laws and local trade practices that govern operations
18	Product type - Specifics on types of petroleum products and implications for different freight planning
19	Firm structure - Organizational set-up of the firms. Hierarchy, power etc.
20	Firm operations structure - Process set of the firms.
21	Sustainability (CA) - Link between sustainability and competitive advantage
22	Sustainability definitions - Respondents opinions and references to sustainability
23	Continuity - Continuous outlook as a factor of sustainability
24	Prevention - Preventing harm as a definition of sustainability

25 Relationship	- Community relationship development as a measure of sustainability.
26 Safety	- Reduction of harm and practices that promote wellbeing
27 Functionality	- Pragmatism as a measure of sustainability
28 Value	- Perceptions of the usefulness of sustainability
29 Sustainability importance	- References and justification for
30 Sustainability performance	- measures relating to sustainability performance and some measurement metrics
31 Economic performance	- Economic sustainability initiatives, measures and factors
32 Environmental performance	- Environmental sustainability initiatives, measures and factors
33 Social performance	- Social sustainability initiatives, measures and factors
34 Sustainability priorities	- How aspects of the 3BL are ranked in order of importance
35 Emissions measurements	- Measures what constitutes emissions and how to evaluate them
36 Proactivity	- Internally developed strategies to improve sustainability
37 Stakeholder involvement	- Inclusive approach to managing externalities
38 Education (training)	- Evidence of workshops, conferences, studies etc.
39 Environmental pressures	- Peculiar factors within business environments that influence managers
40 External influences	- Specific non-firm factors that impact sustainability performance of firms
41 Externalities	- Negative outcomes from product freight operations
42 Sustainability incentives (firm level)	- Internal goals, motives and tools that promote sustainability practices in firms
43 Modality	- Different modes of freight transport
44 Inter-modality	- Combination of modes with different handling
45 Co-modality	- Combination of modes without different handling
46 Multi-Modality	- Non-integrated but varied modes of transport
47 Uni-modality	- Single and non-integrated mode of transport
48 Peer interaction influences	- Evidence of ICT adoption or sustainability practice being induced by activities of industry peers
49 Reactionary	- Responsive strategies or actions for sustainability.
50 Unionism	- Active actions by unions/pressure groups to promote their causes
51 Infrastructure	- ICT or road transport infrastructure
52 Bridging	- Quasi- consolidation hub system for transporting products
53 Corruption	- Inordinate and inappropriate activities by firms, managers, drivers or regulators
54 Competitive perceptions	- Link to competitive advantage but not evidenced with factual data
55 Development	- Improving living and working community conditions
56 Driver behaviour	- Actions and activities of drivers of freight transport vehicles
57 Non-freight actors	- Involved parties without interest in the freight process/operation
58 Road Infrastructure	- Infrastructure to support road transport or the use of road transport
59 Results oriented	- Focus and perceptions of outcomes
60 Queuing and efficiencies	- Product purchase
61 AQUILA programme	- Related to activities of the AQUILA programme
62 Enforcement challenges	- Difficulties of enforcing legal provisions related to freight
63 Certification	- Proffered evidence of quality or other positive practice
64 Short-termism – brief case companies	- Firms with focus on short term practices and profits, often having skeletal legal and physical presence

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Abiye Tob-Ogu is a Research and Teaching Associate at the Sheffield University Management School. His research expertise focuses on ICT and digitalization for sustainability in logistics and road freight transport. He also has interests in sustainable operations and green supply chain management.

Abiye is a Fellow of the UK's Higher Education Academy (HEA) and has several conference publications. He is also a key member of the operations management decision support division (OMDS) and center for logistics and supply chain management (CLSM) at the University of Sheffield. He is currently working with the Stockholm City Council and KTH as part of an EU sustainable freight project led by the University of Sheffield in collaboration with a number of international partners.

Niraj Kumar is a Senior Lecturer in Operations and Supply Chain Management at the University of Liverpool's Management School. In past, he held academic positions at the Sheffield University Management School, Hull University Business School (UK), University of Bath School of Management (UK) and University of Hong Kong (HK). He has a PhD from University of Bath School of Management, an MPhil in Industrial and Manufacturing Systems Engineering from University of Hong Kong and a Bachelor of Technology from NIFFT, Ranchi, India.

Dr. Kumar is a Fellow of the UK's Higher Education Academy. He has more than fifty research publications in peer reviewed journals and international conferences, and some of his research papers are highly cited in reputed international journals. He has worked on a number of research projects with several companies in Aerospace, Retail, Construction, Food and Automobile sectors.

John Cullen is a Professor of Management Accounting in the Management School. Following on from his role as president of the British Accounting and Finance Association (BAFA), John is now Chair of the BAFA Trustees. He has been a member of the CIMA Research Board and a member of the CIMA Examination Oversight Board. He has been a Guest Editor for a number of journals and is also a reviewer for a number of accounting journals (e.g. *Management Accounting Research*, *British Accounting Review*). He has undertaken supply chain consultancy projects in a number of organizations.

John's research interests include supply chain management, supply chain accounting, reverse logistics, management control and corporate governance. His research is mainly case study based and it has focused on both small and large organizations in the public and private sectors. He has received research funding from the Department for Transport for some leading research on reverse logistics.