Dirty works: Enabling carbon management practices in the construction industry

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Abstract

Pressure is growing on the construction industry to reduce carbon emissions. Whilst progress has been made in developing carbon calculation tools to quantify emissions, the uptake of these tools has been slow. We identify the reasons for the slow implementation of carbon management in the construction industry and propose a three step framework for implementing carbon management practices within an organisation to overcome those barriers. Using a case study approach we examine the barriers and drivers to the implementation of a carbon calculation tool. Our findings suggest that barriers can be internal or external to the organisation, but can also be shared between the organisation and the wider industry. To overcome those barriers firstly, there must be external motivation incentivising the organisation. Secondly, the organisation's leadership must take responsibility for setting the organisation's strategy around carbon management. Finally, carbon management must be integrated throughout each team within the organisation.

Key Words

Carbon Management; Barriers to Change; Drivers for Implementation; Construction Industry; Carbon Calculators

1 Introduction

Climate change is 'the greatest challenge of our time' (Fanelli, 2014, p. 15), and to cap the Earth's rising temperatures, a significant reduction in greenhouse gas emissions is needed. An often overlooked sector for achieving such a reduction in carbon emissions is the construction industry. Directly or indirectly the construction and use of infrastructure assets accounts for over half of the United Kingdom's (UK's) total carbon emissions (HM Treasury, 2013) and should be reduced by 50% by 2025 (HM Government, 2013). Although growing attention has been paid to carbon management (CM), which we define as any practice or process that aids the management and reduction carbon emissions, the actual implementation of such practices and consequent reduction of emissions in this industry has only taken place slowly (Xavier et al., 2017). It has been tentatively argued that this is due to the industry's resistance to change (Lines et al., 2015) and slow adaptation of new innovations (Robinson, 2018). Other scholars have stated that challenges stem from the perceived contradiction between investment in environmental concerns and profitability (Porter and van der Linde, 1995), the perception that environmental policies are viewed as a marketing gimmick (Le Breton and Aggeri, 2018), and the danger that if considered after the initial design stage meaningful impact is difficult to achieve (Williams and Dair, 2007). It is not well understood why the uptake of such practices has been slow and how best implement new processes in this area.

Recently, there has been a call for researchers to develop a better understanding of the reasons for the slow transition of organisations to a low-carbon economy and help to identify pathways to a more rapid and transformative change (Wittneben et al., 2012). It is to that end this we aim to explore two research questions:

1) Why have organisations in the construction industry been slow to implement CM practices?
2) How can organisations in the construction industry ease the implementation CM practices?

To answer these questions, we identify the barriers and drivers to accelerate the implementation of CM practices in the construction industry, and develop a conceptual framework suggesting the steps required to enable this change. We use a case study approach to examine the development and piloted implementation of a carbon calculation tool within a selected construction organisation through qualitative data collected over a three year period. In doing so, we fulfil the call of Jackson and Brander (2019) explore the barriers preventing the implementation of carbon calculators in the construction industry. We also make reference to Giesekam et al. (2016) who state there have been

few qualitative studies looking at low-carbon techniques within the construction industry so this paper goes some way to fulfilling that gap.

The remainder of this paper is structured as follows: Section 2 first discusses the construction industry and its challenges in implementing change and innovation before looking at the literature on barriers and drivers to sustainable change; Section 3 presents our methodology and discusses our data coding and analysis; in Section 4 we present our findings; in Section 5 we discuss how CM can be integrated within an organisation and propose a framework for steps required to implement CM practices; and finally we conclude in Section 6.

2 Theoretical Background

2.1 The Construction Industry, Change and Carbon Management

For CM practices to be incorporated within the construction industry, scholars agree that transformational change is required to allow innovative technologies to be implemented and successfully used (BSI, 2016). However, governments and private-sector organisations have long been concerned with how the construction industry deals with change (Fernie et al., 2006). As a result, the industry is often perceived to be lagging behind other industries in terms of implementing innovation, reacting to market tends, improving quality of products (Hoonakker et al., 2010), and is even showing lower levels of productivity (Yuventi et al., 2013). The lack of such timely innovation in this industry has been attributed to four main issues. First, the fragmented nature of supply chains often including a large number of stakeholders making collaboration difficult (Jacobsson and Linderoth, 2010; Yuventi et al., 2013). Second, an absence of accountability between different phases of a construction project (e.g. work-winning and project delivery) which limits efficiencies and makes it hard for teams to understand what is happening outside their area of expertise (Yuventi et al., 2013). Third, a procurement process which encourages a 'race to the bottom' with work often being awarded to the bidder offering the lowest price (Yuventi et al., 2013). Here, other considerations such as the sustainability of products or carbon emissions are often overlooked. Fourth, contractors using temporary project-based models so that new processes and knowledge accrued often fail to be transferred from one project to another (Miozzo & Dewick, 2002).

Regardless of the above indications on the reasons for an absence of innovation, research on CM specifically in the construction industry has only looked at specific technical issues, for example the choice of building materials (e.g. Giesekam et al., 2016), low- or zero-carbon building designs (e.g. Kershaw & Simm, 2014), or measurement practices (e.g. De Wolf et al., 2017). Research specifically

on how CM processes are adopted within organisations is lacking, however, engaging with CM could be promising for the industry which becomes evident by looking more generally at sustainability related efforts. Tan et al. (2015) for example found that a high sustainability performance of contractors in the construction industry leads to higher revenue growth and provides opportunities to achieve competitive advantages over rival organisations. To develop this competitive advantage, organisations establish technical and technological capabilities and knowledge (Pinkse & Dommisse, 2009, Chang et al., 2016), and develop best practice case studies to showcase the positive achievements of such efforts (Chang et al., 2016). However, how individual construction organisations can meet the carbon reduction challenge is not well understood from these investigations.

Other scholars have developed frameworks for CM. Wahyuni and Ratnatunga (2015) create a general template for developing effective CM strategies proposing five steps for managing carbon: develop and understanding of emissions; identifying exposure and cost implications; developing a strategy; implementing the strategy; and monitoring progress. Bekaroo et al. (2019) look at how to reduce employees personal emissions suggesting a circular 'plan-do-check-act' framework starting with setting objectives, learning, reducing, monitoring progress, measuring and then setting new objectives. Whilst both these frameworks are useful in proposing the steps required, they fail to shed light on the overarching factors that need to be in place for organisations to be able to successfully implement CM practices.

2.2 Barriers and Drivers to Sustainable Change

In the absence of research on the introduction of carbon management specifically, research on change in the construction industry more generally shows that there are various barriers which are specific to the area where, and/or type of, change is to be implemented e.g. within the construction process (e.g. Vennström and Eriksson, 2010), the implementation of new technologies (e.g. Porwal and Hewage, 2013), and along sustainability issues (Pinkse and Dommisse, 2009). Barriers identified are then often grouped together, for example, Vennström and Eriksson (2010) identified that barriers to change in the construction industry arise along three categories; attitudinal, industrial and institutional. Attitudinal barriers focus on individuals and their views on change, industrial barriers from other organisations such as competitive pressures and industry practices, and institutional barriers are the 'rules' and refer to laws, standards and procurement processes which made it difficult for the industry to change.

The most recognised categorisation of barriers is the recognition that the observed barriers occur along internal or external boundaries of an organisation. Álvarez Jaramillo et al. (2018) conducted a literature review looking at barriers to sustainability and classified over 170 barriers using this 'established criteria' (p. 522). Del Río González (2005) explains internal barriers are barriers that an organisation has direct control over, such as the organisation's characteristics or strategies. Internal barriers include the organisation's leadership (Arnold and Hockerts, 2011) or the organisation's environmental capabilities (Kesidou and Demirel, 2012). External barriers are barriers that an organisation has little control over, such as policy directions, consumer preferences, or competitors' decisions. External barriers include competitive pressures from rival organisations (Cai and Li, 2018) or lack of government support (Sajjad et al., 2015). Whilst comprehensive, the study of Álvarez Jaramillo et al. (2018) to barriers to sustainability only refers to one case from the construction industry which finds three barriers: acquiring financial capital, a lack of expertise, and the time of work shifts. To that end, we plan to use this categorisation to develop a better understanding of the barriers that exist within the construction industry.

3 Methods and Data

3.1 Procedures and Data Sources

A case study approach (Baxter and Jack, 2008) was used to answer our research questions. The case study followed the development and implementation of a carbon calculator, the Carbon Infrastructure Transformation (CIT) Tool, within a contractor organisation. The CIT Tool quantifies and reports emissions prior to the start of the build phase (see BS 15978 (BSI, 2011) and PAS 2080 (BSI, 2016)) and allows construction estimators, planners and designers to collaborate on carbon reduction practices to minimise carbon emissions and associated costs on large infrastructure projects. Thus, CM practices can be initiated before the construction phase begins, and can both reduce emissions and increase profitability. Given the exploratory nature of the research (Blumberg et al., 2011), a qualitative approach was used to gather data. The data collection can be divided into three phases:

The first phase of data collection for this case study gathered an industry-wide perspective of the challenges involved in integrating the CIT Tool and CM practices within the construction industry. To get the widest possible reach one workshop (Workshop 1) was organised with 23 participants working for 21 organisations across the construction industry: seven participants from contractor organisations, seven from client organisations, four from environmental consultancies, two from engineering consultancies, two from regulatory bodies, and one participant from a technical consultancy. The selected participants were associated with environmental or sustainability roles

within their organisations to be able to have knowledge on current environmental practices within the industry and carbon-related tools and initiatives. Participants were divided into four focus groups for three breakout sessions, addressing first, barriers to the CIT Tool's implementation, second, how to overcome such barriers, and third, other CM practices that are operational within the construction industry. Workshops were used as they allow for a particular subject to be explored in depth (Bryman, 2008), revealing various barriers and challenges faced when implementing CM practices within infrastructure organisations.

The second phase of data collection captured the practitioner's (See Table 1) perspective (construction employee who would use the tool if implemented). This was done in two stages, firstly four semi-structured interviews (lasting on average 39 minutes) were carried out with practitioners from one contractor (Contractor A). Next, a second workshop (Workshop 2) was organised with 13 practitioners from two contractors (Contractor B and Contractor C) who have previously trailed the CIT Tool. The content of these workshops was designed to gain an understanding of how CM practices were perceived throughout the industry and within each selected organisation. The practitioners were also asked to discuss the preliminary findings from Workshop 1 on barriers and enablers to the tool's implementation.

The final phase of data collection explored the current operating practices and processes around CM. For this we focused on Contractor B. During this phase 10 semi-structured interviews (one group and nine individual interviews, averaging 45 minutes) were conducted to investigate the level of understanding within different teams and at different job levels (see Table 1). During this time, one researcher – as an observer – also joined a number of working groups on CM, and conducted open interviews (recorded via field notes only) with a client (Client A) and supplier (Supplier A) of Contractor B.

Table 1: Job titles of interview participants

Contractor A (Interviews 1-4)	**Contractor B** (Interviews 5-14)
Trainee Quantity Surveyor	Group Head Supply Chain
Business Development Manager	Head of Supply Chain – Rail
Quantity Surveyor	Business Development Manager
Planner	Knowledge Manager – Group Work Winning
	Piping Designer – Water
Client A	Planning and Technology Manager
Head of Carbon Neutrality	Estimating Manager
	Business Improvement Director
Supplier A	Group Carbon Manager
Commercial Development Manager	Sustainable Engineering Manager
Sustainable Construction Manager	Finance Director

3.2 Data Coding and Analysis

We used an **iterative** approach to our data analysis drawing from Gioia et al.'s (2012) analysis guide. The first stage of our analysis was to examine the barriers to the tool's implementation within the construction industry. Posters created and transcriptions of the group discussions from Workshop 1 were analysed in NVivo, a commonly used qualitative data analysis software, and from these barriers were grouped into first-order concepts.

Next we integrated data from the four semi-structured interviews with Contractor A and Workshop 2 to identify how this additional data supported or contradicted our initial first order concepts. This allowed us to integrate data from our multiple sources and multiple research tools to allow for 'data triangulation' and 'methodological triangulation' (see Denzin, 2009). Doing this allowed us to reopen the coding to strengthen our concepts and develop second-order themes. Once the second-order themes were agreed upon we suggested categories for the barriers that would describe and explain the findings from our data (see Table 2).

In total, we identified 126 barriers. These were coded into 27 first-order concepts and 10 second-order themes relating to barriers to the tool's implementation within an organisation. These barriers were then categorised in three groups: External Barriers, Internal Barriers and Shared Barriers (see Figure 1 for summary). At this point similar barriers started to reappear and data saturation was reached. As such, our focus shifted to understanding how to overcome these barriers by undertaking semi-structured interviews with Contractor B. Again NVivo was used to code the interview transcripts, mapping the enabling factors discussed to the barriers to gain an understanding of the best ways to integrate CM practices within an organisation.

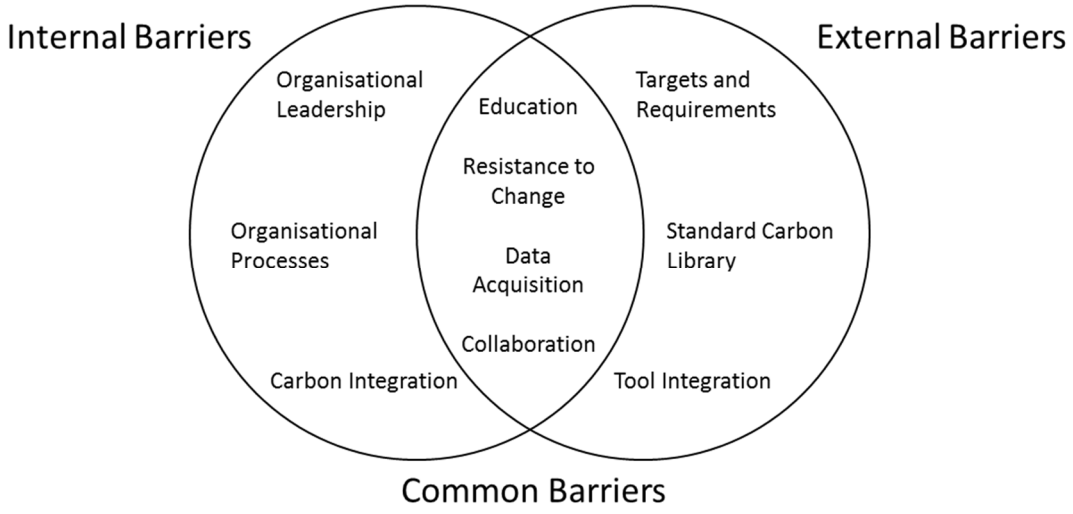

Figure 1: Summary of barriers to the implementation of carbon management within the construction industry

Table 2: Data coding for barriers to implementation

Barriers to implementation *(code refers to workshop number, group and session (e.g. 1D1 means Workshop 1, Group D, Session 1)*	**Theme**	**Category**
Carbon not part of commercial process "I have a commercial background, a big user of the NEC form of contract. I've never seen carbon mentioned in a contract before." 1D1 **Sector / discipline fragmentation** "the tool will be treated great and it will work with the right will, but actually, in order to get the best of it, you've got to do something about how fragmented everything is". 1R2 **Work-winning / delivery disconnect** "There is a bridge between the great work that happens at work winning, and then what you guys do on the delivery side. That is where we are all pulled back and we all fall down." 2K1	Organisational Processes	Internal Barriers
Carbon as bolt-on process "Going from bolt-on to BAU" … "we need to move away from bolt-on processes to administrative processes". 1D1 **Integration with other teams** "where addressing carbon … it is everybody's role, the planners, the procurers, the designers." 1D1	Silo Mentality	
Leadership involvement "it's a big challenge, getting leadership involved because it's such a big issue, people don't have time for it". 1R1 **What is the management's appetite?** "it has to be the bid manager and the project director that have ownership of making sure there is visibility around the strategy and project delivery". 2K2 **Resources required to implement** "It needs a dedicated resource … it can't be a bolt-on, someone has to take it on." 2K1	Leadership	
Lack of regulation for measurement "potentially one of the barriers is the absence of any regulation". 1D1 **Alignment to standards** "you should set a KPI to align your environmental management with how you make money". 1M1 **Need for client leadership** "if you have a joined up approach across client groups then it will make the industry better at responding". 1D1	Targets and Requirements	External Barriers
No common carbon dataset "if the carbon library is something each company still has to go away and develop, that governance piece about how that is put together is always going to be a big issue". 1K1	Standard Carbon Library	
Competition with other tools "are you suggesting you want those people using those other tools to get rid of their tools and to use this tool"? 1R1 **Unique selling point** "is it just going to be another tool or does it have a unique selling point"? 1K1 **Compatible with BIM** "are they compatible with the BIM model, the data that's prescribed to get to that?" 2D1	Tool Integration	
Knowledge deficit "it isn't just knowledge in terms of 'this is how the tool works', it's 'why does this matter to me in my role'". 1D1 **Shortage of skills** "people don't have the knowledge. Before you can get to talk to them the just don't have the basic expertise, so changes and skill". 1R1 **Communication strategy** "the biggest barrier as a whole is communication … I don't see people communicating points of carbon". 2D1	Education	Shared Barriers
Industry buy in "that whole value chain indifference with the client, the designers, through the constructors and supply chain is quite key". 1K1 **Speed of procurement process** "but through talking to our clients, and those outside of the sustainability world, literally the procurement or commercial, or the planners will look me in the eyes and say 'is this going to delay my project'? 1M1 **Engaging the whole supply chain** "there needs to be a mutual benefit, has it got clients and the supply chain to come up with reductions"? 1D1	Collaboration	
People reluctant to share data "we've got one [a barrier] on whether people will want to share their data … we have that around confidentiality as well". 1M1 **Consistent method of collating data** "if you wanted to align different standards of measurement then you have to have a consistent approach for any client request". 1D1 **Extra work collating data** "we can't honestly ask the supply chain to give us this extra carbon data". 1R1	Data Acquisition	
Industry slow to roll out incentives "then we should look at SMEs, this fourth stage with the wider industry with loads of requirements" … "which is slow to change at the best of times". 1M1 **Does the industry want to change?** "you just hear the same and see the same faces and there isn't any real industry leadership, What is the drive in the industry?" 2D2. **What is in it for company/individual** "it's got to be very clear to each organisation, what's in it for them, why should they adopt the tool … it's about what's in it for me, why is this better"? 1M1	Resistance to Change	

4 Findings

Through the initial workshops relating to CM implementation we identified barriers to successful, meaningful CM implementation. Our findings revealed three broad groups which we classify as 'External Barriers', 'Internal Barriers' and 'Shared Barriers'. A lack of targets or requirements that establish what should be achieved through CM practices was seen as one of the biggest barriers to the implementation of CM practices within a construction organisation. Participants often pointed to a lack of regulation providing such targets stating that it was unlikely for their organisation to move towards implementing CM practices if they were not required to do so. Likewise, participants stated that CM tends to be overlooked if the client does not specifically asking for this in the procurement stage and/or incentivised low-carbon solutions. Other participants stated the need for standard datasets to be used throughout the industry to encourage collaboration and common working methods. Finally, another barrier participants pointed to was the fact that many similar tools exist in and beyond the construction industry therefor not knowing which one to use or how the one piloted in our study could provide unique findings or complement other tools. We call to these barriers 'External Barriers' which are barriers outside of the direct control or a construction organisation. Secondly, we found diverse 'Internal Barriers' preventing CM processes within organisations. The participants discussed the lack of desire from their organisation's senior leadership indicating that CM practices were not as important as business as usual. Participants also feel that CM is not fully integrated within organisational processes, and that there is a fragmentation of teams within the organisation with some engaging with CM and other not. We also found evidence of a number of barriers that are 'Shared' to both the organisation and the wider industry. Our participants at these two levels observe a resistance to change to the implementation of CM practices shown by the lack of drive from the industry and slow adoption within organisation. This, they link to an absence of sufficient training and knowledge to implement the practices in meaningful ways. In addition, the participants point to the absence of standardising processes around CM practices and state that currently there is little collaboration throughout the supply chain in order to enable CM practices.

After identifying these barriers, the participants guided us quickly towards potential steps to enable CM in the construction industry. We thus proceeded to detail a framework with steps required to overcome these barriers to enable CM practices within an organisation. We suggest three steps in this framework: Firstly, external motivations for the organisation to start the implementation process. Secondly, the need for the organisation's leadership to take responsibility for implementing CM practices over the long term and within the entire organisation. Finally, CM needs to be integrated

within each team across the organisation, from procurement to project delivery. We will discuss in detail the steps and the associated framework here.

4.1 Enabling CM Practices Within the Organisation

The data shows that the internal barriers can be best overcome through focusing on three aspects. First, construction organisations must be motivated or incentivised from external sources such as regulations, client incentives or industry pressure. Second, the organisation's leadership is required to incorporate CM practices as part of the organisation's vision and strategy. Third, CM must be integrated through each team within the organisation. Each of these internally focused enabling steps we will now explain here closely with your data points.

4.1.1 External Motivation: Supporting CM Practices from Outside the Organisation

The participants described in the interviews how construction organisations can be persuaded to adopt CM practices through external influences. Our analysis shows that complying with regulated targets and meeting client's requirements are major drivers for incorporating CM processes within the organisation.

> *Everything that we do in terms of the supply chain and the materials we get is driven by regulations within the industry and regulations that our clients have to abide by … obviously we will do what we are told to in terms of what is regulated for use to do. (Interview 6).*

The quote shows how this participant sees a clear link between regulations and change. Thus, regulatory pressure is a significant driver to motivate change throughout the industry. The participants for example explain this link by referring to other technological advances such as BIM (Building Information Modelling) that have recently been introduced. The participants explain that BIM was only introduced by organisations after governmental requirements to do so. Regarding the implementation of the CIT Tool specifically the following participant explains:

> *I think a tool like this, and thresholds for carbon reduction, need to be mandated, need to be driven from the government … if BIM wasn't mandated a couple of years back I think supply chains, contractors, consultancies just wouldn't have adopted it. (Interview 4).*

Despite an increase in specifications that organisations can abide to such as BS 15978 and PAS 2080, there is scarce regulation calling for organisations to manage and reduce their carbon emissions on

infrastructure projects. If regulation is lacking in the area then the organisation will require other forms of incentives to change their processes. Another major driver for implementing change that the participants voiced is the interest of the client in CM practices. The participants feel that during the procurement process most bids are assessed on whether they are likely to be finished to the estimated cost and/or on time alone. Emission reductions are not considered in this assessment. The data shows that if emission reduction targets were part of this assessment then organisations would be encouraged to critically examine how they are addressing this. Especially if the clients are starting to request this as this participant observes:

> *If you look at the leadership that is coming from the likes of Client A, Client B, Client C, Client D, a lot of the [carbon reduction] requirements are starting to be mandated as part of that leadership, their role is really important. Without them saying change is needed, change won't happen. (Interview 5).*

However, there are still challenges as not all clients are mandating CM as part of their procurement process, which is a concern of the participants:

> *It's a bit hit and miss at the moment, it is driven by what the client wants so on some jobs we do it and on some jobs we don't. (Interview 10).*

Differences in client requirements/expectations on CM practices also make it difficult for organisations to follow standardised processes within their own organisation, and across teams and projects. Likewise, if a client has a CM tool or carbon library that they are implementing and their contractor is using a different CM tool/library then the reported emissions could vary despite the same approach being used. Instead, the participants state the need for a standardised approach throughout the industry to ensure consistency and avoid the risk of an organisation becoming isolated in their practices:

> *It is a very slow changing industry and that is due to the nature of the works that we do. It can be risky so we can't go our own way, go off on one and do something completely different. (Interview 12).*

Our analysis finds that organisations are concerned about changing business as usual if it is not industry-wide practice yet. They are unlikely to adopt CM practices without being incentivised to do

so. Regulatory pressure and/or incentives however, from the government or the client to adopt CM practices were seen as crucial steps in enabling CB practices. Standardising the way CM is integrated throughout the industry would also encourage more organisations to consider adopting CM practices. The steps revealed here align with the barriers around targets, standardisation and resistance and help form the first part of our enabling framework entitled external motivations (see Figure 2).

4.1.2 Leaderships Role in CM Implementation

The data also shows how the role of a construction organisation's leadership team is important for the successful integration of CM practices. During an informal interview with a participant from Client A, the participant explained how their chief executive had stated the importance of reducing carbon emissions and the need to incorporate CM fully within their organisation. To achieve this the chief executive had identified a 'carbon champion' on their executive board who endorsed the work being done by interdisciplinary teams to reduce carbon emissions. This was particularly beneficial in incorporating CM into the organisation's long-term strategy and direction.

Although Contractor B had an environmental team and a carbon specialist embedded amongst their innovation team there was a feeling that for CM practices to be fully integrated throughout the organisation's top leadership needed to lead from the front. This was explained by two of the participants from this organisation.

> *Leadership should actually talk about it. I don't recall [the CEO] ever talking about carbon, yet, or anyone talking about it at the roadshow or anything like that. If it was given that bit of profile, people see it as more important if their leader is talking about it. They think oh, it must be important, I need to do something about it. If it doesn't get mentioned then obviously people assume it is not as important, simple as that. (Interview 11).*

> *Having buy-in from the leadership, not necessarily saying 'you shalt do this', but who are really pushing the agenda and they are the ones standing up and saying this is the fantastic work that we are doing and should be doing more of. (Interview 6).*

A dedication towards CM practices from the organisation's leadership team can then encourage the organisation to define strategy, develop processes, provide training and encourage collaboration around CM. Speaking about how Client A defined their strategy around CM, one participant said:

They were very much at the forefront of setting a whole strategy that was based around it. I think they did it quite cleverly in that they realised the importance of carbon generally, but they knew that was a key driver in allowing them to achieve other things that they wanted such as reducing their cost base … They set a whole strategy around it, and I think it caught the industry out a little bit, it was quite revolutionary at the time. (Interview 5).

Defining a strategy around CM can give other advantages such as cost savings and efficiencies. However, the data shows that once a strategy has been implemented, it is important to have standardised processes that can be followed across the entire organisation. These processes, the participants feel, must also be clearly communicated to ensure consistency amongst teams and across projects. When asked about the best way to develop standardised processes, one participant suggested starting with one individual from each team across a construction organisation showcase the benefits of incorporating CM practices:

If you could find a link the whole way through, so find one estimator that's keen as mustard to engage with the plan, and you get it demonstrated on one project, then potentially they redo it again, then you can build that momentum. (Interview 12).

This approach would encourage case study exemplars to be created that could then be shared throughout the organisation to help with educating and training staff. This is important as the participants observe that there was an issue with disseminating best practice around CM with practitioners:

We need a flow of information down to people at my level of the organisation … or if it is, I am not aware of anything. (Interview 8).

The development of training materials and examples of CM in practice would help staff recognise the benefits that can be realised through the implementation of CM practices and helps speed the delivery of processes within the organisation.

Finally, leadership on CM practices can encourage collaboration with other organisations to jointly commit to reducing carbon emissions. For a tool such as the CIT Tool to be successful the user will require data on carbon emissions from their supply chain the participants explain:

We have had problems with some suppliers who were not very happy to give us the data, because they don't see the benefit from their side. (Interview 5).

Intellectual property was an important issue with participants from Supplier A who were concerned that if they shared their carbon emissions data with a contractor, the contractor could reverse engineer the method to use on future bids themselves without having to use the original supplier. However, developing collaborative relationships was challenging anyhow for Contractor B as explained in this quote:

We are trying to do a lot of work on collaboration, we are trying to get far better at collaboration but we haven't got that sussed. (Interview 11).

An organisation's leadership has an important role in encouraging collaborative relationships by showing that they are committed to seeing emission reductions throughout their supply chain. One of the issues with collaboration around carbon emissions is that it is highly unlikely that costs and benefits will be shared equally. To deal with this collaborative frameworks need to be developed to help contractors and their supply chain work together to reduce carbon emissions, finding forms of incentives that benefit all The steps revealed here align with the 'External Barriers' and form the first part of our enabling framework on external motivations (see Figure 2).

4.1.3 Integrating Carbon Practices Throughout the Organisation

Finally, a clear integration of carbon practices within a construction organisation was identified by the participants. It is not just with external partners that collaboration is required, the participants feel. For CM practices to be successfully adopted within an organisation a collaborative approach is needed to integrate CM at the core of their organisation. The participants find that CM is currently seen as part of the environmental team's remit only, as this participant explains:

In terms of where it [carbon] sits within [the organisation], it is one specific area of the environmental team rather than spread across the business. (Interview 6).

As such, opportunities for reducing carbon emissions are being missed throughout the organisation. There is also a view that carbon reduction is an afterthought or a 'tick box' exercise to make sure that work-winning bids were compliant when required. An environmental manager from the first workshop explains:

I feel like a minister without a portfolio. No one really quite knows what my purpose is, yet they could learn stuff from what I do. (1D1).

Here, based on the data, the solution is that by integrating CM within each team then more significant carbon savings could be achieved. There was a sense that it was not just the carbon and environmental teams that were isolated from other teams. One participant states:

If I'm honest, in the organisation, we struggle with a bit of a silo mentality, and people do things with the best intent within their own silo not aware of what else is going on in the business. (Interview 11).

To improve the efficiency of the organisation, measures must be taken to break down these 'silos' so that teams (e.g. designers, planners, estimators) can work together to integrate low-carbon designs within projects. Working together can also bring other benefits such as creating efficiencies on the design, reducing costs and saving time and other resources, however to realise these potential efficiencies collaboration is required. The following quote shows this:

This only works if you have actual collaboration and communication between the different disciplines … you could have the most amazing tool in the world, but unfortunately, if there in not that cross-collaboration between sectors or between disciplines, your tool falls flat on its face. (Interview 12).

Breaking down the carbon 'silo' and integrating CM practices within each discipline whilst encouraging open communication between each team would help the organisation in developing a joined up approach to effectively reduce carbon emissions and drive change throughout the organisation.

Overall our analysis finds several factors required to enable CM practices within an organisation. Firstly there is a need for an external motivation to encourage and incentivise the organisation in implementation CM practices. Secondly, the organisation's leadership must take responsibility for seeing CM being integrated within the organisation's strategy and processes, provide training and encourage collaboration. Finally, CM must be fully integrated within each team and not just seen as a task for the organisation's environmental specialists. These steps recognise the barrier of carbon integration and form the final part of our enabling framework in Figure 2.

5 Discussion

We have discussed that while many organisations in the construction industry have tentatively incorporated CM practices, to date there has been little research seeking to understand how CM practices can be successfully integrated within organisations in this industry. We thus provided insights into CM-related barriers and associated steps by answering two research questions: why have organisations in the construction industry been slow to implement CM practices, and how can organisations in the construction industry ease the implementation CM practices?

Our first contribution is towards the limited research of CM practices in the construction industry. Whilst other scholars have looked at specific issues related to CM practices (e.g. De Wolf et al., 2017; Giesekam et al., 2016; Kershaw and Simm, 2014), we have addressed the broader issue of how to integrate these practices within an organisation. Our findings suggest several barriers to overcome including a lack of regulation and incentivisation from clients, the need to develop common standards and processes that can engage the full supply chain, an organisation's leadership, the need for training and education, and overcoming resistance to change. By exploring these issues we were able to suggest steps for overcoming these barriers and enabling CM to be successfully adopted within the construction industry as described in more detail below.

Our second contribution is to add to the growing literature on barriers to environmental practices being adopted within organisations more generally. Several scholars used the 'established criteria' (Álvarez Jaramillo et al., 2018, p. 522) classifying barriers as either internal or external to the organisation. We too found examples of internal and external barriers to overcome. However, we found another level of complexity whereby barriers could be shared both within the organisation and the wider industry. For example, our findings support the views of Robinson (2018) and Lines et al. (2015) that the industry can be perceived as slow, or resistant to change. To overcome these perceptions, training is required to educate employees within the organisation, and also members of the wider industry on what the challenges are in emission reductions, why they should care and how their job role can make a positive difference. Another shared barrier is the need for collaboration. Within organisations there is a need for different disciplines to come together to consider emission reduction. Tools such as the CIT Tool will help with this so that designs can be optimised for carbon reductions before they are finalised. There is also a need to form collaborative partnerships to develop amongst supply chain members. Studies suggest that up to three quarters of work carried out in the construction industry is performed by sub-contractors (Segerstedt and Olofsson, 2010), and

developing shared goals around emission reduction will be vital for the industry to make serious cuts in carbon emissions.

Our third contribution, and perhaps most importantly, are three steps that an organisation can take to enable CM practices within their organisation. We summarise these steps in a framework showing the factors required for organisations to be able to successfully implement CM practices. As shown in Figure 2, we suggest three steps that are required to successfully implement CM practices, such as the integration of the CIT Tool. Firstly, there must be external motivations for the organisation to start the implementation process. Secondly, the organisation's leadership must take responsibility in driving change within the organisation. Finally, CM has to be fully integrated within each team in the organisation, from procurement to project delivery.

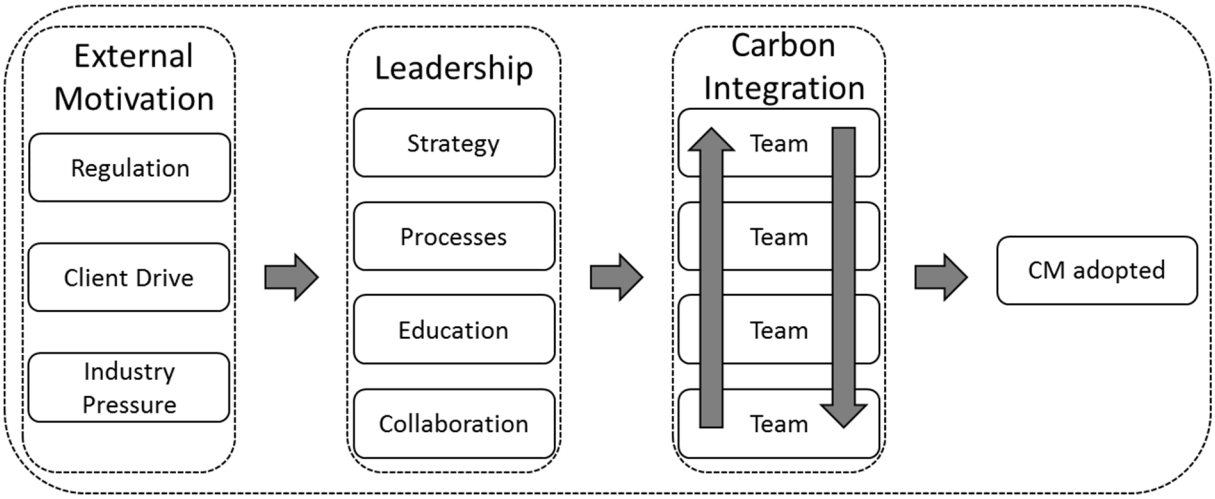

Figure 2: Framework of the steps required to successfully implement carbon management within a construction organisation

The first step required is external motivation for the organisation to consider the implementation of CM processes. Regulation is considered one of the most effective measures for motivating the construction industry on environmental issues, however often regulatory practices lag behind best practice or do not exist at all (Williams and Dair, 2007). The construction industry is heavily regulated in other areas, this means that for emission reduction to be considered seriously regulations must be developed too. Without strict regulation, client leadership in the form of procurement requirements became the main reason for an organisation to think of adopting of CM processes. Like Giesekam et al. (2016), we found that reducing cost on the project was still seen as the most important requirement for clients, and as a result contractors will not expend time and resources on reducing environmental impacts. Our framework also shows that expectations of CM practices also need to come from the client and the broader industry uptake. For example, recently a number of organisation have started

becoming certified against PAS 2080. The more organisations that do this, the more pressure there is on the organisation to follow to avoid the perception that they are not acting at a similar level.

Secondly, the executive leadership of the organisation must commit to the implementation of CM practices. Silence from the organisation's leadership can be taken can suggest that CM is not considered a high priority. In contrast, when the leadership engage with carbon reduction it is straight forward to incorporate CM part of their corporate strategy, develop processes for implementing change, educate their staff and open collaborative relationships with their suppliers. This supports the findings of Chen and Chang (2013) who found that transformational leadership has a positive influence on the implementation of green performance once implemented. However, as stated above there must first be a reason for the executive leadership to act, for example, in the Netherlands, the CO_2 Performance Ladder – a management tool to encourage organisations to reduce their emissions – was mandated on the construction industry as part of the procurement process. Rietbergen et al. (2017) found a large shift in positions from boards of directors before and after this was mandated for them. Beforehand they had shown little leadership in the area but later CM became a recurring topic in management meetings, which led to better performance on these issues from their organisations. As the leadership's appetite grows for implementing CM, it will also become easier for each team to integrate CM practices.

The final step to successfully implement CM practices within an organisation is integrating carbon practices within each team. The environmental specialists we engaged with through the workshops and interviews often gave the impression that they were on the periphery of their organisations and that they were only called upon when a specific environmental task came up. As Yuventi et al. (2013) state, the lack of accountability between teams makes it difficult for others to appreciate tasks outside their silo. For CM practices to be adopted within the organisation it is important to overcome this issue so that each team engages with carbon reduction and it is not seen solely as the responsibility of the 'carbon specialist'. If each team is considering what they can do to reduce emissions it becomes easier to collaborate with other teams to develop the most efficient designs. Chang et al. (2016) found that developing demonstrable case studies is crucial for increasing the profile of sustainable construction. We propose starting with small case studies showing how CM practices such as the CIT Tool could be used to bring teams together, increase efficiency and reduce cost and carbon emissions. One of our findings was that a lack of standard processes acted as a barrier to change. These case studies can be used to develop consistent approaches that can be scaled up to be followed on larger projects.

Tan et al. (2015) conclude by stating that within the construction industry, integrating sustainable practices can increase an organisation's economic performance and competitiveness. Here we have shown the barriers to overcome and the steps required for an organisation within the construction industry to take to integrate CM practices which would bring these wider benefits.

5.1 Limitations and Future Research

A number of issues are worthy of further discussion and research. One limitation to this research is that despite engaging with the wider industry during the workshops, all interviewees worked in work-winning roles rather than project delivery. As a result, the processes discussed for promoting CM were specific to the strategy of the organisation. Future research should develop an understanding of the relationships between those in work-winning roles and those in project delivery to understand the difficulties of implementing CM practices during the construction phase of projects. Pinkse and Dommisse (2009) found that transferring knowledge between projects was difficult due to the large number of stakeholders involved and the uniqueness of each project. As such, future research should consider how CM practices are shared between projects so that best practice is ensured on future projects. Finally, another area worthy of future research would be to better understand the role of collaboration between organisations to improve CM practices on projects. This research points to the need for policy makers to emphasise the importance of multiple stakeholders in collaborating in carbon management issues to enable individual organisations to move forward. Achieving emission reductions in the most efficient way goes beyond one organisation and requires a high degree of collaboration between supply chain actors during the design, build and use of the asset. Therefore it is important to understand how organisations can work together to jointly reduce the environmental impact of a project.

6 Conclusion

With growing pressure to mitigate to climate change, the construction industry has a significantly role to reduce the amount of carbon emitted to the atmosphere. To achieve these reductions in emissions, CM processes must be adopted within the construction industry, however such practices are still in their infancy. Our paper seeks firstly to understand the barriers that slowed the implementation of CM practices within the industry, and secondly to reveal the steps required for an organisation to successfully adopt CM practices. Our research found several barriers that were hindering the implementation of carbon management processes within the industry, which we classified along internal and external barriers, a common practice used in the change literature. In addition to this grouping we also identified shared barriers. Our external barriers occur due to a lack of regulation,

incentives or industry pressure to integrate CM practices. Over these barriers construction organisations have little control. Our internal barriers allow more direct control from a construction organisation. These barriers include their leadership's appetite for change, developing new processes and integrating CM throughout the organisation. The shared barriers are issues that arise on the intersection of organisation and the wider industry. These barriers need addressed within the organisation and also the wider industry such as overcoming resistance to change, improving training and education and developing collaborative partnerships.

Our research paper shows the importance that CM practices can play for the construction industry and associated organisation. Even though rarely implemented, the paper shows how stakeholders across the industry point towards the importance for their industry to advance its implementation. While currently one of the 'dirtiest' industry across the UK, the size of this industry with its potential to drastically reduce emissions if a coherent carbon methodology, leadership and regulation is established paired with aware stakeholders is promising and could mean a step change for UK's construction organisations, industry and policy makers.

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