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INVESTIGATING CULTURAL AND STRUCTURAL INFLUENCES ON OPTIMISING ENGINEER-TO-ORDER PROJECT DELIVERY AND SUSTAINABILITY

ABSTRACT

Several culture theories, which explain the formation, embedment, and propagation of organisational culture, suggest that certain organisational culture practices of an executing organisation may enable sustainable outcomes in project manufacturing. However, practices that support sustainability may not support project delivery, and vice versa. We explore the effects of organisational culture practices and structural complexity on the ability of manufacturing projects to optimise both sustainability and project delivery. We use data envelopment analysis (DEA) to calculate a sustainability-delivery quotient – a measure of each organisation's ability to optimise both sustainability and project delivery outcomes – for 186 projects conducted in the UK. By conducting generalised linear modelling and censored regression of the sustainability-delivery quotient, we estimate the effects of the GLOBE organisational culture dimensions, principal components of culture dimensions, and project structural complexity indicators. Results indicate a noteworthy gap between the delivery of projects and their sustainability performance, which is worse. Both institutional and in-group collectivism may support the optimisation of each. However, neither the principal components of culture dimensions nor structural complexity indicators are likely to be significant. We discuss the managerial implications.

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MANAGERIAL RELEVANCE STATEMENT

The intensified spotlight on sustainability comes with recognising the challenge in achieving it alongside other, often conflicting, business goals. We examine this conundrum within the context of project manufacturing. We investigate the effects of organisational culture practices and structural complexity on the ability of engineer-to-order projects to optimise both sustainability and project delivery.

Our key finding is that both in-group and institutional collectivism culture practices may support attempts to optimise both sustainability and project delivery.

Our findings are most relevant managerially at the strategic planning level within project-based organisations, whose core business model is project manufacturing. The results indicate that a strategy to pursue, if they wish to optimise both project delivery and sustainability, is to foster in-group and institutional collectivism organisational culture practices, particularly if self-evaluation identifies such a weakness or absence of these.

Yet our results also have more general managerial relevance: Our survey indicates sustainability performance is poor relative to project delivery, which suggests the project manufacturing field has some way to go before sustainability is deeply imbedded and realised in projects.

KEYWORDS:

Sustainability performance; project delivery; organisational culture practices; structural complexity; engineer-to-order; project manufacturing; triple bottom line; cost, time and quality.

I. INTRODUCTION

It is reasonable to argue that sustainable manufacturing is a core competence because sustainably can generate competitive advantage [1]. Recent literature on this has trended towards the roles of supply chain management [2], technology [e.g.,3], systems modelling [e.g., 4], and product lifecycle management [e.g., 5]. The importance of these is undisputed. However, one conundrum that could provide competitive edge to sustainable manufacturing is how to manufacture sustainably yet efficaciously. It is vital to address this increasingly recognised paradox: a complex, multi-objective problem characterised by several desirable yet often conflicting goals [e.g., 6].

In this empirical paper, we examine the conditions that might support sustainable yet efficacious project or engineer-to-order (ETO) manufacturing where one-of-a-kind products are engineered according to individualised customer requirements [7, 8]. Essentially, each ETO product is the outcome of a project involving engineering and manufacturing activities [8]. For example, a reactor for a new refinery or an in-situ ore crusher for a new copper mine will be engineered to order because each must exactly fit its unique purpose and context. For manufacturers, ETO capabilities increase differentiation [9] and help drive profitability: in a 2016 survey of leading manufacturers, top ETO performers reported higher revenue and profit margin growth [10].

Project manufacturing can be deemed sustainable if does not deplete social, environmental, or economic capital; it satisfies the triple bottom line [11]. Since each product differs from others, essentially requiring a bespoke production process [7, 9], it is a greater challenge to embed sustainable practices in project manufacturing than in the production of non-customised products, for example, mass or even batch production. The very nature of project-based work introduces extra challenges. A key characteristic of projects is that they

are temporary, having predetermined end dates [e.g., 12]. This encourages the project-success-as-delivery model [13], wherein a successful project is one whose delivery is to time, cost and quality, the so-called 'iron triangle' [see 14]. However, this model is not necessarily congruent with sustainability, because it encourages a shorter-term, narrow-scope mind-set [15], as opposed to the longer-term, expansive ethos that engenders sustainability. Consequently, it is of interest to study what might enable organisations to achieve the equilibrium where project manufacturing maximises both sustainability performance and project delivery.

Drawing from several culture theories, this paper posits that an executing organisation's culture is an enabler of sustainable outcomes in project manufacturing. This proposition distils from research on global sustainability, suggesting certain sustainability values support sustainability behaviours [16-19]. Nevertheless, there is no precise mapping of such values globally onto those prevalent in organisations, according to major studies on organisational culture [20-22], and the project management literature [23-25] suggests the cultural practices that support project delivery may not be conducive to sustainability.

Additionally, we investigate whether optimisation of sustainability performance and project delivery is related to greater structural complexity, as embedding sustainability may necessarily involve more project elements, in turn increasing constituents of structural complexity such as size [26] and variety [27]. It is potentially valuable to study complexity, as it is among the most critical issues project practitioners face because it makes projects "harder to understand, foresee, and keep under control…" [28] and can, potentially, reshape project contexts such that standard 'best practices' no longer achieve the expected effects on project performance [29-32] and potentially reduce

Therefore, this paper aims to explore the effect of organisational culture practices (of executing organisations) on the ability of manufacturing projects to achieve an optimal mix of sustainability and project delivery outcomes; and the extent such projects are characterised by structural complexity. Specifically, we address three research questions (*RQ*s):

- *RQ*1: Which organisational culture practices enable projects to optimise sustainability performance and project delivery?
- *RQ*2: What cultural practices combinations can collectively influence a project delivery with optimal standards in sustainability performance??
- *RQ*3: Beyond cultural practices, are projects achieving optimisation of sustainability performance and project delivery characterised by greater structural complexity?

The paper's key contribution is that it is, to the best of our knowledge, the first to have estimated, by means of *RQ*1 and *RQ*2, the effect organisational culture might have on achieving sustainability in manufacturing without compromising business goals. Doing so advances the field on sustainable manufacturing strategies [33], with a focus on the trade-offs organisations must make to achieve sustainability alongside conflicting business goals [6, 34].

The paper proceeds as follows: Following this introduction, we review the literature that shapes our thesis. The third section describes the instruments and models; whilst the fourth reports and discusses the results. We conclude by reflecting on how our aims are met, the value our study offers for project practice and future research directions. We begin by defining environmental, social, and economic sustainability. We then examine the state of research on sustainability in project management, including project manufacturing. Next, we explore the foundations of organisational culture, and the proposition that this may underpin sustainability behaviours. We then compare the elements of organisational culture consistent

with sustainability against those that might support project delivery. Finally, we draw from the literature on project complexity to consider whether sustainable projects can be characterised by greater structural complexity.

II. LITERATURE

A. The three pillars of sustainability

From the sustainability-as-capital viewpoint [35], we see *environmental sustainability* as maintaining the physical environment's "natural capital" [36]. This involves minimizing waste and the consumption of non-renewable natural resources, while maximizing the use of renewables. It also involves maintaining "a condition of balance, resilience, and interconnectedness" [37], such that human needs are met while maintaining bio-diversity and regeneration of ecosystems. *Social sustainability* comprises the organic or inorganic formation of human communities that support the healthy living and wellbeing of not only current but future generations [38, 39]. Such communities typically promote equity, diversity, quality of life, interconnectedness, democracy, and governance [40]. A salient illustration of sustaining diversity is the UN Convention for the Safeguarding of the Intangible Cultural Heritage [41]. *Economic sustainability* prescribes economic production and consumption that does not compromise or preclude the ability of future generations to achieve such activity of similar magnitude [42].

Economic sustainability perhaps most directly influences the other pillars, since society and the environment are both resource bases and sinks for economic production [43]. Yet, we also observe significant overlaps between environmental and social sustainability in, for example, national parks or 'areas of natural beauty' that countries preserve [44]. As such, although other configurations, including sub-models, have been proposed and interaction among the three pillars is itself a subject of ongoing enquiry [45], there is consensus that

sustainability in any setting is only achievable where joint efforts are made on all three pillars [46, 47]. Thus, a recent trend has been to examine sustainability in business on a holistic basis, encompassing performance on environmental, economic, and social dimensions, typically known as the 'triple bottom line' [48, 49].

B. Sustainability in project management

The study of sustainability in project management is underdeveloped compared to supply chain management, for example. Reviews [e.g., 50, 51] suggest most of such research concerns international development projects [e.g., 52] or construction projects [e.g., 53].

Silvius and Nedeski [54] summarise the tensions between project work and sustainability. A key tension is the temporal versus the perpetual. Whereas projects are time-constrained with a determinate end [55], sustainability aims to ensure perpetuity of capital; sustainability goals are not time-limited. *Cui bono* is another tension: whom does it benefit? Genuine sustainability has an unbounded, global focus. It emphasizes the assurance of the capital of current and future generations. By contrast, projects tend to have a narrow, short-term focus, satisfying specific owners [56].

We have identified two broad streams of research that consider ways to address these tensions so that projects may embed and achieve sustainability. The first concerns capability. This stream contends that the project management profession lacks the capability to achieve sustainability. Most projects carry economic objectives and lack the capacity to implement social and environmental sustainability [57]. Indeed, Martens and Carvalho [50] suggest that project management professionals lack sustainability competencies. Such competence, according to Gareis, et al. [58], would boost project management practitioners' capability, especially to handle project complexity and uncertainty [see, e.g., 59].

The 'rethinking project management' movement is the second stream. This idea reconceptualizes projects to embed sustainability. Some studies directly tackle project time constraint. Since project outcomes and benefits may occur after it ends, to achieve sustainability, we should conceive of the project lifecycle as beyond the project end; there should be no boundary between the temporary (project) and permanent (executing) organisation [60]. Thomson, et al. [61] also suggest closer integration of the management of project lifecycle stages and sustainability goals. Others consider ways to embed sustainability through outcomes, by ensuring indicators of project performance include sustainability [62, 63], correlating project performance and sustainable outcomes [64] and by viewing how sustainability factors influence project performance [52]. Yet others consider ways to embed sustainability through project selection criteria that lead to sustainable projects [65] and portfolio selection processes that embed sustainability [66].

While these studies are encouraging, there remains an urgent need for further research within both streams. Our study overlaps both, with potential contributions. One the one hand, it investigates organisational-level sustainability capability, in this case via culture. On the other, it analyses how that capability may enable sustainability in well-delivered projects.

C. Organisational culture

Culture can be defined as the 'shared characteristics' of individuals [e.g., 67, p. 41] within a collective. At a fundamental level, members of a culture may share basic axioms [68]. More tangibly, members may share values. Rokeach [69: 124] defines values as "abstract ideals, positive or negative, not tied to any specific object or situation, representing a person's beliefs about modes of conduct and ideal terminal modes…". Values can also be defined as "beliefs … that refer to desirable goals that motivate action … and transcend specific actions and situations" Schwartz [70: 3]. The later definition suggests a causal link,

whereby shared values can lead to shared practices and, ergo, behavioural norms among members of a culture. Feather [71, 72] theorised on the basis of expectancy-value theory that causation occurs because the more important an individual considers a value, the more positive the connotation they attach to behaviours consistent with that value.

Schein [73] defines organisational culture as the characteristic behaviour of members of the same organisation arising from their shared values and beliefs. Several theories support the formation, embedment, and propagation of this. Schneider's [74] *Attraction-Selection-Attrition* (ASA) model suggests a like-attracting-like mechanism: Both individuals and organisations seek out and choose one another on the basis of perceived fit. As time passes, attrition purges the organisation of ill-fitting individuals. This strengthens organisational culture as there is greater homogeneity among the remaining employees [74, 75].

Cultural immersion theory [20] suggests employees who have been with an organisation for some time will use shared schemas or scripts to interpret and respond to stimuli [67]. They will respond to similar circumstances in similar ways, which reduces behavioural differences and creates behavioural norms within an organisation [76]. For example, employees may use specific, inhouse methodologies for managing environmental impact, leading to near uniformity on environmental management.

Normative isomorphism [20] is also likely as individuals try to conform to organisational standards. Often, organisations have career systems [77] in place whereby they train, assess and certify individuals; these instil values through 'core' knowledge areas but also prescribe 'best practices'.

Social network theory [78] also suggests intra-organisational networks will influence individuals, either through *cohesion*, where direct interaction with other individuals leads to

socially constructed perceptions of project manufacturing, or *structural equivalence* where, for example, individuals are incentivised to conform, given organisational expectations.

D. Proposed cultural genesis for sustainability practices in organisations

The foregoing discussion suggests sustainability practices in an organisation may have a cultural genesis, as Isensee, et al. [19] suggests. Pfitzer, et al. [79] allude to this in the case of social enterprises, whereas Dubey, et al. [80] empirically demonstrate organisational culture is a significant moderator of the effects of external pressures of sustainability benchmarking. Linnenluecke and Griffiths [81] offer several theoretical propositions on how organisational culture may engender corporate sustainability. Fundamentally, members of an organisation may tend to share axioms about sustainability, for example, that anthropogenic climate change exists or that it is 'fake news'. Similarly, they may share 'sustainability values' in the form of positive (or negative) beliefs [69] about sustainability. For instance, they may believe humans are equal to other sentient entities, or as masters of the universe [82]. Values may also be 'instrumental' [83], which in this case would be beliefs leading to sustainability as an end state; such as the belief that manufacturing must be carbon neutral.

As such, we may describe an organisation where members strongly share axioms and values regarding sustainability as exhibiting a sustainability culture, in contrast to an anti-sustainability culture where members strongly share negative axioms and values that do not support sustainability. Studies [e.g., 67] show there is often a gap between strongly held values and practices consistent with them. Therefore, sustainability practices may not be manifest in all organisations with strong sustainability values, although it is likely that those exhibiting such practices do indeed have strongly shared axioms and consistent values on this. Hence, we can infer that organisational culture may influence behaviour in a way that is reflected in sustainability outcomes in project manufacturing. We can point to several studies

[84-86] that confirm the influence of organisational culture on operational outcomes, such as Pagell and Gobeli [87], who found a link between manager attitudes and behaviours, related to sustainability.

However, it is not clear which dimensions of organisational culture are instrumental in enabling sustainability practices. The United Nations Millennium Declaration stated the values that support sustainable development are freedom, equality, solidarity, tolerance, respect for nature, and shared responsibility [18, 88]. However, these articulated values do not map against any cultural dimensions offered by seminal research in organisational culture, namely Hofstede [22], the Competing Values Framework [21], and GLOBE [20]. It is difficult, therefore, to posit how such dimensions relate to sustainability behaviour. Leiserowitz et al [16, 17] illustrate this complexity in their literature review on values potentially supporting global sustainability. They report that the Great Transition scenario [89] suggests individualism is instrumental in incrementally improving quality of life globally (hence a positive for society), but they note its links to high levels of consumerism (hence a negative for the environment). Clearly, the quest to determine which organisational culture dimensions support sustainable outcomes – as partly sought by *RQ1* – is challenging and far from trivial.

E. Culture clash: culture for sustainability versus for project delivery

Further, an organisational culture that enables sustainability may not necessarily be conducive to project delivery, and vice versa. Knowing which organisational culture practices support sustainable outcomes does not resolve doubt over which also enable project delivery, as *RQ1* articulates.

Studies suggest that project delivery is positively related to the ‘masculinity’ [23, 24]. This, according to Hofstede [90, p. 6] is the “degree to which values like assertiveness,

performance, success and competition, which in nearly all societies are associated with the role of men, prevail over values like the quality of life, maintaining warm personal relationships, service, care for the weak, and solidarity, which in nearly all societies are more associated with the role of women". By this definition, masculinity does not appear consistent with sustainability as embodied by the Millennium Declaration values.

Using Hofstede's scales [22], Chipulu, et al. [24] found individualism to correlate negatively with project delivery. This suggests, collectivism – its opposite on the scale – may influence delivery positively. Similarly, King and Bu [91] found from a comparative study that high institutional collectivism among Chinese project practitioners could contribute to superior project delivery via its enhanced team performance. By contrast, no link has yet been established between collectivism and sustainability.

Gu, et al. [25] suggest that a 'results orientation' positively influences overall project performance, including project delivery. Arguably, none of the indicators used by Gu et al. [25] for the results orientation scale are consistent with sustainability; indeed some, e.g. '…strong pressure to complete the job' may indeed discourage sustainability behaviours.

Given the foregoing contentions, it is critical to understand how cultural dimensions may together enable the achievement of sustainable outcomes with project delivery. There could be combinations of cultural practices that support both or indeed undermine both. This notion of culture values acting in concert appears in previous research; Inglehart and Baker [92] consolidated several overlapping culture dimensions into two higher dimensions, which they found usefully explain modernisation patterns. Thus, *RQ*2 is relevant.

F. Are sustainable projects structurally more complex?

The project complexity literature concurs on identifying structural complexity as among the most important complexity categories [29-31]. Elements of structural complexity

include size [26], variety [27], and the interdependency [93] or interconnectedness [59] of project components, such as people and tasks.

Attempting to embed sustainability in projects means integrating distinct additional elements. They may require additional expertise from environmental engineers, product requirements, technologies, manufacturing processes, stakeholder input from communities impacted, and so on. As such, sustainable projects may be characterised by greater structural complexity, observable from the outside via proxies such as greater cost, more people, or longer duration. This motivates *RQ3.*

III. METHODS

A. Measures and data

Survey data collection

We collected data via email survey, including reminders to non-respondents, between 2016 and 2019. Participants were small, and medium-sized enterprises (SMEs) in the United Kingdom (UK) within the manufacturing sector. SMEs are defined by size, having between 0 and 250 employees; they make up 99% of business in the UK [94]. We gained access to them via regional chambers of commerce for manufacturing. Altogether, we invited 869 SMEs to participate.

The respondent in each SME was a functional manager responsible for production, whom we asked to evaluate cultural practices within their organisation and comment on a single ETO project their organisation had recently completed, about which they had first-hand knowledge. Therefore, an important validity screen was to exclude responses where the respondent lacked firsthand experience of a recent ETO project run by their organisation to personally comment on. We achieved 186 valid responses, representing a 21% response rate.

We describe and summarise below the key sets of variables in the survey.

Project characteristics

Respondents began by providing information on the project's structural characteristics: the duration, budget and number of people involved. Table 1 summarises each variable. These data indicate that projects were consistent with SME characteristics; they comprised small to medium duration, budget, and size. The majority lasted up to two years, had budgets up to £1m, and involved fewer than 50 people.

Table 1: Summary of ETO Project Characteristics

Variable	**Category**	**Frequency (N = 186)**	
Duration: *What was the project duration?*	Less than a year	76	41%
	1-2 years	81	44%
	3 to 5 years	21	11%
	Longer than 5 years	6	3%
	Frequency Missing = 2		
Budget: *What was the project budget?*	Less than £500k	95	51%
	At least £500k but less than £1m	66	35%
	At least £1m but less than £5m	19	10%
	At least £5m	6	3%
Number of People: *How many people were involved in the project?*	Less than 10	66	35%
	At least 10 but less than 50	91	49%
	At least 50 but less than 100	18	10%
	At least 100	10	5%
	Frequency Missing = 1		

Organisational culture scales

As cited, studies such as Erez and Earley [67] report a gap between cultural values and practices. Therefore, to measure organisational culture within the executing organisation, we used the 'as is' culture practice measures developed by project GLOBE [for the full survey items, please see: 95]. This is because its scales have been validated in multiple countries including the UK for measuring cultural practices at the organisational level. Second, all nine GLOBE dimensions are widely understood, both in academia and industry, because they

originate from pre-existing cultural frameworks [primarly, Hofstede: 22, 96]. The following are the definitions [95] of the GLOBE cultural practice dimensions:

- *Assertiveness:* The organisation encourages and enables individuals to share their points of view, even if doing so may cause conflict or disharmony. Indicators include: 'people are generally assertive' and 'people are generally tough, not tender'.
- *Future orientation:* The organisation prioritizes long-term planning and behaviours that support longer-term goals. Indicators include: 'the way to be successful in this organisation is to plan ahead' and 'the accepted norm is to plan for the future rather than accept the status quo'.
- *Gender egalitarianism:* Organisational practices support and promote gender equality. Indicators include: 'most people believe work would be more effectively managed if there were many more women in positions of authority than there are now'.
- *Humane orientation:* Members of the organisation support and care for each other. Indicators include: 'people are generally very concerned about others' and 'people are generally very sensitive toward others'.
- *In-group collectivism:* Organisational practices promote a sense of belonging among employees as members of and critical contributors to its success. The collective(s) within form organically from the bottom up. Indicators include: 'group members take pride in the individual accomplishments of their group manager', and 'the organization shows loyalty towards employees'.
- *Institutional collectivism:* The organisation prioritizes its own wellbeing over individuals'. Collective strength arises from top-down edicts. Indicators include: 'managers encourage group loyalty even if individual goals suffer' and 'group cohesion is more valued than individualism'.

- *Performance orientation:* The organisation prioritizes the achievement of work goals. Indicators include: 'employees are encouraged to strive for continuously improved performance' and 'major rewards are based on only performance'.
- *Power distance:* The organisation is dominated by vertical, hierarchical power structures, which discourage equality and informality. Symmetrical interpersonal relationships across senior levels are uncommon. Indicators include: 'subordinates are expected to obey their boss without question' and 'people in positions of power try to increase their social distance from less powerful individuals'.
- *Uncertainty avoidance:* There is low tolerance for uncertainty in the organisation. It systemically attempts to minimise uncertainty through behaviours, norms, and bureaucracy. Indicators include: 'orderliness and consistency are stressed, even at the expense of experimentation and innovation' and 'most work is highly structured, leading to few unexpected events'.

Table 2: Globe Cultural Practice Dimensions: Summary Statistics

Cultural Practice	**Mean Score**	**SD**	**Alpha**	**AVE**
Assertiveness	3.21	1.00	0.692	0.593
Future orientation	2.89	1.21	0.79	0.626
Gender egalitarianism	3.50	1.25	0.701	0.537
Humane orientation	3.12	1.09	0.828	0.544
In-group collectivism	3.11	0.96	0.736	0.603
Institutional collectivism	3.27	1.04	0.706	0.652
Performance orientation	3.06	1.12	0.823	0.566
Power distance	3.22	1.07	0.691	0.532
Uncertainty avoidance	3.08	1.14	0.687	0.548

Besides applying descriptive statistics, we subjected each scale to Cronbach alpha calculations, to estimate internal consistency and confirmatory factor analysis (CFA) and ensure indicator items load strongly on assigned scales. All alpha coefficients were sufficiently large to indicate internal consistency. Similarly, the CFA fit the data adequately: Although the chi-square value was significant (*chi-square* = 1382, *DF* = 428, *p* = <.0001),

the standardized RMR (SRMR) was 0.0263, RMSEA was 0.0382, and Bentler Comparative Fit Index (CFI) was 0.9959. Additionally, the indicators loaded strongly on each cultural dimension so that the average variance explained (AVE) exceeded 0.5 in all cases. These results indicated it appropriate to use the summated scores of each culture dimension in further analysis. Table 2 also shows the summary statistics for the cultural dimensions.

Project delivery measures

Given the bespoke production processes across ETO projects, we cannot use actual quantities from projects to compare their performances. One ETO project for one client, incurring greater cost, does not necessarily imply its poorer performance than another ETO project for a different client. Therefore, we instead measured project delivery by asking functional managers to respond (on a seven-point, agree-disagree Likert scale) to the following survey items:

1. *The project delivered the product on time.*
2. *The project delivered the product within budget.*
3. *The product met the specified quality, i.e., it conformed to agreed and expected standards.*

All three items have been extensively validated in previous studies [e.g., 24, 97].

Sustainability performance measures

A criticism of the triple bottom line is that it may misleadingly imply accurate capture of the sustainability performance of an organization in line with that of financial performance using bottom line measures [98, 99]. Such a reductive approach often fails to fully capture the complexity of sustainability. Indeed, John Elkington, originator of the term ‘Triple-bottom-line’ [100], goes so far as to propose its ‘strategic recall’ [101]. In practice, comprehensively capturing sustainability performance is so elusive that the literature [102] details a myriad of

measures for the three pillars; no validated scales have reached consensus. Critically for this study, although several studies have considered triple-bottom-line measures for project selection [e.g., 52, 62], nowhere does the literature specify how we should measure the sustainability performance of ETO projects.

Therefore, we selected focus groups as instrument to generate items on how ETO projects can contribute to each of the three sustainability pillars. The lead author facilitated this, recruiting six postgraduate (MSc) students studying project management. The focus group elicited their views on the mechanisms through which ETO projects may contribute to sustainability. Then, based upon this data, initial measures of sustainability mapped on the three pillars were generated. A few days later, the participants reviewed the draft survey items, which were later refined based on this feedback.

Two important features of the measures of sustainability in ETO projects emerged from the focus group. A project's planned benefits are not actualized upon its delivery. Rather, it can take a long time for benefits to materialize [103, 104]. Therefore, one crucial feature that emerged was that our items should measure the expected contribution to sustainability of the product from the project over its operational lifetime. A second feature was that the items should assess the external contribution of the product to the environment, society, and economy, rather than its internal contribution to business goals. In this sense, the items are outwardly-oriented measures of *strong sustainability*, which intends to effect change, as opposed to *weak sustainability*, which seeks to maintain the status quo and is typified by inward-looking measures of sustainability performance [105].

Like with project delivery, we retained three individual items, one for each of environmental, economic, and social sustainability. We thus asked the functional manager to respond to the following items (on a seven-point, agree-disagree Likert scale):

Thinking about the anticipated impact of the product from the project during its entire operational life, the project will:

1. *benefit the wellbeing of society, for example by improving the wellbeing of communities that use the product.*
2. *benefit the environment, for example by using technology that minimizes greenhouse gas emissions.*
3. *benefit the local and national economy, for example through commercial success.*

B. Models

Estimating sustainability-delivery quotient

We used data envelopment analysis (DEA) to estimate the sustainability-delivery quotient. DEA is now a standard technique for evaluating the efficiency of decision-making units (DMUs), the project executing organisations in this case. Yet rather than for efficiency evaluation, we used DEA to score each project's ability to maximise sustainability and project delivery outcomes. We refer to this score as the sustainability-delivery quotient.

We applied the variable returns to scale formulation, setting sustainability performance measures as outputs, and the project delivery measures as inputs. To use them as inputs, we first reverse coded the project delivery measures, so that a lower score was preferable to a higher score. Thus, for each project, the quotient is the weighted sum of sustainability outcomes divided by the weighted sum of the project delivery outcomes. Since we are using single-item measures, each is individually weighted, thereby allowing each organisation to trade off these different outcomes according to its priorities.

We chose DEA because it is non-parametric. There are no assumptions regarding the functional form of the relationship between the sustainability and project delivery outcomes. Hence, we can model the unknown process by which each organisation makes its trade-off

between sustainability and project delivery. Effectively, each decides on its own function for the trade-off. To determine the score, DEA compared each project with other projects based on its project delivery outcomes. For given sustainability outcomes, projects with the lowest inputs (which in this case are high project delivery scores) achieved the maximum score. All other projects' scores were submaximal. Hence, an important property of the DEA approach is that each project's quotient is contextualised by what is achievable in other ETO projects. This approximates the reality of ETO projects: although each organisation implements a bespoke production process, there remain actual constraints from sector, market, or economic conditions, for example.

We ran the DEA models using the OPTMODEL algorithm in SAS9.4. We estimated to two types of quotients. First, we estimated a constrained quotient, whereby the maximum score cannot exceed 1. Second, we estimated an unconstrained quotient using the so-called 'super-efficiency' DEA model, by removing the upper-bound constraint and allowing projects to score above 1.

Principal components of organisational culture dimensions

To address *RQ2* on the co-influence of cultural dimensions, we first subjected the nine cultural dimensions to principal component analysis (PCA). Although PCA extracts as many components as the original number of variables, the objective is to retain only the first few, which capture most of the variance in the data set, as the components are extracted in hierarchical order by decreasing percent of variance explained.

We conducted the PCA using the FACTOR procedure in SAS9.4, using Kaiser's rule to determine the number of components to retain. Additionally, we implemented the VARIMAX rotation so that the extracted components were orthogonal. Subsequently, we applied the retained components as explanatory variables.

Regression modelling of the sustainability-delivery quotient

By conducting generalised linear modelling (GLM) and censored regression of the sustainability-delivery quotient, we estimated the effects of the GLOBE organisational culture dimensions, principal components of culture dimensions, and project structural complexity indicators. We began with the GLM, an approach deemed more suitable because, unlike multiple regression, it has the advantage of estimating relative parameter effects of the categories of class variables. To clearly illustrate its composition, we summarise the GLM form as:

$$\mathbf{Y} = \mathbf{X}\beta + \mathbf{W}\theta + \mathbf{Z}\gamma + \epsilon \quad [1]$$

where

- **Y** is a vector of the dependent variable, namely the unconstrained sustainability-delivery quotient.
- **X**, $\boldsymbol{W}$ and **Z** are, respectively, matrices of culture dimension variables, components of culture dimensions, and indicators of project structural complexity.

  As indicators of structural complexity, we used budget, duration, and number of people involved in the project, which should increase to address any structural complexity arising from attempts to be more sustainable.
- $\beta, \theta,$ and γ are vectors of the effect parameters of culture dimension variables, components of culture dimensions, and project structural complexity indicators.
- ϵ is a random vector.

Additionally, to ensure that the model included only variables that added explanatory value, we implemented a stepwise selection criterion. Hence, rather than the standard GLM

procedure, we implemented the GLMSELECT procedure in SAS9.4. We set *p-value* for entry as 0.2, and 0.05 for stay.

Next, to confirm that the significance of both institutional and in-group collectivism is robust to the upper-bound constraint on the sustainability-delivery quotient, we run a Tobit censored regression model. We implemented this using the QLIM procedure in SAS9.4. We specified the constrained sustainability-delivery quotient as a dependent variable, with upper bound censoring at unity.

IV RESULTS & DISCUSSION

A. Results

Project Delivery and Sustainability Performance

Respondents generally scored project delivery lowest on time (*mean* = 4.8, *SD* = 1.6), median on budget (*mean* = 5.0, *SD* = 1.7), and highest on quality (*mean* = 5.2, *SD* = 1.4). Respondents scored ETO projects low on the sustainability measures: economic (*mean* = 3.0, *SD* = 1.5); social (m*ean* = 3.0, *SD* = 1.5); and environmental (*mean* = 2.9, *SD* = 1.4).

Thus, the mean of means for the sustainability performance measures was 3, which is significantly lower than for the project delivery measures of 5. Consequently, our survey suggests that, while ETO projects are perceived to be delivered moderately well, they are seen as being moderately poor on sustainability performance.

Sustainability-delivery quotient

Although six projects achieved the constrained maximum score of 1, scores were generally low (*mean* = 0.26, *SD* = 0.22). Detailed inspection of the six top-scoring projects reveals they all achieved maximum values on economic sustainability, but only three and one, respectively, scored the maximum on social and environmental sustainability.

Upon removing the constraint, four of the six projects, which had achieved the constrained maximum of 1, now achieved higher scores ranging from 1.2 to 2.49. Consequently, the average of the unconstrained score was slightly higher at 0.27, with a standard deviation of 0.28.

Principal components of organisational culture dimensions

The PCA produced four components, which explained 87.8% of the variance. Table 3 shows the loadings of each cultural dimension on the components, the variance each component explains, and the labels we attached to each component based upon the variables that load highly on it.

Table 3: Principal Components of Cultural Dimensions

Cultural Practice	**PCA1**	**PCA2**	**PCA3**	**PCA4**
Assertiveness	0.0636	-0.1568	0.7038	-0.3513
Future orientation	0.7515	-0.3538	-0.1806	-0.0527
Gender egalitarianism	-0.1023	-0.2193	-0.2114	0.9939
Humane orientation	-0.3049	0.7871	-0.174	-0.1049
Institutional collectivism	0.1357	-0.0032	-0.2421	0.4624
In-group collectivism	-0.2868	0.5806	0.1721	-0.1995
Performance orientation	0.2176	0.1969	-0.0222	-0.1928
Power distance	-0.32	-0.0511	0.7213	0.0113
Uncertainty avoidance	0.4905	-0.1655	-0.1274	0.0403
Variance explained	**26.7%**	**24.4%**	**20%**	**16.7%**
Component label	**"Future assurance seeking"**	**"Humane, in-group collectivism"**	**"Hierarchical control but also assertiveness"**	**"Strong gender egalitarianism with weak institutionalism"**

Regression modelling of the sustainability-delivery quotient

Appendix I provides tables with details of the full model fit statistics and parameter estimates of the two regression models we run. We report the key findings below.

The final GLM model was a good fit for the data [(*F-value* = 19.02, *DF* = 2, $p < 0.0001$); *R-square* = 0.1752, and *adjusted R-square* = 0.1660]. The final model retained only

two of the explanatory variables, which were institutional collectivism (β = 0.06278, *F-value* = 5.78, p = 0.0172), and in-group collectivism (β = 0.06497, *F-value* = 5.28, p = 0.0227).

The Tobit model confirmed the significance of the estimated effects of both institutional collectivism (β = 0.0516, *t-value* = 2.57, p = 0.0103) and in-group collectivism (β = 0.0677, *t-value* = 3.11, p = 0.0019).

Overall, both the GLM and Tobit models indicate that stronger levels of institutional and in-group collectivism may indeed support the optimisation of both sustainability and project delivery. By contrast, none of the other variables considered appears to have any significant effect.

B. Discussion

Our survey results indicate that ETO projects perform better on delivery than they do on sustainability. This is not surprising. As argued earlier, the nature of project-based work being temporary and determinate for example [12, 55] and the project design in ETO manufacturing being bespoke [7, 9] are both adverse to sustainability. Nonetheless, the performance gap is noteworthy. While ETO projects are perceived to be delivered moderately well, they are regarded as performing moderately poorly on sustainability. Furthermore, contrasting Marnewick [57], who suggested differentials among the three pillars, our results indicate that the performance of ETO projects is uniformly poor across all three pillars, not just the social and environmental.

Importantly, however, our results also confirm broad culture theory [e.g., 79, 81], wherein certain organisational culture practices of an executing organisation may enable sustainable outcomes in project manufacturing. Regression modelling of the sustainability-delivery quotient suggests that both in-group and institutional collectivism may support ETO

manufacturers' attempts to optimise both sustainability performance and project delivery outcomes.

The estimated positive effect of collectivism on the project delivery component of the sustainability-delivery quotient is consistent with both Chipulu, et al. [24] and King and Bu [91], who document similar effects. On the other hand, we should consider indirect evidence to explain how collectivism may impact the sustainability component. Firstly, collectivism is linked to universalism [20], whose typical indicators – social justice, world peace, world beauty, environmental protection, equality, unity with nature, and broad mindedness – are strongly representative of sustainability [70]. Secondly, whereas in-group collectivism fosters a sense of togetherness, institutional collectivism prioritizes collective benefits over individuals. These qualities are consistent with some of the values the United Nations Millennium Declaration [18, 88] claimed support sustainable development, particularly equality, solidarity, and shared responsibility.

The insignificance of both long-term orientation [20, 22] and humane orientation [20] is noteworthy. Hofstede [96] found that long-term orientation significantly correlates with economic development at the national level. Our analysis suggests that, in the context of optimising ETO project delivery and sustainability, collectivism subsumes both. As defined by GLOBE, long-term orientation is inward looking, prioritizing an organisation's long-term health, rather than outwardly considering all. Hence a strong long-term orientation, even if not detrimental, may not influence sustainability. Similarly, humane orientation focuses on nurturing human relations, which may explain its insignificance since many regard sustainability as implying equal moral standing among all species.

We did not find any of the principal components of cultural values significant. This indicates that, within the context of optimising sustainability performance and project

delivery, the culture dimensions are adequately distinct from one another so that their collective influences do not subsume individual dimensions, as previously observed by studies such as Inglehart and Baker [92]. This helps clarify our understanding of cultural influences.

Similarly, regression modelling did not reveal any significant structural complexity indicators. Drawn from SMEs, our sample comprised small to medium projects rather than large to extremely large 'mega-projects'. Systems thinking suggests complexity increases non-linearly with size, so that mega-projects are incomparably more complex than medium ones [106]. Therefore, until a fuller range of projects sizes is investigated, we should be cautious about drawing inferences from the revealed non-significance of structural complexity indicators.

V CONCLUSION

The rapidly expanding recognition of the gravity of sustainability comes with the weighty challenge of achieving it in harmony with potentially conflicting business goals. We examined this conundrum within the context of manufacturing projects. Our survey results indicated a noteworthy gap between the (moderately good) delivery of ETO projects and their (moderately poor) sustainability performance. An anonymous reviewer pointed out that it is significant that, in contrast to Marnewick [57], sustainability performance was uniformly poor across all three pillars. Hence, given the importance of sustainability, it is imperative that manufacturing projects improve sustainability performance on all three pillars. Our research offers some guidance on the conditions that may enable them to do so without sacrificing project delivery. Based on our results, we conclude that strong collectivism, present in the organisational culture of the executing organisation, can support sustainable and efficacious project manufacturing.

Yet, cultures do not arise fortuitously. To support their goals, organisations may develop and consolidate culture, promoting shared axioms, narratives, beliefs, values, symbols, norms, and practices [20, 22]. Hence, to deeply embed supportive culture practices, organisations must do so as explicit, deliberate strategy [20, 67, 73]. This implies self-evaluating their own collectivism and then implementing requisite changes to close the gap [107].

The study contributes to an increasingly important body of research on strategies manufacturers should pursue to achieve sustainable manufacturing [33]. First, it provides empirical evidence for the notion [see, e.g., 79, 81] that organisational culture consistent with sustainability values leads to stronger outwardly measurable, sustainable behaviours. Second, it empirically demonstrates that there are culture practices able to support an organisation's ability to optimise sustainability and project delivery outcomes together. To the best of our knowledge, it is the first study to estimate the effect of organisations' cultures on their capacity to achieve sustainability alongside other business goals.

Still, we have found limitations and means by which future research could extend our paper. Firstly, since all our sample cases were drawn from UK project manufacturing, it would be interesting to learn whether our study could be replicated in other countries or sectors. Secondly but similarly, appreciating the limitations from drawing on SME data only, future research could usefully test whether the estimated non-significance of the structural complexity indicators holds when much larger projects are included in the analysis.

Thirdly, given our 'black-box' approach whereby we examined effects on outcomes, rather than on the processes within ETO projects that produce the outcomes, future studies into when sustainability could be embedded into project life cycles and, therefore, when cultural effects may be most salient, could be valuable.

Fourthly, given the limitations of the triple bottom line we have noted, future research could consider basing sustainability performance on more holistic frameworks, for example measured impact on United Nations Sustainability Development Goals (UNSDGs).

Finally, given that sustainability performance in projects is relatively poor, the project management field might benefit from studies developing and testing theory on how sustainability may benefit projects intrinsically. Confirmation of such inherent benefits will engender a stronger sustainability ethos, which could help close the gap between sustainability performance and project delivery.

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