Engineering project networks: providing 'sustainable work systems' for construction knowledge workers

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ENGINEERING PROJECT NETWORKS: PROVIDING 'SUSTAINABLE WORK SYSTEMS' FOR CONSTRUCTION KNOWLEDGE WORKERS

ABSTRACT

Purpose: The construction industry faces three emergent developments that in all likelihood will transform the industry into the future. Firstly, engineering project networks (EPNs), in which teams collaborate on projects remotely in time and space, are transforming global construction practices. Secondly, as a major consumer of resources and significant producer of green-house gases, construction is under pressure to reduce its carbon footprint. Thirdly, the construction industry presents as one of the least socially sustainable work environments, with high job dissatisfaction, skewed work-life balance, and over representation of depressive and mental disorders. It is incumbent on the industry to reconcile these issues. Specifically, what scope is there to shape the evolution of EPNs towards a configuration that both promotes sustainability generally, and enhances quality of work-life issues, while at the same time continuing to apprehend the economic dividends for which it is adopted? As salient as this question is, it has not been broached in the literature. This study, therefore, sets out to survey the extent to which EPNs align with the sustainability agenda, more broadly, and that of employee work-place satisfaction, more specifically.

Approach: A literature review of current knowledge of these concerns is explored and a summative assessment presented.

Findings: As the first in its kind, the study brings to light that EPNs go a long way towards facilitating economic objectives, part way towards realising ecological and

sociological objectives, but make hardly any impact on improving employee work satisfaction.

Originality: This paper examines an entirely novel area that has henceforth, have not been studied. Future research should take up this finding to determine how EPNs may be further adapted to accommodate these wider necessary objectives.

KEYWORDS

Engineering Project Networks, virtual teams, remote working, offshore outsourcing, sustainability, working unit.

INTRODUCTION

Engineering Project Networks (EPNs) are digitally mediated teams with access to information sources and comprise team members typically placed in different organisations in various locations (Mignone et al., 2016, Hosseini et al., 2018a). They require traditional face-to-face communication, as well as a host of lean digital interactions that occur in a virtual environment (Merschbrock et al., 2018, Tibaut and Zazula, 2018). The use of EPNs has been on the rise (Kokkonen and Vaagaasar, 2018), particularly due to the emergence of Building Information Modelling (BIM) (Pärn et al., 2017, Tibaut and Zazula, 2018), in which EPNs are the primary working unit for completing tasks (Cao et al., 2017, Liu et al., 2017). EPNs will be a central component of organisational structures in the near future and will become the way that construction organisations conduct their businesses (Nitithamyong and Skibniewski, 2011, Oraee et al., 2017). This insight was denoted by Becerik-Gerber et al. (2012, p. 234) who declared that:

"Today's construction projects require project teams that are geographically dispersed

and working across multiple time zones and numerous organisational boundaries in a variety of cultures."

Despite this, many areas associated with use of EPNs within the construction context have remained unexplored (Kokkonen and Vaagaasar, 2018). Of these, studies investigating the links between using EPNs and sustainability are missing from the literature (Cao et al., 2018). Given that sustainability is a phenomenon of the highest priority in contemporary construction research (Kajikawa et al., 2011, Darko et al., 2017, Nikmehr et al., 2017), exploring the extent of alignment between EPNs and sustainability is of particular importance (Tibaut and Zazula, 2018).

Sustainable work systems are defined as working units that fulfil all the requirements of sustainability (Kira and Lifvergren, 2014), and as such, the present study's main objective is to provide a background to the question: Are EPNs sustainable work systems? The outcome will raise awareness of the potential and challenges of implementing EPNs as the construction industry moves inevitably towards sustainability. The study has organisational implications, assisting managers and practitioners in identifying how various dimensions in EPNs can be manipulated to make these work systems more sustainable.

BACKGROUND

Engineering project networks

In their widely-accepted definition, Jarvenpaa and Leidner (1999) refer to *virtual teams* as temporary, geographically dispersed, culturally diverse and electronically communicative teams. The term 'temporary' in this definition refers to teams with short life cycles in which members might have never worked together previously, and may not work together again (Siebdrat et al., 2014). Teams with virtuality have been treated as

the spin-off of information and communications technology (Howard et al., 1989, Schweitzer and Duxbury, 2010). In the construction context, with regard to the definition presented by El-Ghandour and Al-Hussein (2004) and Abrishami et al. (2014), ICT is considered a collective reference to the integration of computing technology and information processing. Moreover, the term EPN in the construction industry has been used interchangeably with virtual teams, defined as: *"Groups of geographically, organisationally and/or time dispersed intelligent workers with different skills and in different positions of the hierarchy, heavily reliant on ICTs to accomplish engineering tasks which for all are held accountable"* (Hosseini and Chileshe, 2013, p. 1103).

EPNs have become an important element in the construction industry (Bosch-Sijtsema and Henriksson, 2014, Iorio and Taylor, 2014), where teams in contemporary construction projects almost entirely operate as EPNs (Iorio and Taylor, 2015, Oraee et al., 2017, Kokkonen and Vaagaasar, 2018, Merschbrock et al., 2018). EPNs are teams responsible for the planning, design and construction of a construction project through a collaborative venture involving members coming from a wide range of organisations (Mignone et al., 2016, Oraee et al., 2017).

Sustainability in the construction context

Construction's negative impacts in increasing carbon emissions, fermenting climate change, waste generation, change of land use, and loss of biodiversity are well documented (Nikmehr et al., 2017, Banihashemi et al., 2018). And as a corollary to a raised level of awareness, adopting sustainable construction has become an essential part of the strategy pursued by construction companies (Alwan et al., 2015, Alwan et al., 2017, Banihashemi et al., 2017). In essence, construction companies are increasingly expected to embrace sustainable construction through all available avenues (Darko et al., 2017,

Kalutara et al., 2017, Banihashemi et al., 2018).

The term sustainability is well-known, first surfacing in the literature in the 1960s (Martek et al., 2018). It initially focused on environmental degradation, pollution and health hazards (Kalutara et al., 2017). Sustainability in the current construction research literature, however, refers to: *"...creating performance and functionality, whilst encouraging social and economic progress and minimising the negative environmental impacts"* (Foong et al., 2017, p. 1)

Sustainability in that sense requires the simultaneous pursuit of otherwise competing objectives, namely, the triple-bottom line approach: advancing social progress, improving the environment, and promoting the strategic interests and profitability of construction firms (Saito et al., 2017, Martek et al., 2018). The idea is to use all possible means for integrating the principles of sustainability into all undertakings, across the entire lifecycle and supply chain of construction projects (Wang et al., 2014a). This definition of sustainability is broadening the boundaries of its coverage, with increasing relevance for companies to revisit the whole value creation chain, and shift to a life-cycle perspective that concerns both products and work systems alike (Gareis et al., 2013, Zink, 2014, Kubek et al., 2015, Olanipekun et al., 2017).

SUSTAINABLE WORK SYSTEMS

Concerns over sustainability are shifting from overarching general targets (e.g. economic, ecological) to narrowly defined objectives like corporate sustainability, etc. (Morse, 2010, Gareis et al., 2013). These will result in four stages of planned change for systems: awareness and recognition; commitment; design and implementation; and dynamic state of sustainability (Docherty et al., 2009a), as illustrated in Figure 1.

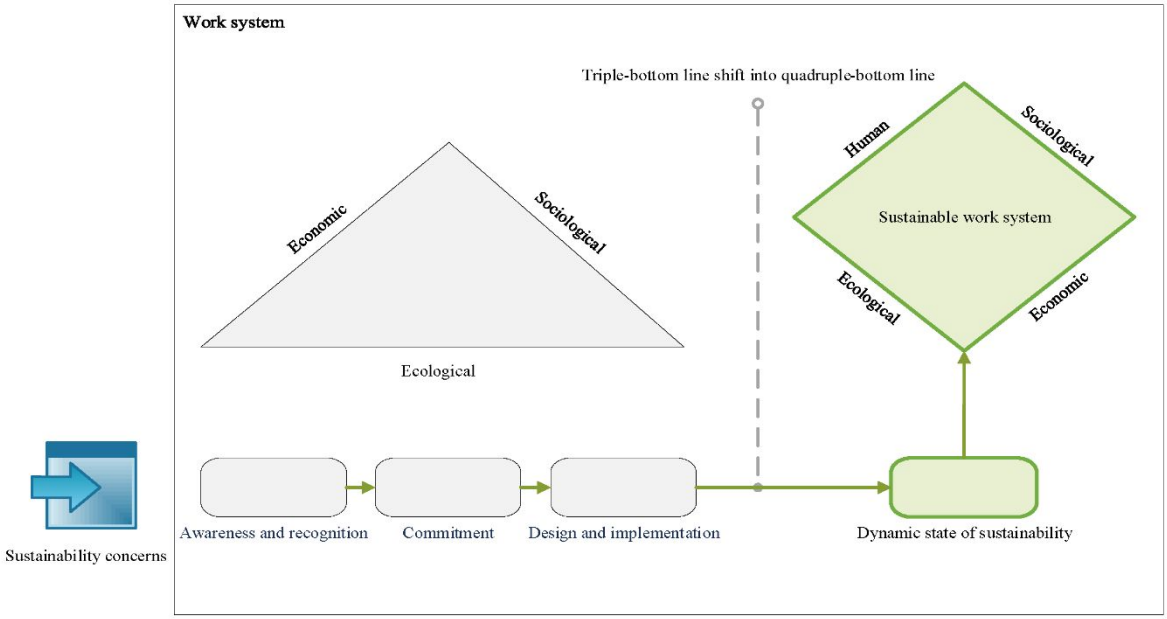

Figure 1. Work systems and sustainability planned changes

The long path through the three stages toward sustainability results in a state in which a work system becomes capable of operating in a dynamic manner (see Figure 1). There will be a shared commitment to sustainability within the work system that underlies all operations. All participants in the work system are committed to the learning community of the engaged stakeholders. Specifically,finding sustainable solutions, maintaining trust, and respecting diverse priorities, demands and ideas (Docherty et al., 2009a)(Zink, 2014, Simanto and Macht, 2017). A sustainable work system has three main attributes. It: 1) regenerates the resources used (employees, ecological, etc.); 2) does not deplete one kind of capital at the expense of another; and 3) invests in maintaining the overall viability of the system (Kubek et al., 2015). Traditional work systems favour economic gains at the expense of the social environment, and in so doing deplete employee resources (Kira and Lifvergren, 2014). Sustainable work systems, however, assign equal value to stimulating employee well-being and development, while also attempting to generate positive outcomes for the economic, social and ecological

environments affected by their operations (Docherty et al., 2009b). In fact, a sustainable work system extends the triple-bottom line approach of sustainability into a quadruple-bottom line one (see Figure 1), in which human, sociological, ecological, and economic perspectives are inevitably interconnected in every project problem and opportunity (Kira and Lifvergren, 2014).

Given the widespread use of teams as the dominant work system in contemporary organisations, growing attention has been paid to the sustainability of teams (Macht and Nembhard, 2015). According to Simanto and Macht (2017, p. 807) *"...sustainability systems, however, must be achieved at a team level."* Despite the availability of definitions and theoretical principles for forming teams that resemble sustainable work systems, translating these principles into operational practices has proven an unexplored topic for research (Kira and Eijnatten, 2008, Renard et al., 2013), as discussed next.

PREVIOUS RESEARCH AND GAP

A thorough review of the literature, along with major studies on sustainable work systems, are tabulated chronologically in Table 1. As can be seen, studies allocated to sustainable work systems are scarce. Interest in the field begins with research into the use of technology to make work systems and operations more humane, as argued by Manuaba (2007) and Olin and Shani (2003). The core theme, however, centres around the quest to make organisations operate as sustainable work systems. In recent years, the focus, however, has shifted to organisation members – the issues that affect individuals, such as fatigue and motivation (cf.Lorincová et al., 2019, Thynne and Rodwell, 2019). Even so, none of these studies has yet been conducted within project-based industries, such construction. This is despite the construction industry being a unique context, distinct

from other fields (Pryke, 2012). Thus, this represents a gap in the literature, justifying this present study.

Table 1. Major studies on sustainable work systems (journal articles indexed in Scopus)

Author (years)	Industry/ context	Unit of analysis	Focus of findings
Thynne and Rodwell (2019)	Paramedics	Teams	Key issues of fatigue and recovery
Lorincová et al. (2019)	Slovak enterprises	Organisation	motivational programs for human resource
Hellman et al. (2019)	Municipality in Sweden	Organisation	The Stamina model application
Srinivasan et al. (2015)	Manufacturing	Individuals	Repetitive precision tasks
Duarte et al. (2015)	Brazil	Organisation	Dimensions of project management
Zink (2014)	Conceptual paper	Organisation	Contradictions of social, ecological, and economic goals
Zink and Fischer (2013)	Conceptual paper	Individuals interacting with elements of an organisation	Human factors and ergonomics
Zink (2011)	Europe	Organisation	Tasks of human resource management
Koukoulaki (2010)	Safety	Organisations	New framework for safety
Moore and Wen (2009)	Tourism in China	Industry	Work-life balance
Manuaba (2007)	Global	Teams	Technology selection
Olin and Shani (2003)	telecommunication	Organisations	Proposed framework for technology adoption

REVIEW METHODS

Review of the literature is a widely accepted approach towards advancing knowledge, particularly where there is a likelihood for overlooking some features of an area of research (Darko et al., 2017). Given that linking EPNs with sustainable construction is an

untapped research area (Kokkonen and Vaagaasar, 2018), conducting a systematic review of the now available literature, to spot and investigate the links between EPNs and sustainability is warranted. Elsevier's Scopus represents a powerful, highly recognised scholarly search engine that allows researchers to track the current research progress in a particular area (Tober, 2011). Hence, this study first uses Scopus to identify published research papers that define links between EPNs and sustainable construction. A systematic literature search was conducted in Scopus using various combinations of six relevant keywords, "sustainable construction", "sustainability", "sustainable development", "engineering project networks", "virtual teams", and "remote working." The combinations of keywords included: "sustainable construction" AND "engineering project networks"; "sustainability" AND "engineering project networks"; "sustainable development" AND "engineering project networks"; "sustainable construction" AND "virtual teams"; "sustainability" AND "virtual teams"; "sustainable development" AND "virtual teams"; "sustainable construction" AND "remote working"; "sustainability" AND "remote working"; and "sustainable development" AND "remote working." The keywords appeared in the titles, abstracts, or keywords of papers. The document type was limited to "all" and date range "published all years to present." Although many previous review studies limited the document type to "article" and specified the date range, following the procedure by Darko and Chan (2016), given the limited number of published papers on the topic of the present review, it was necessary to limit the document type to "all" and the date range to "published all years to present" in order to identify as many as possible relevant papers on the topic. Another attempt to identify more papers was repeating the literature search within Web of Science and Google Scholar. These two academic search engines have also been widely used in previous

review studies, and Google Scholar is favoured, given its wide coverage.

A total of 71 papers (10 papers each from Scopus and Web of Science and 51 papers from Google Scholar) were obtained through literature search. Some duplication occurred where several papers turned up across multiple search engines. Additionally, some of the keywords appeared on the title, abstract, or keywords, yet the research objectives identified within the paper had nothing to do with EPNs or sustainable construction. Such papers were excluded. Finally, the remaining valid papers were selected for this literature review study and were used as data.

EPNS AND THE QUADRUPLE-BOTTOM LINE

The review of the literature provides a picture of how and in what ways EPNs are associated with the elements of the quadruple-bottom line, as tabulated in Table 2 and discussed next.

Table 2. The quadruple-bottom line and EPNs

Sustainability bottom line	Dimensions associated with EPNs
The economic bottom line	Responding to the challenges affecting construction businesses
	Increasing innovation adoption
	Process-oriented advantages
The ecological bottom line	Sustainability by ICT (SICT) • Direct effects • Enabling effects and • Systematic effects
The sociological bottom line	Contribution to the growth of social resources across the entire supply chain of operation

The human bottom line	Positive outcomes for organisations
	Adverse implications on human resources

The economic bottom line

EPNs have become a 'component of business' for construction organisations (Nyongesa et al., 2017, Kokkonen and Vaagaasar, 2018). It is estimated that more than 60% of contemporary professional workers act as members of EPNs in organisations (Takeuchi et al., 2013). Such interest in EPNs across the construction industry can be attributed to three major reasons.

Challenges affecting construction businesses

EPN team working has gained such momentum in the construction industry with the construction economic environment facing many challenges (Committee on the Offshoring of Engineering, 2008, Hosseini et al., 2018a). The economic environment is changing at an unprecedented rate as it responds to globalising pressures (Ramalingam et al., 2014). In addition, the dynamic of the workforce as the fundamental component of the industry is changing and economic fluctuations are generating fierce competition, which highlights the prominence of international partnering (Chinowsky and Songer, 2011, Horta et al., 2013, Cao et al., 2018). The scale and complexity of construction projects has also increased (Solis et al., 2012, Mignone et al., 2016), with all the challenges, exacerbated by increasing demands from clients for higher levels of quality and tighter schedules (Abbasianjahromi et al., 2016). As illustrated in Table 2, EPNs can assist in addressing these challenges. That is, with EPNs, construction enterprises can manage globally dispersed resources in order to achieve global integration and local

responsiveness. EPNs are high performance and are typically creative teams; EPNs provide access to both explicit and tacit knowledge and improve performance in dynamic and unpredictable business environments (Hosseini and Chileshe, 2013, Peñarroja et al., 2013, Hosseini et al., 2018b). New developments like BIM are intended to blur the boundaries between design, construction and operations phases (Elghaish et al., 2020). As a result, EPNs can demonstrate similar advantages during the construction and operation phases of projects (Hosseini et al., 2018b). Evidence from industry shows that EPNs can be particularly beneficial to projects through bringing together various skills from a wide range of organisations in handling tasks in large-sized projects (see Mignone et al. (2016), Merschbrock et al. (2018) for details). They can also reduce the costs of delivering projects, while creating value through enabling outsourcing alternatives in completing projects (Vorakulpipat et al., 2010).

Overcoming such challenges has necessitated a change in the way that current construction organisations operate (Messner, 2008, Chinowsky and Songer, 2011). With regard to EPNs, construction organisations have the opportunity to try two major avenues for addressing their economic requirements (Akintoye et al., 2012, Toole et al., 2013): increasing innovation adoption; and exploiting process-oriented advantages of EPNs. These are discussed below.

Increasing innovation adoption

Construction firms that fail to adopt innovations effectively: *"... quickly lose their efficiency, their effectiveness, their customers, their employees, and so on"* (Toole et al., 2011, p. 60). Therefore, the future of the construction industry is increasingly becoming poised to harness the benefits of technological innovations (Vishal, 2014, Sepasgozar et al., 2016). Consequently, the construction industry has witnessed unprecedented interest

in using web-based methods (Wong and Zhang, 2013, Wang et al., 2014b). A salient example is BIM, described as a 'paradigm shift' for the construction context (Succar and Kassem, 2015, Cao et al., 2018). Evidence demonstrates that the level of BIM adoption within the industry has increased significantly over the last five years and will rise progressively in the near future (McGraw-Hill, 2012, Pärn et al., 2017, Merschbrock et al., 2018). The use of BIM will be: *"no longer optional, but rather a standard practice within the industry."* (Farnsworth et al., 2014, p. 18)

From another standpoint, construction firms rely heavily on the knowledge created beyond their boundaries for acquiring essential information on innovation (Aouad et al., 2010, Shokri-Ghasabeh and Chileshe, 2014). Implementing EPNs culminates in higher levels of partnership and exchange of information between the organisations involved (Vorakulpipat et al., 2010). Hence, use of EPNs would result in higher levels of innovativeness in the industry (Gann and Salter, 2000). This further underlines the central role played by EPNs in addressing the economic bottom line.

Process-oriented advantages of EPNs

Implementing EPNs in manufacturing and business organisations has been assessed as a shift from failure to success (Duarte and Snyder, 2006). Major gains from utilising EPNs are associated with their capabilities for crossing geographical, organisational and temporal borders, through modifying work procedures (Fuller et al., 2012, Zelenika and Pearce, 2014). This brings about profits for businesses due to lower wages (Hunsaker and Hunsaker, 2008), the cut in office space costs, decreased travel expenses, along with improved capability to address local market concerns (Messner, 2008, Schweitzer and Duxbury, 2010, Ford et al., 2017). Cisco (CISCO, 2007), speaking of their client, the US Postal Service, state: *"We calculate that an effective virtual conferencing solution can*

reduce annual traveling costs by $10 million."

EPNs enhance processes, and as such, improve productivity (Chen and Messner, 2010), along with timing effectiveness through quick turnaround (Gressgård, 2011, Ford et al., 2017). ERNs also enhance the quality of deliverables (Gignac, 2005). Challenges, however, exist in such arrangements, one being the lack of familiarity with local norms and building codes for remote collaborators, sometimes referred to as a major hindrance of using EPNs on real-life projects (Vorakulpipat et al., 2010). This can be addressed by utilizing representatives with adequate local knowledge and putting them into a position to remote team members. These representatives will act as the connection point between project, headquarters and the remote team office (see Mignone et al. (2016) and Vorakulpipat et al. (2010) for operational details).

In addition, they have flexible and agile structures, due to their access to a comprehensive pool of the best talent, with an increased level of creativity and innovativeness expected out of such configurations (Hunsaker and Hunsaker, 2008, Algesheimer et al., 2011, Ford et al., 2017). In addition, adding value to organisational business processes by enhancing the effectiveness of knowledge management in a knowledge-intensive industry such as construction is of paramount importance (Vorakulpipat et al., 2010, Mignone et al., 2016).

The ecological bottom line

EPNs take advantage of ICT for communications and data exchange, and as such, they are ICT-oriented systems (Nitithamyong and Skibniewski, 2011). As a result, the engagement of EPNs with sustainability can be defined under the umbrella of *"Sustainability by ICT" (SICT), focused on "creating, enabling, and encouraging sustainable patterns of production and consumption by means of ICT."* (Hilty and

Aebischer, 2015, p. 21) From the perspective of SICT, EPNs engage with sustainable construction in various ways (Hilty and Aebischer, 2015): (1) direct effects, (2) enabling effects and (3) systematic effects, as illustrated in Table 2.

Direct effects are the problems resulting from ICT. Implementing EPNs is not in line with the agenda of an ecological bottom line. The variety of materials contained in ICT hardware that EPNs use makes recycling less efficient. Indeed, digital ICT is the first technology that uses more than half of the periodic table of elements, where 57-60 chemical elements are used to build a microprocessor (Hilty et al., 2011). On the other hand, from an enabling effect perspective, EPNs with dependency on ICT have a great potential for fostering a transition to less material-intensive operations (Hilty and Aebischer, 2015).

EPNs can augment the sustainability of projects in terms of ecological bottom line, through reducing CO_2 emissions, eliminating physical transportation needs of personnel to meetings or to their workplaces (Precup et al., 2006). That said, the total impacts of ICT in terms of energy utilisation and emissions reduction is not necessarily positive (Fuchs, 2008, Huesemann and Huesemann, 2008). On a global scale, the total energy consumption by ICT has grown rapidly to 2% of all energy consumption today, roughly equal to the percentage of energy consumption by the aviation industry (Hilty et al., 2011). Thus, assessing the contribution of EPNs to the ecological bottom line is a matter of comparing the impacts of activities that would take place if EPNs were not in operation against the impacts of EPNs themselves. The impact difference is the contribution. However, these substitutions may take effect at multiple levels, and form a hierarchy of impacts. The reality is that reliance on ICT can generate new social interactions, and as a result, need for more transport (Fuchs, 2008). ICT-based

substitution is effective if constraints are in place, such as, for example, if transport were limited by policy. In the absence of such effective limitations, the enabling ICT innovations like EPNs develop more slowly and serve mainly to stimulate additional activities instead of replacing existing activities (Hilty et al., 2011). As such, the positive enabling power of EPNs might be lower than the direct harmful consequences.

The sociological bottom line

The sociological bottom line for a work system relates to its contribution to the growth of social resources (Yigitcanlar, 2010). This occurs through open and equal interactions among various stakeholders and the societal environment influenced by the operations of the system (Kira and Eijnatten, 2008, Fischer and Zink, 2012). A sustainable work system focuses on the entire system impacted by it, not just those with special interests, its shareholders or customers (Kira and Lifvergren, 2014). Equal attention is given to the entire supply chain of operation, organisations upstream and downstream of the activity must work towards resource development, in a sustainable manner. Current EPNs fail to fulfil this requirement, because a work system cannot be deemed sustainable if it exploits external resources and other work systems, as the means of production, to gain economic advantage (Kubek et al., 2015). The worst case is when, to benefit only a selected segment, a work system outsources some value creation activities to less developed communities like developing countries (Hancock and Drury, 2011). And this is the primary strategy pursued by a typical EPN in the construction context (Nayak and Taylor, 2009). The construction industry no longer operates in a local market as organisations, particularly those from developed economies, seek to reap the benefits of internationalising by tapping available global resources (Horta et al., 2013).

Notwithanding the above negative points, EPNs have the capacity to improve cross-

cultural interaction, provide recruitment opportunities to available talent in less developed countries, modernise organisational culture, and improve knowledge transfer to less developed work systems (Precup et al., 2006). With the above in mind, the final outcome of EPNs pertaining to the sociological bottom line is a matter of question, and relies on a comprehensive analysis of the balance between their positive and negative effects.

The human bottom line

Growth and sustainability of human resources has received only secondary attention in the construction sector (Kira and Lifvergren, 2014, Siew et al., 2016). Evidence shows that 48% of employees lose sleep as a result of stress, while 50% refer to workload and client demands as their biggest sources of anxiety (Chapman, 2017). Modern technologies, such as those used in EPNs, breach the barriers between work and life (Andres et al., 2012). Working in EPNs is fraught with extra demand for increased skills, multitasking, and higher levels of effort. As a result, human resources in EPNs are exposed to serious issues: work-life balance, work intensification, and low job satisfaction (Mignone et al., 2016). Moreover, EPNs are supposed to enhance the level of collaboration and social interactions among members (Oraee et al., 2017). Findings from empirical investigation of real-life projects, however, show acute problems with lack of collaboration and problems with social interactions among team members in EPNs (Liu et al., 2017, Merschbrock et al., 2018).

In general, despite the advantages of using EPNs in the construction context, as illustrated in Table 2, their impacts on the human bottom line is seen as negative. On several occasions, due to the detrimental impacts of such negative impacts on human

resources functionality, EPNs have transformed to collocated structures, in order to offset the negative impacts (Mignone et al., 2016, Merschbrock et al., 2018).

DISCUSSION

On the one hand, sustainable construction has become a priority across the construction industry (Silvius et al., 2012), with companies under immense pressure to demonstrate their alignment with the sustainability agenda across the full range of construction activities (Banihashemi et al., 2018), through to the corporate level (Zink, 2014). On the other hand, EPNs are coming to play a crucial role in the future of the construction industry, and are becoming increasingly mainstream on construction projects (Mignone et al., 2016, Merschbrock et al., 2018). The facts above, hint at a challenge for construction organisations, as illustrated schematically in Figure 2.

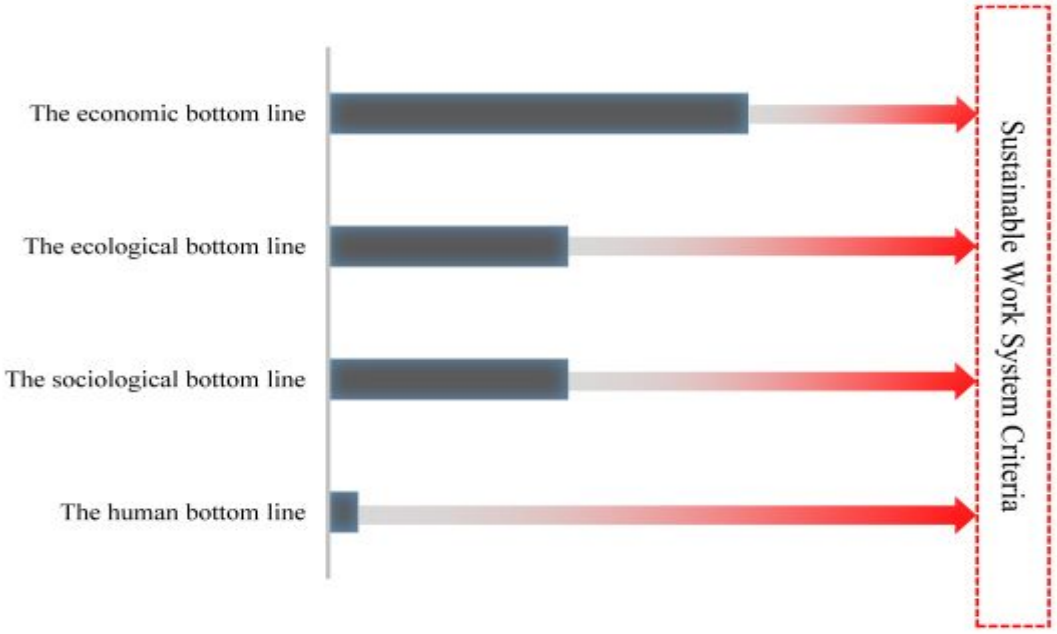

Figure 2. Schematic comparison of EPNs against sustainable work systems

As inferred from Figure 2, the gap between EPNs operations and what is expected of sustainable work systems is narrow, and they satisfy the requirements of the economic bottom line. In fact, it provides the rational justification for organisations to use them

(Mignone et al., 2016). The distance between sustainable work system criteria and what EPNs offer becomes wider only when it comes to ecological and sociological bottom lines. As discussed, the overall contribution of ICT-based systems like EPNs to the ecological bottom line is a matter of intricate analyses and not necessarily positive (Fuchs, 2008, Hilty et al., 2011).

Overall, EPNs, as implemented on construction projects, extend and amplify the current priorities and objectives of construction firms (Ramalingam et al., 2014). The construction industry rather infamously is well known for prioritising financial outcomes over and at the expense of the environment, social considerations or human needs (Banihashemi et al., 2017), the case observed here. Indeed, EPNs offer more effective pathways to cost reduction – they do generate greater profitability – and this is its greatest benefit (Becerik-Gerber et al., 2012). However, in line with traditional construction practice objectives, ecological, sociological and human resource imperatives feature a poor second. Specifically, EPNs do not notably enhance human conditions on the job, with the sustainability of work systems unimproved as a consequence of EPN introduction. To some extent this outcome may not be a surprise; many in the industry understand that innovation uptake in construction is almost wholly driven by economic incentives (Kale and Arditi, 2010). All other considerations aside, if there were no cost benefit, EPNs would not be in use. But a greater question arises as to the potential of EPNs to improve outcomes across the other three sustainability dimensions. 'To what extent could EPNs also facilitate improvements across other sustainability performance indicators, if this were prioritized?'

A fair discussion of the potential for EPNs to generate greater sustainability outcomes than currently witnessed entails consideration of at least two driving forces:

globalization of construction and construction workplace culture. In developed countries, the construction industry is mature and characterized by high competitiveness, and by growth rates comparable to GDP; which to say generally not more than about 3% to 5%. It is also prone to economic cyclical uncertainty – not being able to generate inventory as occurs in manufacturing – and is therefore relatively riskier. For low end construction it is also disadvantaged by low entry barriers. The financial bottom line is therefore a major, perennial concern (Banihashemi et al., 2017). Construction cannot easily ship its products, given that buildings are effectively one-off and built in situ, while resources inputs are frequently cheaper sourced close to the construction site (Arashpour et al., 2017). EPNs, however, do offer a mechanism for firms to operate more widely within a market, or even across markets, by accessing a larger catchment of experts, and in coordinating a larger logistics network. This ability provides a significant competitive edge in high-end major infrastructure projects or complex commercial endeavours, where the pool of world-class design, engineering and managerial experts, along with world-class technology inputs, is limited. In this regard, EPNs not only offer immediate operational cost reductions, but extend opportunities for firms to engage with a wider range of markets and projects, potentially offering higher rates of return.

The endemic poor work culture in construction, so well documented in literature – terrible work life balance, health and safety concerns, high stress and suicide rates – is attributed to a variety of culprits (Turner et al., 2009). These include historically entrenched practices, male-dominated 'macho' mindsets (Lingard and Turner, 2015), and low levels of innovation (Singh, 2014). But it is also true that sustainability parameters, such as the environment and human conditions, cannot do well when finances are weak.

That is, while sustainability ideology puts the economy, environment and society on an equal footing, where the progression of the one should not be undertaken at the expense of another, in practice none can be adequately achieved without first establishing adequate fiscal performance (Martek et al., 2018).

In this view, the failure of the construction industry to give sufficient consideration to sustainability concerns can be reasonably attributed to the fact that the construction industry, as compared to other industries, persistently rates as marginally profitable. Indeed, the practices of poor treatment of workers, as well as practices that waste resources and pollute the environment have been documented as transfer pricing strategies in which the human and environmental costs of construction are shunted on to third party stakeholders unable to resist or mitigate the consequences that must be borne as a result of actions taken by constructors. Simply, workers are compelled to work long hours because to not do so risks job loss (Lingard et al., 2012). Legislation protecting workers' rights are frequently ignored or circumvented, because to follow them risks projects become loss-making ventures, threatening the very existence of the firms that employ workers. In short, for all the many and varied remedies put forward for improving the construction industries performance across the sustainability parameters, the most direct and relevant barrier to be crossed is construction industry profitability (Martek et al., 2018). In this regard EPNs do serve a potentially valuable service. They offer the prospect of improved economic outcomes. With this, R&D and innovations many be pursued through retained earnings. Beyond that, proactive transdisciplinary efforts to recalibrated the priorities of construction firms to be more accommodating of sustainability goals regarding the environment, society at large, and the workforce in particular, become more practicable, as argued by Bieluch et al. (2017). Moreover, as

firms become more specialised, and with this shift increasingly reliant on a limited pool of professionals, the individual employee will be further liberated to move more freely between firms, choosing the one offering the best working conditions. Hence, EPNs not only serve to assemble the best team of people for any given project but contrariwise offer increased opportunities for people to choose the best companies and projects to work for. Facilitation of greater marketplace interaction may thus be the greatest advantage of EPNs and ultimately allow the marketplace itself to decide the ideal balance of sustainability objectives to be chased and captured.

In summary, EPNs do improve the financial bottom line of construction firms but have not yet majorly impacted other sustainability measures. But by offering a road to increased efficiency and profitability, EPNs indirectly make it viable to consider a shift to adopting these other priorities. EPNs have not changed the current organisational culture of construction firms, which place a low priority on non-economic sustainability goals, but should a proactive shift in the industry work culture take place, they would be a suitable platform for facilitating such a goal realignment.

CONCLUSION

EPNs are an increasing and inevitable development in the way business is conducted in construction projects. They represent an effective tool for facilitating work teams in a globalized age in which disparate and transient individuals can bring together requisite skills from anywhere around the world, for as long as necessary, and to the degree required, to facilitate projects. At the same time, sustainability is moving centre stage in dominating the agenda in construction. The very scope of sustainability has changed from simply mitigating the negative effects of resource depletion, pollution and health risks, to positively pursuing a balanced outcome across the goals of economic

prosperity, environmental preservation and social equity.

The difficulty is that EPNs, while effective in facilitating the processes of project management, are not conducive, as currently formulated, in promoting sustainability generally. More importantly, the extent and nature of this incompatibility is yet to be tested and verified in the literature.

The study is the first attempt to bring together EPNs and the concept of sustainable work systems within the construction context. This study makes a case for the necessity of change in managing EPNs in the construction industry, based on findings imported from other disciplines, and modifying to the construction context. This contributes to "the transferability and applicability" of existing knowledge from other disciplines to a specific construction setting. This transference marks the originality for this study, as argued by Chileshe (2005). This study has brought together what little has been done to map the compatibility of current EPNs with the pursuit of sustainability. Its central tenet is that the construction industry is an industry that presents its workforce with a relatively onerous work environment; one in which job dissatisfaction, employee turnover, long work hours and poor work-life balance, and depression and mental health issues abound. Consequently, in additional to the three bottom-line measures traditionally identified as the pillars of sustainability – economy, environment and equity – this paper proposes a fourth 'e' pillar – employee (or the human factor).

From the literature, such as is available, EPNs, as currently practiced, are thrust up against these four sustainability pillars and examined for compatibility. Overall EPNs fall short of being able to facilitate the future needs of construction firms to align with the expected future demands to be sustainable. On the economic dimension, EPNs do reasonably well; less so on the ecological front, and even less so in the social equity

domain. This is principally because while EPNs prove to be an effective medium for managing projects, they actually do so, not so much by improving efficiency, but, by extracting more time and energy from employees; expecting them to work out of normal hours and to be on-call continuously.

In this regard, EPNs prove to be wholly unsustainable across the fourth introduced pillar of 'employee.' They act more as an exploitative mechanism to leverage and transfer social and human resources as the price paid to achieve marginal economic outcomes. This study therefore signals the need for further work in this field. The next step is to examine how social and employee capital can be enhanced while maintaining the current economic benefits afforded by EPNs. In this regard a body of recommendations combining fully sustainable work practices within the current operational guidelines of the PMBOK, IPMA, Prince2 or similar, is needed. This will be the focus of subsequent research by the authors. Besides, the focus of the study was on knowledge workers in EPNs. This calls for future studies to extend the concept of sustainable work system beyond EPNs – and knowledge workers – and involve both blue- and white-collar workers active in the industry. Another fertile and necessary ground for future research can be developing guidelines and principles for shifting EPNs towards operating as sustainable work systems, incorporating the quadruple bottom line features.

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