



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*

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4 *and working across multiple time zones and numerous organisational boundaries in a*
5 *variety of cultures.”*
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9 Despite this, many areas associated with use of EPNs within the construction context
10 have remained unexplored ([Kokkonen and Vaagaasar, 2018](#)). Of these, studies
11 investigating the links between using EPNs and sustainability are missing from the
12 literature ([Cao et al., 2018](#)). Given that sustainability is a phenomenon of the highest
13 priority in contemporary construction research ([Kajikawa et al., 2011](#), [Darko et al., 2017](#),
14 [Nikmehr et al., 2017](#)), exploring the extent of alignment between EPNs and sustainability
15 is of particular importance ([Tibaut and Zazula, 2018](#)).
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25 Sustainable work systems are defined as working units that fulfil all the requirements of
26 sustainability ([Kira and Lifvergren, 2014](#)), and as such, the present study’s main objective
27 is to provide a background to the question: Are EPNs sustainable work systems? The
28 outcome will raise awareness of the potential and challenges of implementing EPNs as
29 the construction industry moves inevitably towards sustainability. The study has
30 organisational implications, assisting managers and practitioners in identifying how
31 various dimensions in EPNs can be manipulated to make these work systems more
32 sustainable.
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43 **BACKGROUND**

44 **Engineering project networks**

45
46 In their widely-accepted definition, [Jarvenpaa and Leidner \(1999\)](#) refer to *virtual teams* as
47 temporary, geographically dispersed, culturally diverse and electronically
48 communicative teams. The term ‘temporary’ in this definition refers to teams with short
49 life cycles in which members might have never worked together previously, and may
50 not work together again ([Siebdrat et al., 2014](#)). Teams with virtuality have been treated as
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4 the spin-off of information and communications technology ([Howard et al., 1989](#),
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6 [Schweitzer and Duxbury, 2010](#)). In the construction context, with regard to the definition
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8 presented by [El-Ghandour and Al-Hussein \(2004\)](#) and [Abrishami et al. \(2014\)](#), ICT is
9
10 considered a collective reference to the integration of computing technology and
11
12 information processing. Moreover, the term EPN in the construction industry has been
13
14 used interchangeably with virtual teams, defined as: “*Groups of geographically,*
15
16 *organisationally and/or time dispersed intelligent workers with different skills and in*
17
18 *different positions of the hierarchy, heavily reliant on ICTs to accomplish engineering*
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20 *tasks which for all are held accountable*” ([Hosseini and Chileshe, 2013, p. 1103](#)).
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23
24 EPNs have become an important element in the construction industry ([Bosch-Sijtsema](#)
25
26 [and Henriksson, 2014](#), [Iorio and Taylor, 2014](#)), where teams in contemporary construction
27
28 projects almost entirely operate as EPNs ([Iorio and Taylor, 2015](#), [Oraee et al., 2017](#),
29
30 [Kokkonen and Vaagaasar, 2018](#), [Merschbrock et al., 2018](#)). EPNs are teams responsible for
31
32 the planning, design and construction of a construction project through a collaborative
33
34 venture involving members coming from a wide range of organisations ([Mignone et al.,](#)
35
36 [2016](#), [Oraee et al., 2017](#)).
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40 41 **Sustainability in the construction context**

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43 Construction’s negative impacts in increasing carbon emissions, fermenting climate
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45 change, waste generation, change of land use, and loss of biodiversity are well
46
47 documented ([Nikmehr et al., 2017](#), [Banihashemi et al., 2018](#)). And as a corollary to a raised
48
49 level of awareness, adopting sustainable construction has become an essential part of
50
51 the strategy pursued by construction companies ([Alwan et al., 2015](#), [Alwan et al., 2017](#),
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53 [Banihashemi et al., 2017](#)). In essence, construction companies are increasingly expected
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55 to embrace sustainable construction through all available avenues ([Darko et al., 2017](#),
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4 [Kalutara et al., 2017](#), [Banihashemi et al., 2018](#)).

5
6 The term sustainability is well-known, first surfacing in the literature in the 1960s
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8 ([Martek et al., 2018](#)). It initially focused on environmental degradation, pollution and
9
10 health hazards ([Kalutara et al., 2017](#)). Sustainability in the current construction research
11
12 literature, however, refers to: “...*creating performance and functionality, whilst*
13
14 *encouraging social and economic progress and minimising the negative environmental*
15
16 *impacts*” ([Foong et al., 2017, p. 1](#))

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20
21 Sustainability in that sense requires the simultaneous pursuit of otherwise competing
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23 objectives, namely, the triple-bottom line approach: advancing social progress,
24
25 improving the environment, and promoting the strategic interests and profitability of
26
27 construction firms ([Saito et al., 2017](#), [Martek et al., 2018](#)). The idea is to use all possible
28
29 means for integrating the principles of sustainability into all undertakings, across the
30
31 entire lifecycle and supply chain of construction projects ([Wang et al., 2014a](#)). This
32
33 definition of sustainability is broadening the boundaries of its coverage, with increasing
34
35 relevance for companies to revisit the whole value creation chain, and shift to a life-
36
37 cycle perspective that concerns both products and work systems alike ([Gareis et al., 2013](#),
38
39 [Zink, 2014](#), [Kubek et al., 2015](#), [Olanipekun et al., 2017](#)).

40 41 42 43 **SUSTAINABLE WORK SYSTEMS**

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45 Concerns over sustainability are shifting from overarching general targets (e.g.
46
47 economic, ecological) to narrowly defined objectives like corporate sustainability, etc.
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49 ([Morse, 2010](#), [Gareis et al., 2013](#)). These will result in four stages of planned change for
50
51 systems: awareness and recognition; commitment; design and implementation; and
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53 dynamic state of sustainability ([Docherty et al., 2009a](#)), as illustrated in Figure 1.
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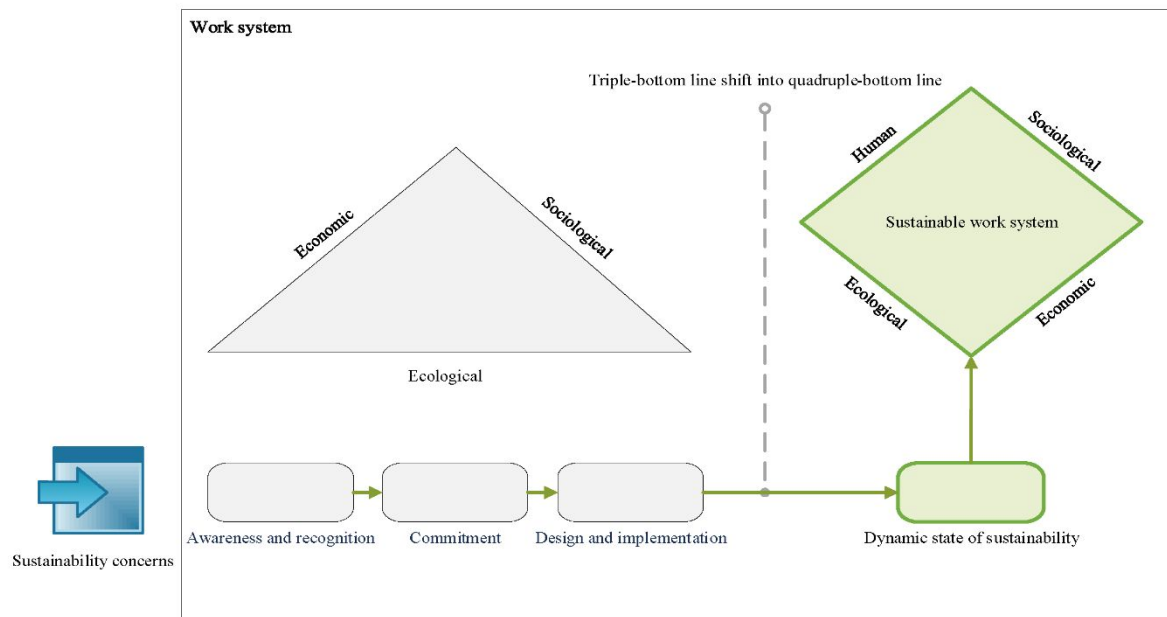


Figure 1. Work systems and sustainability planned changes

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

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4 environments affected by their operations ([Docherty et al., 2009b](#)). In fact, a sustainable
5
6 work system extends the triple-bottom line approach of sustainability into a quadruple-
7
8 bottom line one (see Figure 1), in which human, sociological, ecological, and economic
9
10 perspectives are inevitably interconnected in every project problem and opportunity
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12
13 ([Kira and Lifvergren, 2014](#)).

14
15
16 Given the widespread use of teams as the dominant work system in contemporary
17
18 organisations, growing attention has been paid to the sustainability of teams ([Macht and](#)
19
20 [Nembhard, 2015](#)). According to [Simanto and Macht \(2017, p. 807\)](#) “...sustainability
21
22 *systems, however, must be achieved at a team level.*” Despite the availability of
23
24 definitions and theoretical principles for forming teams that resemble sustainable work
25
26 systems, translating these principles into operational practices has proven an unexplored
27
28 topic for research ([Kira and Eijnatten, 2008](#), [Renard et al., 2013](#)), as discussed next.
29
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31 32 **PREVIOUS RESEARCH AND GAP**

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34 A thorough review of the literature, along with major studies on sustainable work
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36 systems, are tabulated chronologically in Table 1. As can be seen, studies allocated to
37
38 sustainable work systems are scarce. Interest in the field begins with research into the
39
40 use of technology to make work systems and operations more humane, as argued by
41
42 [Manuaba \(2007\)](#) and [Olin and Shani \(2003\)](#). The core theme, however, centres around the
43
44 quest to make organisations operate as sustainable work systems. In recent years, the
45
46 focus, however, has shifted to organisation members – the issues that affect individuals,
47
48 such as fatigue and motivation (cf. [Lorincová et al., 2019](#), [Thynne and Rodwell, 2019](#)). Even
49
50 so, none of these studies has yet been conducted within project-based industries, such
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52 construction. This is despite the construction industry being a unique context, distinct
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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

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3
4 untapped research area ([Kokkonen and Vaagaasar, 2018](#)), conducting a systematic review
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6 of the now available literature, to spot and investigate the links between EPNs and
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8 sustainability is warranted. Elsevier's Scopus represents a powerful, highly recognised
9
10 scholarly search engine that allows researchers to track the current research progress in
11
12 a particular area ([Tober, 2011](#)). Hence, this study first uses Scopus to identify published
13
14 research papers that define links between EPNs and sustainable construction. A
15
16 systematic literature search was conducted in Scopus using various combinations of six
17
18 relevant keywords, "sustainable construction", "sustainability", "sustainable
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20 development", "engineering project networks", "virtual teams", and "remote working."
21
22 The combinations of keywords included: "sustainable construction" AND "engineering
23
24 project networks"; "sustainability" AND "engineering project networks"; "sustainable
25
26 development" AND "engineering project networks"; "sustainable construction" AND
27
28 "virtual teams"; "sustainability" AND "virtual teams"; "sustainable development" AND
29
30 "virtual teams"; "sustainable construction" AND "remote working"; "sustainability"
31
32 AND "remote working"; and "sustainable development" AND "remote working." The
33
34 keywords appeared in the titles, abstracts, or keywords of papers. The document type
35
36 was limited to "all" and date range "published all years to present." Although many
37
38 previous review studies limited the document type to "article" and specified the date
39
40 range, following the procedure by [Darko and Chan \(2016\)](#), given the limited number of
41
42 published papers on the topic of the present review, it was necessary to limit the
43
44 document type to "all" and the date range to "published all years to present" in order to
45
46 identify as many as possible relevant papers on the topic. Another attempt to identify
47
48 more papers was repeating the literature search within Web of Science and Google
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50 Scholar. These two academic search engines have also been widely used in previous
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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 |
| | Responding to the challenges affecting construction businesses |
| The economic bottom line | Increasing innovation adoption |
| | Process-oriented advantages |
| The ecological bottom line | Sustainability by ICT (SICT) |
| | <ul style="list-style-type: none"> • 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 |

| | |
|-----------------------|---|
| | Positive outcomes for organisations |
| The human bottom line | |
| | 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

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4 responsiveness. EPNs are high performance and are typically creative teams; EPNs
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6 provide access to both explicit and tacit knowledge and improve performance in
7
8 dynamic and unpredictable business environments ([Hosseini and Chileshe, 2013](#), [Peñarroja](#)
9
10 [et al., 2013](#), [Hosseini et al., 2018b](#)). New developments like BIM are intended to blur the
11
12 boundaries between design, construction and operations phases ([Elghaish et al., 2020](#)). As
13
14 a result, EPNs can demonstrate similar advantages during the construction and operation
15
16 phases of projects ([Hosseini et al., 2018b](#)). Evidence from industry shows that EPNs can
17
18 be particularly beneficial to projects through bringing together various skills from a
19
20 wide range of organisations in handling tasks in large-sized projects (see [Mignone et al.](#)
21
22 [\(2016\)](#), [Merschbrock et al. \(2018\)](#) for details). They can also reduce the costs of delivering
23
24 projects, while creating value through enabling outsourcing alternatives in completing
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26 projects ([Vorakulpipat et al., 2010](#)).

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32 Overcoming such challenges has necessitated a change in the way that current
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34 construction organisations operate ([Messner, 2008](#), [Chinowsky and Songer, 2011](#)). With
35
36 regard to EPNs, construction organisations have the opportunity to try two major
37
38 avenues for addressing their economic requirements ([Akintoye et al., 2012](#), [Toole et al.,](#)
39
40 [2013](#)): increasing innovation adoption; and exploiting process-oriented advantages of
41
42 EPNs. These are discussed below.

43 44 45 *Increasing innovation adoption*

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48 Construction firms that fail to adopt innovations effectively: “... *quickly lose their*
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50 *efficiency, their effectiveness, their customers, their employees, and so on*” ([Toole et al.,](#)
51
52 [2011, p. 60](#)). Therefore, the future of the construction industry is increasingly becoming
53
54 poised to harness the benefits of technological innovations ([Vishal, 2014](#), [Sepasgozar et](#)
55
56 [al., 2016](#)). Consequently, the construction industry has witnessed unprecedented interest
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4 in using web-based methods ([Wong and Zhang, 2013](#), [Wang et al., 2014b](#)). A salient
5
6 example is BIM, described as a ‘paradigm shift’ for the construction context ([Succar and](#)
7
8 [Kassem, 2015](#), [Cao et al., 2018](#)). Evidence demonstrates that the level of BIM adoption
9
10 within the industry has increased significantly over the last five years and will rise
11
12 progressively in the near future ([McGraw-Hill, 2012](#), [Pärn et al., 2017](#), [Merschbrock et al.,](#)
13
14 [2018](#)). The use of BIM will be: “*no longer optional, but rather a standard practice*
15
16 *within the industry.*” ([Farnsworth et al., 2014, p. 18](#))
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20 From another standpoint, construction firms rely heavily on the knowledge created
21
22 beyond their boundaries for acquiring essential information on innovation ([Aouad et al.,](#)
23
24 [2010](#), [Shokri-Ghasabeh and Chileshe, 2014](#)). Implementing EPNs culminates in higher
25
26 levels of partnership and exchange of information between the organisations involved
27
28 ([Vorakulpipat et al., 2010](#)). Hence, use of EPNs would result in higher levels of
29
30 innovativeness in the industry ([Gann and Salter, 2000](#)). This further underlines the central
31
32 role played by EPNs in addressing the economic bottom line.
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36 *Process-oriented advantages of EPNs*

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38 Implementing EPNs in manufacturing and business organisations has been assessed as a
39
40 shift from failure to success ([Duarte and Snyder, 2006](#)). Major gains from utilising EPNs
41
42 are associated with their capabilities for crossing geographical, organisational and
43
44 temporal borders, through modifying work procedures ([Fuller et al., 2012](#), [Zelenika and](#)
45
46 [Pearce, 2014](#)). This brings about profits for businesses due to lower wages ([Hunsaker and](#)
47
48 [Hunsaker, 2008](#)), the cut in office space costs, decreased travel expenses, along with
49
50 improved capability to address local market concerns ([Messner, 2008](#), [Schweitzer and](#)
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52 [Duxbury, 2010](#), [Ford et al., 2017](#)). Cisco ([CISCO, 2007](#)), speaking of their client, the US
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54 Postal Service, state: “*We calculate that an effective virtual conferencing solution can*
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4 *reduce annual traveling costs by \$10 million.”*

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6 EPNs enhance processes, and as such, improve productivity ([Chen and Messner, 2010](#)),
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8 along with timing effectiveness through quick turnaround ([Gressgård, 2011](#), [Ford et al.,](#)
9
10 [2017](#)). ERNs also enhance the quality of deliverables ([Gignac, 2005](#)). Challenges,
11
12 however, exist in such arrangements, one being the lack of familiarity with local norms
13
14 and building codes for remote collaborators, sometimes referred to as a major hindrance
15
16 of using EPNs on real-life projects ([Vorakulpipat et al., 2010](#)). This can be addressed by
17
18 utilizing representatives with adequate local knowledge and putting them into a position
19
20 to remote team members. These representatives will act as the connection point between
21
22 project, headquarters and the remote team office (see [Mignone et al. \(2016\)](#) and
23
24 [Vorakulpipat et al. \(2010\)](#) for operational details).

25
26 In addition, they have flexible and agile structures, due to their access to a
27
28 comprehensive pool of the best talent, with an increased level of creativity and
29
30 innovativeness expected out of such configurations ([Hunsaker and Hunsaker, 2008](#),
31
32 [Algesheimer et al., 2011](#), [Ford et al., 2017](#)). In addition, adding value to organisational
33
34 business processes by enhancing the effectiveness of knowledge management in a
35
36 knowledge-intensive industry such as construction is of paramount importance
37
38 ([Vorakulpipat et al., 2010](#), [Mignone et al., 2016](#)).

45 46 **The ecological bottom line**

47
48 EPNs take advantage of ICT for communications and data exchange, and as such, they
49
50 are ICT-oriented systems ([Nitithamyong and Skibniewski, 2011](#)). As a result, the
51
52 engagement of EPNs with sustainability can be defined under the umbrella of
53
54 *“Sustainability by ICT” (SICT), focused on “creating, enabling, and encouraging*
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56 *sustainable patterns of production and consumption by means of ICT.”* ([Hilty and](#)
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4 [Aebischer, 2015, p. 21](#)) From the perspective of SICT, EPNs engage with sustainable
5
6 construction in various ways ([Hilty and Aebischer, 2015](#)): (1) direct effects, (2) enabling
7
8 effects and (3) systematic effects, as illustrated in Table 2.
9

10
11 Direct effects are the problems resulting from ICT. Implementing EPNs is not in line
12
13 with the agenda of an ecological bottom line. The variety of materials contained in ICT
14
15 hardware that EPNs use makes recycling less efficient. Indeed, digital ICT is the first
16
17 technology that uses more than half of the periodic table of elements, where 57-60
18
19 chemical elements are used to build a microprocessor ([Hilty et al., 2011](#)). On the other
20
21 hand, from an enabling effect perspective, EPNs with dependency on ICT have a great
22
23 potential for fostering a transition to less material-intensive operations ([Hilty and](#)
24
25 [Aebischer, 2015](#)).
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29
30 EPNs can augment the sustainability of projects in terms of ecological bottom line,
31
32 through reducing CO₂ emissions, eliminating physical transportation needs of personnel
33
34 to meetings or to their workplaces ([Precup et al., 2006](#)). That said, the total impacts of
35
36 ICT in terms of energy utilisation and emissions reduction is not necessarily positive
37
38 ([Fuchs, 2008](#), [Huesemann and Huesemann, 2008](#)). On a global scale, the total energy
39
40 consumption by ICT has grown rapidly to 2% of all energy consumption today, roughly
41
42 equal to the percentage of energy consumption by the aviation industry ([Hilty et al.,](#)
43
44 [2011](#)). Thus, assessing the contribution of EPNs to the ecological bottom line is a matter
45
46 of comparing the impacts of activities that would take place if EPNs were not in
47
48 operation against the impacts of EPNs themselves. The impact difference is the
49
50 contribution. However, these substitutions may take effect at multiple levels, and form a
51
52 hierarchy of impacts. The reality is that reliance on ICT can generate new social
53
54 interactions, and as a result, need for more transport ([Fuchs, 2008](#)). ICT-based
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4 substitution is effective if constraints are in place, such as, for example, if transport
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6 were limited by policy. In the absence of such effective limitations, the enabling ICT
7
8 innovations like EPNs develop more slowly and serve mainly to stimulate additional
9
10 activities instead of replacing existing activities ([Hilty et al., 2011](#)). As such, the positive
11
12 enabling power of EPNs might be lower than the direct harmful consequences.
13
14

15 16 **The sociological bottom line**

17
18 The sociological bottom line for a work system relates to its contribution to the growth
19
20 of social resources ([Yigitcanlar, 2010](#)). This occurs through open and equal interactions
21
22 among various stakeholders and the societal environment influenced by the operations
23
24 of the system ([Kira and Eijnatten, 2008](#), [Fischer and Zink, 2012](#)). A sustainable work system
25
26 focuses on the entire system impacted by it, not just those with special interests, its
27
28 shareholders or customers ([Kira and Lifvergren, 2014](#)). Equal attention is given to the
29
30 entire supply chain of operation, organisations upstream and downstream of the activity
31
32 must work towards resource development, in a sustainable manner. Current EPNs fail to
33
34 fulfil this requirement, because a work system cannot be deemed sustainable if it
35
36 exploits external resources and other work systems, as the means of production, to gain
37
38 economic advantage ([Kubek et al., 2015](#)). The worst case is when, to benefit only a
39
40 selected segment, a work system outsources some value creation activities to less
41
42 developed communities like developing countries ([Hancock and Drury, 2011](#)). And this is
43
44 the primary strategy pursued by a typical EPN in the construction context ([Nayak and](#)
45
46 [Taylor, 2009](#)). The construction industry no longer operates in a local market as
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48 organisations, particularly those from developed economies, seek to reap the benefits of
49
50 internationalising by tapping available global resources ([Horta et al., 2013](#)).
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57 Notwithstanding the above negative points, EPNs have the capacity to improve cross-
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4 cultural interaction, provide recruitment opportunities to available talent in less
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6 developed countries, modernise organisational culture, and improve knowledge transfer
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8 to less developed work systems ([Precup et al., 2006](#)). With the above in mind, the final
9
10 outcome of EPNs pertaining to the sociological bottom line is a matter of question, and
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12 relies on a comprehensive analysis of the balance between their positive and negative
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14 effects.
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17 **The human bottom line**

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20 Growth and sustainability of human resources has received only secondary attention in
21
22 the construction sector ([Kira and Lifvergren, 2014](#), [Siew et al., 2016](#)). Evidence shows that
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24 48% of employees lose sleep as a result of stress, while 50% refer to workload and
25
26 client demands as their biggest sources of anxiety ([Chapman, 2017](#)). Modern
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28 technologies, such as those used in EPNs, breach the barriers between work and life
29
30 ([Andres et al., 2012](#)). Working in EPNs is fraught with extra demand for increased skills,
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32 multitasking, and higher levels of effort. As a result, human resources in EPNs are
33
34 exposed to serious issues: work-life balance, work intensification, and low job
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36 satisfaction ([Mignone et al., 2016](#)). Moreover, EPNs are supposed to enhance the level of
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38 collaboration and social interactions among members ([Oraee et al., 2017](#)). Findings from
39
40 empirical investigation of real-life projects, however, show acute problems with lack of
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42 collaboration and problems with social interactions among team members in EPNs ([Liu](#)
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44 [et al., 2017](#), [Merschbrock et al., 2018](#)).
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50 In general, despite the advantages of using EPNs in the construction context, as
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52 illustrated in Table 2, their impacts on the human bottom line is seen as negative. On
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54 several occasions, due to the detrimental impacts of such negative impacts on human
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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.

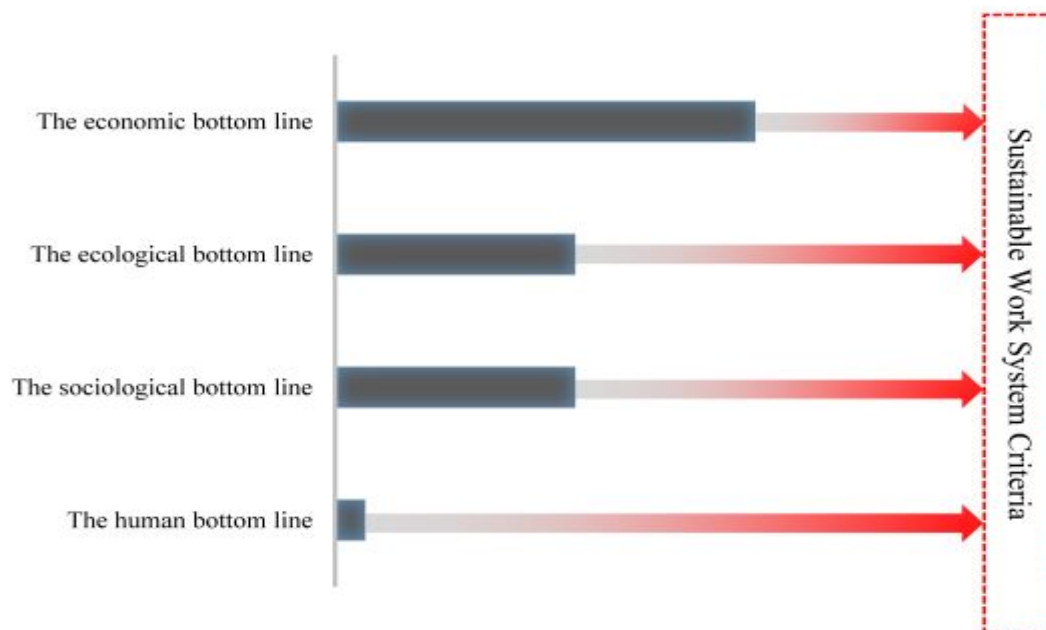


Figure 2. Schematic comparison of EPNs against sustainable work systems
As inferred from Figure 2, the gap between EPNs operations and what is expected of sustainable work systems is narrow, and they satisfy the requirements of the economic bottom line. In fact, it provides the rational justification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

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4 ([Mignone et al., 2016](#)). The distance between sustainable work system criteria and what
5
6 EPNs offer becomes wider only when it comes to ecological and sociological bottom
7
8 lines. As discussed, the overall contribution of ICT-based systems like EPNs to the
9
10 ecological bottom line is a matter of intricate analyses and not necessarily positive
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12
13 ([Fuchs, 2008](#), [Hilty et al., 2011](#)).

14
15 Overall, EPNs, as implemented on construction projects, extend and amplify the current
16
17 priorities and objectives of construction firms ([Ramalingam et al., 2014](#)). The construction
18
19 industry rather infamously is well known for prioritising financial outcomes over and at
20
21 the expense of the environment, social considerations or human needs ([Banihashemi et](#)
22
23 [al., 2017](#)), the case observed here. Indeed, EPNs offer more effective pathways to cost
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25 reduction – they do generate greater profitability – and this is its greatest benefit
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28 ([Becerik-Gerber et al., 2012](#)). However, in line with traditional construction practice
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30 objectives, ecological, sociological and human resource imperatives feature a poor
31
32 second. Specifically, EPNs do not notably enhance human conditions on the job, with
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34 the sustainability of work systems unimproved as a consequence of EPN introduction.
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36 To some extent this outcome may not be a surprise; many in the industry understand
37
38 that innovation uptake in construction is almost wholly driven by economic incentives
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41 ([Kale and Arditi, 2010](#)). All other considerations aside, if there were no cost benefit, EPNs
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43 would not be in use. But a greater question arises as to the potential of EPNs to improve
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45 outcomes across the other three sustainability dimensions. ‘To what extent could EPNs
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47 also facilitate improvements across other sustainability performance indicators, if this
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49 were prioritized?’
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55 A fair discussion of the potential for EPNs to generate greater sustainability outcomes
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57 than currently witnessed entails consideration of at least two driving forces:
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4 globalization of construction and construction workplace culture. In developed
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6 countries, the construction industry is mature and characterized by high
7
8 competitiveness, and by growth rates comparable to GDP; which to say generally not
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10 more than about 3% to 5%. It is also prone to economic cyclical uncertainty – not being
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12 able to generate inventory as occurs in manufacturing – and is therefore relatively
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14 riskier. For low end construction it is also disadvantaged by low entry barriers. The
15
16 financial bottom line is therefore a major, perennial concern ([Banihashemi et al., 2017](#)).
17
18 Construction cannot easily ship its products, given that buildings are effectively one-off
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20 and built in situ, while resources inputs are frequently cheaper sourced close to the
21
22 construction site ([Arashpour et al., 2017](#)). EPNs, however, do offer a mechanism for firms
23
24 to operate more widely within a market, or even across markets, by accessing a larger
25
26 catchment of experts, and in coordinating a larger logistics network. This ability
27
28 provides a significant competitive edge in high-end major infrastructure projects or
29
30 complex commercial endeavours, where the pool of world-class design, engineering and
31
32 managerial experts, along with world-class technology inputs, is limited. In this regard,
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34 EPNs not only offer immediate operational cost reductions, but extend opportunities for
35
36 firms to engage with a wider range of markets and projects, potentially offering higher
37
38 rates of return.
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40 The endemic poor work culture in construction, so well documented in literature –
41
42 terrible work life balance, health and safety concerns, high stress and suicide rates – is
43
44 attributed to a variety of culprits ([Turner et al., 2009](#)). These include historically
45
46 entrenched practices, male-dominated ‘macho’ mindsets ([Lingard and Turner, 2015](#)), and
47
48 low levels of innovation ([Singh, 2014](#)). But it is also true that sustainability parameters,
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50 such as the environment and human conditions, cannot do well when finances are weak.
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4 That is, while sustainability ideology puts the economy, environment and society on an
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6 equal footing, where the progression of the one should not be undertaken at the expense
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8 of another, in practice none can be adequately achieved without first establishing
9
10 adequate fiscal performance ([Martek et al., 2018](#)).

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13 In this view, the failure of the construction industry to give sufficient consideration to
14
15 sustainability concerns can be reasonably attributed to the fact that the construction
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17 industry, as compared to other industries, persistently rates as marginally profitable.
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19 Indeed, the practices of poor treatment of workers, as well as practices that waste
20
21 resources and pollute the environment have been documented as transfer pricing
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23 strategies in which the human and environmental costs of construction are shunted on to
24
25 third party stakeholders unable to resist or mitigate the consequences that must be borne
26
27 as a result of actions taken by constructors. Simply, workers are compelled to work long
28
29 hours because to not do so risks job loss ([Lingard et al., 2012](#)). Legislation protecting
30
31 workers' rights are frequently ignored or circumvented, because to follow them risks
32
33 projects become loss-making ventures, threatening the very existence of the firms that
34
35 employ workers. In short, for all the many and varied remedies put forward for
36
37 improving the construction industries performance across the sustainability parameters,
38
39 the most direct and relevant barrier to be crossed is construction industry profitability
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41 ([Martek et al., 2018](#)). In this regard EPNs do serve a potentially valuable service. They
42
43 offer the prospect of improved economic outcomes. With this, R&D and innovations
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45 many be pursued through retained earnings. Beyond that, proactive transdisciplinary
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47 efforts to recalibrated the priorities of construction firms to be more accommodating of
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49 sustainability goals regarding the environment, society at large, and the workforce in
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51 particular, become more practicable, as argued by [Bieluch et al. \(2017\)](#). Moreover, as
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4 firms become more specialised, and with this shift increasingly reliant on a limited pool
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6 of professionals, the individual employee will be further liberated to move more freely
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8 between firms, choosing the one offering the best working conditions. Hence, EPNs not
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10 only serve to assemble the best team of people for any given project but contrariwise
11
12 offer increased opportunities for people to choose the best companies and projects to
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14 work for. Facilitation of greater marketplace interaction may thus be the greatest
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16 advantage of EPNs and ultimately allow the marketplace itself to decide the ideal
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18 balance of sustainability objectives to be chased and captured.
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23 In summary, EPNs do improve the financial bottom line of construction firms but have
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25 not yet majorly impacted other sustainability measures. But by offering a road to
26
27 increased efficiency and profitability, EPNs indirectly make it viable to consider a shift
28
29 to adopting these other priorities. EPNs have not changed the current organisational
30
31 culture of construction firms, which place a low priority on non-economic sustainability
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33 goals, but should a proactive shift in the industry work culture take place, they would be
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35 a suitable platform for facilitating such a goal realignment.
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38 **CONCLUSION**

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41 EPNs are an increasing and inevitable development in the way business is conducted in
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43 construction projects. They represent an effective tool for facilitating work teams in a
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45 globalized age in which disparate and transient individuals can bring together requisite
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47 skills from anywhere around the world, for as long as necessary, and to the degree
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49 required, to facilitate projects. At the same time, sustainability is moving centre stage in
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51 dominating the agenda in construction. The very scope of sustainability has changed
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53 from simply mitigating the negative effects of resource depletion, pollution and health
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55 risks, to positively pursuing a balanced outcome across the goals of economic
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4 prosperity, environmental preservation and social equity.
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6 The difficulty is that EPNs, while effective in facilitating the processes of project
7 management, are not conducive, as currently formulated, in promoting sustainability
8 generally. More importantly, the extent and nature of this incompatibility is yet to be
9 tested and verified in the literature.
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15 The study is the first attempt to bring together EPNs and the concept of sustainable
16 work systems within the construction context. This study makes a case for the necessity
17 of change in managing EPNs in the construction industry, based on findings imported
18 from other disciplines, and modifying to the construction context. This contributes to
19 “the transferability and applicability” of existing knowledge from other disciplines to a
20 specific construction setting. This transference marks the originality for this study, as
21 argued by [Chileshe \(2005\)](#). This study has brought together what little has been done to
22 map the compatibility of current EPNs with the pursuit of sustainability. Its central tenet
23 is that the construction industry is an industry that presents its workforce with a
24 relatively onerous work environment; one in which job dissatisfaction, employee
25 turnover, long work hours and poor work-life balance, and depression and mental health
26 issues abound. Consequently, in addition to the three bottom-line measures
27 traditionally identified as the pillars of sustainability – economy, environment and
28 equity – this paper proposes a fourth ‘e’ pillar – employee (or the human factor).
29 From the literature, such as is available, EPNs, as currently practiced, are thrust up
30 against these four sustainability pillars and examined for compatibility. Overall EPNs
31 fall short of being able to facilitate the future needs of construction firms to align with
32 the expected future demands to be sustainable. On the economic dimension, EPNs do
33 reasonably well; less so on the ecological front, and even less so in the social equity
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4 domain. This is principally because while EPNs prove to be an effective medium for
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6 managing projects, they actually do so, not so much by improving efficiency, but, by
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8 extracting more time and energy from employees; expecting them to work out of normal
9
10 hours and to be on-call continuously.
11

12
13 In this regard, EPNs prove to be wholly unsustainable across the fourth introduced pillar
14
15 of ‘employee.’ They act more as an exploitative mechanism to leverage and transfer
16
17 social and human resources as the price paid to achieve marginal economic outcomes.
18
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20 This study therefore signals the need for further work in this field. The next step is to
21
22 examine how social and employee capital can be enhanced while maintaining the
23
24 current economic benefits afforded by EPNs. In this regard a body of recommendations
25
26 combining fully sustainable work practices within the current operational guidelines of
27
28 the PMBOK, IPMA, Prince2 or similar, is needed. This will be the focus of subsequent
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30 research by the authors. Besides, the focus of the study was on knowledge workers in
31
32 EPNs. This calls for future studies to extend the concept of sustainable work system
33
34 beyond EPNs – and knowledge workers – and involve both blue- and white-collar
35
36 workers active in the industry. Another fertile and necessary ground for future research
37
38 can be developing guidelines and principles for shifting EPNs towards operating as
39
40 sustainable work systems, incorporating the quadruple bottom line features.
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