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## A directed content analysis of viewpoints on the changing patterns of Lean Six Sigma research

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**A Directed Content Analysis of Viewpoints on the Changing  
Patterns of Lean Six Sigma Research**

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## A Directed Content Analysis of Viewpoints on the Changing Patterns of Lean Six Sigma Research

### Abstract

**Purpose:** This article builds on previous studies that explored the research patterns over 15 years, to consider the current status of the integration of Lean and Six Sigma. More specifically, this research addresses whether Lean and Six Sigma are stronger together and explores the reasons why Lean researchers and practitioners may be less likely to integrate Six Sigma in their work.

**Methodology:** The research utilises a survey of 25 established and respected academics and practitioners from 16 countries. The questionnaire is analysed using a direct content approach and coded in NVivo

**Findings:** The findings suggest that challenges may lie in the perception and understanding of statistics as well as short term rather than long term focus on improvement. The findings also suggest that academics and practitioners believe that Lean Six Sigma has developed over time and will continue to develop and improve as a methodology rather than being replaced with a new methodology.

**Research Limitations:** The survey has a sample size of 25, albeit all respondents are established and very experienced practitioners and academics.

**Practical Implications:** For organisations who are introducing or refreshing their continuous improvement initiatives, this research identifies some of the challenges and provides the opportunity to address them to maximise the opportunities for success and sustainability.

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3 **Originality:** The value of this paper is that it further addresses the debate over the  
4 integration of Lean and Six Sigma for many organisations which still employ Lean alone,  
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6 but beyond this it explores how they will continue to develop and whether they are a  
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8 permanent edition to the quality management landscape or a transition to something else.  
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13 **Keywords:** Lean Six Sigma; Research Patterns; Academics; Practitioners;  
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15 Integration  
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### 18 **Introduction**

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21 The focus of most articles is on the research subject, methodology applied and analysis  
22 and findings of related research. In their article entitled ‘A Critical Perspective on the  
23 Changing Patterns of Lean Six Sigma Research (*Anonymised*), explored research patterns  
24 of the most prolific researchers in Lean, Six Sigma, and Lean Six Sigma (LSS) through  
25 their publications rather than the detail of the contents of those articles.  
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35 The stated purpose of this approach was to explore whether there was evidence to indicate  
36 if Lean and Six Sigma were growing closer through an increase in publications focussed  
37 on an integrated Lean Six Sigma methodology and whether researchers, who specialised  
38 in either Lean or Six Sigma, were expanding or changing their research focus to include  
39 other methodologies or the integrated methodology.  
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49 This research is intended to further explore the findings from the article by *Anonymised*  
50 (2019) by first establishing the viewpoints of leading academics and practitioners  
51 regarding those research findings and then analysing the findings to establish whether  
52 there is a wider agreement or challenge regarding the initial findings. In addition, this  
53 research explores reasons for the agreements or challenges.  
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3 This article presents an overview of the initial findings, the methodology used in this  
4 research and the analysis and findings. The limitations of the current research are also  
5 detailed and recommendations for future research are provided. Overall, the intention of  
6 this research is to provide an additional dimension of thinking and evidence to  
7 organisations when considering single or integrated methodologies for their own  
8 continuous improvement initiatives.  
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### 18 **The Changing Patterns of Lean Six Sigma Research**

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21 At this stage in their practical application and academic exploration, the origins of both  
22 Lean and Six Sigma have been explored and written about in detail. Antony et al. (2017)  
23 present a full overview of the origins of Six Sigma within Motorola and its relationship  
24 with Total Quality Management (TQM), similarly, the development of 'Lean' from its  
25 origins in the Toyota Production System.  
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33 This article is focussed on the progress of the relationship between Lean and Six Sigma  
34 from the initial introduction of the term 'Lean Six Sigma' (Wheat et al, 2001) through to  
35 discussion of the way in which Lean Organisations may benefit from Six Sigma adoption  
36 and vice versa (Arnheiter & Maleyeff, 2005), whether Lean was a precursor to Six Sigma  
37 (Shah et al, 2008) and how best to integrate Lean and Six Sigma (Salah et al, 2010).  
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47 This issue of how best to integrate Lean and Six Sigma has been the subject of  
48 considerable discussion and it has been argued that it remains an unresolved issue (Snee  
49 and Hoerl, 2007). *Anonymised* (2019) presented structured searches of the SCOPUS  
50 database and identified 21 most prolific researchers in Lean, Six Sigma, and Lean Six  
51 Sigma published in each of the most recently completed five-year periods 2000-2004,  
52 2005-2009 and 2010-2014.  
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3 The search findings suggest that there is a clear progression of content focus over the  
4 search period from Lean or Six Sigma through to Lean and Six Sigma and finally to  
5 Lean Six Sigma integration. The findings indicated that researchers in Six Sigma more  
6 readily include Lean in their own research, whereas researchers in Lean were more  
7 likely to remain focussed on Lean exclusively. The foregoing would suggest that not  
8 only is the approach by which the integration of Lean and Six Sigma still debated but  
9 additionally the integration itself, where there is evidence that organisations apply only  
10 Lean (for example, Radnor & Osborne, 2013) or Six Sigma (for example, Tolga Taner  
11 et al. 2007) exclusively in their continuous improvement approaches. This research is  
12 intended to further explore the extent of the 'marriage' between Lean and Six Sigma  
13 (Antony et al. 2017) and the perception of the barriers and challenges around this.  
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## 32 **Methodology**

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34 To further explore the relationship between Lean and Six Sigma and the associated  
35 research focus and publication pattern, a panel of academics and practitioners (n=25)  
36 were selected by the authors. This method was deployed to understand the phenomena  
37 the research question posed through development of criteria to establish validity. The  
38 criteria applied to this selection were that the panel of respondents were well established,  
39 experienced and prominent in their fields and represented a wide range of disciplines and  
40 geographic areas. A balance was also sought between academics (n=13) who were based  
41 in twelve different countries and practitioners (n=12) who were based in seven different  
42 countries.  
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3 In order to further detail the breakdown of the panel and in particular support  
4 identification of any vocational or geographical patterns in the responses, the anonymised  
5 breakdown of the twenty-five respondents is shown in Table 1.  
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17 Given the exploratory nature of the research and the intention to examine the culture  
18 around the changing pattern of research, a qualitative approach to the study was adopted  
19 (Myers, 2013), with data being collected through a questionnaire that contained five open  
20 questions. Questions one and two were directly drawn from the findings of the article on  
21 which this current research is based, which is discussed above. The remaining three  
22 questions were developed to widen the exploration of the research phenomena applying  
23 the combined experience of the authors as well as the wider published literature. The  
24 purpose was to additionally consider whether the current methodologies were sufficient  
25 to support the delivery of holistic operational or business excellence as explored by  
26 Corbett (2011). Also considered was whether the respondents felt that other  
27 methodologies may be integrated in the future and whether the respondents saw any other  
28 methodologies or systems evolving in the future. These questions were intended to  
29 explore the perceptions of the longevity of Lean Six Sigma and the suggestions that as  
30 methodologies they could be considered to be ‘fads’ and with that the prediction that they  
31 will be replaced by new methods in the future (Naslund, 2008).  
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54 The full questions are presented below:  
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- 57 (1) *Do you believe that Lean and Six Sigma are stronger together and is there*  
58 *sufficient evidence of this?*  
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3 (2) *Research suggests that a Six Sigma practitioner or academic is more likely to*  
4 *integrate Lean methodologies into their work than a Lean practitioner is to*  
5 *integrate Six Sigma. Is this true in your experience and if so why do you think*  
6 *this is?*  
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12 (3) *Do you think the present quality/process improvement philosophy and*  
13 *infrastructure such as LSS is sufficient for achieving operational excellence?*  
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16 (4) *Do you consider that other methodologies will be integrated with LSS, for*  
17 *example, the developing interest in Green Lean Six Sigma?*  
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21 (5) *Can you imagine any other quality/process improvement system evolving over*  
22 *time?*  
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27 It is further commented that in question 4, the inclusion of Green Lean Six Sigma is used  
28 purely as an example to respondents as it is one area of growing interest to researchers  
29 and practitioners alike (Cherrafi et al. 2017).  
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35 Once obtained, the data were imported into NVivo 12, a qualitative analysis software  
36 programme and a directed content analysis approach was performed to code the data. This  
37 approach was undertaken as the authors consider that prior research could benefit from  
38 further description and exploration of the findings and to include key concepts or opinions  
39 within the approach to coding (Potter & Levine-Donnerstein, 1999). The goal, therefore,  
40 was to validate or extend the previous research (Hsieh & Shannon, 2005), which, in turn,  
41 assisted in the coding of the data in NVivo. This approach has been described as deductive  
42 category application (Mayring, 2000).  
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55 The directed approach may be considered to lead to what is described by Hsien &  
56 Shannon (2000) as an informed but nonetheless strong bias as the research approach can  
57 be viewed as seeking to confirm previous findings, rather than to confirm or negate them.  
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3 The recommendation of an independent auditor was therefore adopted, and the questions  
4 were reviewed prior to distribution. In the same way, the selection of panel members was  
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The recommendation of an independent auditor was therefore adopted, and the questions were reviewed prior to distribution. In the same way, the selection of panel members was equally reviewed for the purpose of achieving balance between the numbers of practitioners and academics.

### **Analysis and Findings**

The views of the twenty five respondents were coded by question as part of the overall coding strategy (Saldana, 2009) described above. In addition, any emerging themes were dynamically coded as part of the data analysis. This section presents the analysis presented in order of the questions administered.

#### ***Integration of Lean and Six Sigma***

The first question asked of the panel was ‘Do you believe that Lean and Six Sigma are stronger together and is there sufficient evidence for this?’

Twenty four of the twenty-five respondents stated in their respective views, Lean and Six Sigma were stronger together. Respondent H stated that ‘They cannot exist independent of each other’ and Respondent C stated, ‘I have always believed that the division between the two is at least arbitrary and at worst unhelpful.’. The only respondent who disagreed (Respondent W) stated “I would think that academically Lean and Six Sigma are stronger together. Nonetheless, the factory floor day is so busy, that it seems to me that it would be difficult for the organization to combine two goals and continuous improvement strategies.”. This suggests that while in principle they are stronger, the respondent is of the view that there are practical difficulties in operationalising this. This view is at odds with the other eleven practitioners who responded to the question mentioned above.

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3 To explore some of the emerging themes raised by respondents beyond their views of  
4 whether Lean and Six Sigma were stronger together and the context of those responses,  
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6 NVivo was used to generate a word cloud, which is provided at Figure 1.  
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21 The context for the frequency of the words ‘together’, ‘combined’ and ‘stronger’ can be  
22 drawn from the general agreement of respondents to the basic core of the question of  
23 whether they believe that Lean and Six Sigma are stronger together. However, it can be  
24 seen from Figure 1 that the next most commonly used word in the responses was ‘tools’.  
25 This frequency can be attributed to respondent’s A, B, G, I and Y who shared the view  
26 that the tools of either Lean or Six Sigma should be applied depending on the problem  
27 that was being targeted. This largely reflects a practitioner viewpoint but can perhaps be  
28 summarised in the comment by respondent C, who stated, ‘Why would we “limit”  
29 ourselves to the use of only one methodology when a wider combination is available?’.  
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44 The consensus view of twenty four of the twenty-five respondents was that Lean and Six  
45 Sigma are complementary and are stronger when deployed together with a practical theme  
46 developing that suggests each methodology contains different set of tools (although there  
47 are some common ones in both toolboxes) that can be applied according to the problem  
48 being tackled. This supported the emerging pattern presented in the initial research by  
49 *Anonymised* (2019) of the trend of research presenting integrated Lean Six Sigma and  
50 moving on from only Lean or Six Sigma focussed research.  
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### ***Researcher Openness to Integration of Lean and Six Sigma***

This second question was again drawn from the findings of the initial review of researcher behaviour and explored the finding that it was more likely that a Six Sigma researcher or practitioner would adopt or integrate Lean methodology than a Lean practitioner would adopt Six Sigma. In turn it was postulated that a Six Sigma researcher or practitioner was more likely to move the focus of their research to the integrated Lean Six Sigma methodology as was indicated in the analysis of the patterns of researcher publications.

Twenty three of the twenty-five respondents in the current research clearly stated in their experience that it was true that Six Sigma researchers and practitioners were more likely to integrate lean methodologies than the contrary. Respondent D disagreed and stated, 'From my standpoint, this is false, when someone is looking for process improvement, he might think in both methodologies, despite with which of them he starts practicing', respondent R also disagreed and stated, 'In fact in my experience with the Public Sector there was a movement there from lean six sigma to just lean.' Of the respondents who stated that they felt this was true, nineteen additionally provided their rationales as to why they felt this was the case. The rationales are shown in Table 2.

INSERT TABLE 2 HERE

There are several points of consensus that arise from the rationales presented by the respondents. First, it can be seen that there is agreement that Six Sigma is more statistically based than Lean as evidenced in the comments by respondents L and M. However, it is noted that the word 'perceived' is used in the responses of respondent I,

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3 and B, who consider it something of a moot point as proponents of Lean use data as well  
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5 and simply do not present it as thoroughly as a Six Sigma trained individual.  
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10 Other rationales presented include a focus on silo benefits (respondent G) and fast  
11 tangible results (respondent E). Training is also referenced within the responses, with A  
12 commenting that their experience is that the training for Six Sigma is more structured,  
13 with staff being selected for the purpose, while Lean practitioners are often self-selected.  
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15 In addition to this, respondent K and V commented that Lean was included as an  
16 important part of the Six Sigma body of knowledge and the broader methodology.  
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26 In summary, the main contributory factor commented on is that Six Sigma is, or is  
27 perceived, as more complicated than Lean and perhaps there is room to consider this  
28 within Six Sigma research and training design and delivery. This may also be  
29 symptomatic of the gaps in vision and strategy deployment when organisations introduce  
30 Lean Six Sigma and issues arise such as training and staff development as well as clear  
31 roadmaps for deployment and integration into priorities, performance, and internal  
32 communication.  
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#### 45 ***Sufficiency of Lean Six Sigma in Supporting Operational Excellence***

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48 The findings from the original article around the patterns of Lean Six Sigma research  
49 were considered, which initially explored the relationship between the two  
50 methodologies. The third question was intended to move beyond the original research  
51 and consider that, if Lean and Six Sigma were considered to be stronger together, would  
52 their integrated use be sufficient alone to deliver operational excellence in organisations?  
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60 and if not, what else may be required.

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5 Twenty-one respondents stated that their view was that Lean Six Sigma alone was not  
6 sufficient to drive operational excellence but was a key or contributory component. Four  
7 respondents who considered that Lean Six Sigma alone was sufficient, all caveated this  
8 with qualifiers around the holistic adoption of organisation wide Lean Six Sigma rather  
9 than solely the use of tools and techniques. The four respondents who shared this view  
10 were a mix of practitioners and academics and all from different countries. While the  
11 majority clearly stated that Lean Six Sigma alone was not sufficient, they did agree that  
12 it was a component within operational excellence. Eleven of the respondents provided  
13 views on which additional components or elements were also required. These are  
14 summarised in Table 3.  
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35 While there is a spread of viewpoints on the additional required components, the themes  
36 focus on the wider business strategy in terms of the importance of strategy, leadership,  
37 culture and training in complementing Lean Six Sigma to develop and deliver operational  
38 excellence. These comments were made by three practitioners and one academic who are  
39 based in the UK and Ireland, as well as a practitioner in Poland. The importance of the  
40 role of data analytics has been commented on by respondents who are both academics  
41 and based in the Netherlands and China, respectively.  
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54 In summary, while respondents have agreed that Lean and Six Sigma are stronger  
55 together, they have also predominantly agreed that LSS is not sufficient alone to support  
56 an organisation in delivering operational excellence and the need for strategy, leadership,  
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3 culture, social responsibility, external partner relationships and training, are important  
4 factors as well as emerging areas such as big data and data analytics.  
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### 10 *The integration of other methodologies*

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13 This research started with the question of the integration of Lean and Six Sigma., given  
14 that this itself was a journey, it was logical to the researchers that additional views were  
15 sought on whether they considered if there were any other methodologies or approaches  
16 that might be integrated with Lean Six Sigma. For contextual purposes, respondents were  
17 given the example of Green Lean Six Sigma. The responses are summarised in Table 4  
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34 The most common response is the recognition of the development of Green Lean Six  
35 Sigma, which was the example provided in the question. All five respondents are  
36 academics and based in India, Greece, New Zealand and South Korea. Other  
37 considerations presented were the integration of agile which was referenced by a  
38 practitioner in Mexico and an academic in the Netherlands. Practitioners in Ireland and  
39 Singapore considered the potential future impact of artificial intelligence on LSS Finally,  
40 the most common response out with the example of Green LSS was academics in Ireland,  
41 US and the Netherlands and a practitioner in the UK who all commented on the potential  
42 integration of data sciences.  
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57 In summary, there is broad agreement that Lean Six Sigma practitioners and academics  
58 not only view Lean and Six Sigma as stronger together but also believe that they can be  
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3 further improved and made more effective by the integration of other methodologies in  
4 the future, even where such a specific methodology is not yet known. This is shown  
5 through respondent C's comment, *'I think that proponents of LSS should always be open*  
6 *to incorporate the latest available thinking, whatever that is.'* This is supported by  
7 respondent D, who stated, *'I consider that LSS is the framework to integrate whatever*  
8 *other tool or technique'* and respondent M, *'...managers, engineers, academics and*  
9 *consultants always wish to expand their ideas into other sectors'*.

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22 However, while respondents are generally agreed in their belief of openness to the  
23 integration of other approaches and methodologies in the future, this view also comes  
24 with a warning about integration for the sake of integration. Respondent C comments,  
25 *'However, any new integration should have meaningful substance, and not just be a re-*  
26 *badging to sell services.'* Respondent I added, *'There will always be others who would*  
27 *like to add more approaches to LSS to suit their objectives; however only truly effective*  
28 *combinations will stand out in the long run'*. The responses support the view that the  
29 respondents view Lean Six Sigma as evolving and not a static methodology. They  
30 generally view that wider changes will impact and integrate with Lean Six Sigma but  
31 any additional integration with other tools and methodologies must have clear value.  
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As He & Goh (2015) pointed out, when LSS becomes more pervasive and inclusive, it  
will offer opportunities for excellence in performance in the production of goods and  
services in a wide variety of businesses.

### ***The Future of Lean Six Sigma***

The final question focussed on the future of Lean Six Sigma and whether respondents  
viewed it as likely to be replaced or evolves into something else. The analysis of keywords

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3 used in the respondent's comments is shown in Figure 2.  
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12 The most frequently used words in the responses are 'improvement', 'process' and  
13 'system'. The analyses show a shared context in the use of these words. Respondents  
14 clearly view and welcome Lean Six Sigma as being subject to a philosophy of continuous  
15 improvement itself and their comments suggest a journey of where LSS came from. As  
16 respondent C states, *'I see LSS as the combination of more than 100 years of learning on  
17 how to design, manage and continuously improve processes.'* Respondent E also  
18 comments, *'we see that the fundamental techniques such as 5-why, Ishikawa diagrams  
19 or SPC are part of every major improvement method or system (TQM, BPR, Lean, Six  
20 Sigma) and thereby have existed multiple decades.'* Finally, respondent M states, *'Lean  
21 and Six Sigma have been around over 30 years now in some shape or another and I don't  
22 see them disappearing soon.'*  
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40 Looking forward, this theme of continuous improvement is also evidenced in the views  
41 of the respondents and can be summarised through respondent K's comment, *'I think if  
42 LSS can embrace new methods and new thinking in terms of business improvement and  
43 innovation, the fundamental philosophy of LSS will not be obsolete.'* This view is echoed  
44 by respondent C who states, *'I can imagine that we will build on what has gone before  
45 and hence the right way to imagine it, is that systems will "evolve" and improve over  
46 time.'* Further respondent O comments, *'Both have already been evolving a lot since its  
47 origin, and I believe they'll keep evolving over time as practitioners contribute their  
48 experience from different sectors all over the world.'*  
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5 In summary, the respondents broadly agree that Lean Six Sigma itself has been the  
6 product of applied continuous improvement and evolution of the methodologies which  
7 have preceded it and share many tools and techniques that have lasted the test of time.  
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12 The respondents equally agree that Lean Six Sigma will continue to evolve and improve  
13 rather than be replaced.  
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### 18 **Discussion**

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20 While not unanimous, twenty four respondents stated that they felt that Lean and Six  
21 Sigma are stronger together. This viewpoint is supported in the wider literature where the  
22 importance of integration has been emphasised (Antony et al, 2017). Lean Six Sigma has  
23 been increasingly studied and applied as one program (Lameijer et al, 2017).  
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#### 31 ***The Organisational Selection of Lean, Six Sigma or Lean Six Sigma***

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33 It remains common to see articles that explore case studies or a focus on exclusively on  
34 Lean or Six Sigma across a range of industries and sectors (Bateman, Radnor & Glennon,  
35 2018; Lindskog, Hemphala, & Eriksson, 2017; Kuvvetli & Firuzan, 2017; Gupta, Sharma,  
36 & Sunder M, 2016). In considering the integrated deployment of Lean Six Sigma,  
37 research has explored areas such as readiness factors (Antony, 2014), success factors  
38 (Juliani & de Oliveira, 2017), failure factors (Albliwi et al, 2014) and sustainability  
39 (Cherrafi et al, 2016).  
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51 However, there remains a gap in understanding why organisations select to deploy only  
52 Lean or only Six Sigma and doing so may potentially limit the full realisation of benefits  
53 generated from continuous improvement efforts It may be that the selection is based on  
54 their business strategy, sense of urgency, extent to the degree of benefits to be accrued  
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3 from different CI strategies, nature of the problem to be tackled, their vision of continuous  
4 improvement or their definition of value. The selection is often more random and based  
5 on the preference or knowledge of an individual, the advice of a single consultant or even  
6 the only methodological option known to the organisation and, therefore, adopted by  
7 default. Therefore, there is a research gap in this area. It is recognised that use of a holistic  
8 approach to business process improvement in an integrated management system is on the  
9 increase (*Anonymised*); however, where researchers previously only focussed on one  
10 methodology or another. It was agreed by 14 out of 15 respondents in this research that a  
11 Six Sigma researcher or practitioner was more likely to integrate Lean than the other way  
12 around. It is common to see that many companies have taken “Lean” into account though  
13 they still call their programs “Six Sigma” (He & Goh, 2015).  
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### 30 *A 'fear' of Statistics*

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32 As shown in Table 2, the respondents provided their views on whether they viewed Lean  
33 practitioners to be less likely to adopt Six Sigma. These rationales are further explored in  
34 Table 5 which presents the rationale by country of operation of the respondents.  
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40 INSERT TABLE 5 HERE  
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45 Exploring the responses by country demonstrates some different perspectives among  
46 respondents of those countries. For example, there is a consensus in the UK that  
47 respondents perceive the core issue to be a fear and avoidance of statistics and a more  
48 structured selection and training process for Six Sigma practitioners and more broadly  
49 where respondents see Lean as part of the Six Sigma syllabus. Whereas in the US, the  
50 respondents consider the focus on quick wins and lack of a wider consideration of impact  
51 and a ‘bigger picture’ to be the issue.  
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5 The responses suggest that there is a need to focus on the understanding of the statistical  
6 tools that sit more within the Six Sigma methodology for problem solving scenarios. A  
7  
8 fear of statistics would suggest a gap in broader training and education which is restrictive  
9  
10 for organisations seeking to tackle problems of variation in processes rather than simply  
11  
12 waste and process flow issues. This consideration has implications for the way in which  
13  
14 statistics are taught in business and engineering courses in higher education and how the  
15  
16 fear is tackled in courses for managers, more generally. Quite often, statistics is poorly  
17  
18 taught with irrelevant examples and case studies as statistics courses are delivered by  
19  
20 statisticians or mathematicians in the department of statistics or mathematics in many  
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22 universities and not engineers or business management tutors (Antony and Kaye, 1999).  
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31 In 2005, Makrymichalos et al. identified similar considerations from their research and  
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33 commented on the importance of including statistical thinking based on three core  
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35 principles (i.e., process, data and variation) in wider business subjects. However, it can  
36  
37 be argued that while exposure to statistics may assist in lessening the ‘fear’ and improving  
38  
39 understanding, it is not only exposure to statistics which is required but also the correct  
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41 statistics, that are supportive of how statistical thinking is applied through Six Sigma  
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43 deployment in the workplace (Maleyeff & Kaminsky, 2002). The respondents in this  
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45 research also commented on the perception of difficulty, which may also have  
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47 implications for the approaches taken when delivering Six Sigma training, in particular.  
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49 Perhaps it is worthwhile looking into a research topic on the reasons for not adopting  
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51 “statistical thinking” across many companies today especially at the senior management  
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56 level.  
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### ***Continuous Improvement for Lean Six Sigma***

This research additionally sought respondent's views on what methodologies may emerge to be integrated or replace Lean Six Sigma. Some researchers have argued that Lean Six Sigma development has followed the life cycle of a fad and predicted that it would be replaced by a new methodology that would be process based (Naslund, 2008). This perception is also referred to by Respondent 'T' who comments on this perception amongst some management consultants.

Respondents in this research have presented a view that the integrated methodology should in itself be subject to continuous improvement, evolve and incorporate additional facets or dimensions. The stated consensus is that Lean Six Sigma has evolved over a 30-year period of time already and while they go on to provide views on what may drive that evolution, they are clear that they do not see an actual replacement for Lean Six Sigma emerging. This is also a warning from respondents about attempts to integrate additional approaches or dimensions 'for the sake of it' and ensuring overall value.

Respondents additionally offered their views on the methodologies or elements that they viewed as being likely to impact on the evolution of Lean Six Sigma. These are broken down by country in Table 6.

INSERT TABLE 6 HERE

Perhaps the clearest pattern in considering the responses by country of operation is that three of the four respondents based in the UK, and the respondents in the US and China did not identify or suggest any specific methodology that may be integrated with Lean

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3 Six Sigma in the future. However, all of the respondents clearly stated that they were  
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5 open to the possibility of other methodologies being integrated with Lean Six Sigma in  
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7 the future.  
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### 10 11 12 13 14 **Limitations of the research**

15 This study was limited to 25 responses. The authors are planning to carry out a study  
16  
17 looking into the reasons for the reluctance of Lean researchers and practitioners to  
18  
19 integrate Six Sigma into their research/practice. The teaching of statistics to support  
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21 continuous improvement initiatives and potentially reduce concerns around complexity  
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23 is also suggested as an area for future research. In addition, research on organisational  
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25 selection criteria for CI methodologies including Kaizen, Lean, Six Sigma or LSS is an  
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27 understudied area. Matching methodologies with the vision, strategy, and business  
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29 approach to continuous improvement may support successful and sustainable  
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31 deployment.  
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### 38 **Conclusion**

39 The research article on the changing patterns of Lean Six Sigma (*Anonymised*) found an  
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41 increase in the number of researchers who were exploring integrated methodologies  
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43 rather than Lean or Six Sigma alone. The respondents in this survey agreed with this and  
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45 their view that Lean and Six Sigma are stronger together is strongly supported. [The](#)  
46  
47 [intended contribution of this article is to further evidence the current state of integration](#)  
48  
49 [of lean and six sigma and identify from both practitioner and academics any barriers and](#)  
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51 [challenges from the perspectives of proponents of lean or Six Sigma in regard to](#)  
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53 [challenges to such integration given that](#) respondents agreed that Lean researchers are  
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55 less likely to incorporate Six Sigma than vice versa. This may suggest that there is a need  
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3 to review how statistics are taught in Higher Education, but also that they are taught in a  
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5 manner relevant to continuous improvement. This may not exclusively be the case for  
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7 higher education but may also be a consideration for the delivery of Lean Six Sigma  
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9 training.  
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13 What is clear from the views of the 25 experienced and respected academics and  
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15 practitioners who participated in this survey is that they do not view Lean Six Sigma as a  
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17 static methodology that may be replaced by any currently unforeseen methodology. A  
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19 further contribution of this study is the identification of the consensus by respondents that  
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21 they view Lean Six Sigma development to date as an evolution and indicated that it would  
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23 continue to evolve as a methodology, suggesting that the respondents do not only see the  
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25 application of Lean Six Sigma in continuous improvement but also view the methodology  
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27 as subject to continuous improvement.  
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<b>Respondent</b>	<b>Role</b>	<b>Country</b>	<b>Respondent</b>	<b>Role</b>	<b>Country</b>
<b>A</b>	Practitioner	Ireland	<b>N</b>	Academic	South Korea
<b>B</b>	Practitioner	UK	<b>O</b>	Practitioner	Singapore
<b>C</b>	Practitioner	UK	<b>P</b>	Academic	Germany
<b>D</b>	Practitioner	Mexico	<b>Q</b>	Academic	US
<b>E</b>	Academic	Netherlands	<b>R</b>	Academic	New Zealand
<b>F</b>	Academic	India	<b>S</b>	Academic	Greece
<b>G</b>	Practitioner	US	<b>T</b>	Academic	Australia
<b>H</b>	Practitioner	US	<b>U</b>	Academic	Spain
<b>I</b>	Academic	Ireland	<b>V</b>	Practitioner	Saudi Arabia
<b>J</b>	Academic	Singapore	<b>W</b>	Practitioner	Mexico
<b>K</b>	Academic	China	<b>X</b>	Practitioner	Poland
<b>L</b>	Academic	India	<b>Y</b>	Practitioner	UK
<b>M</b>	Practitioner	UK			

Table 1. Anonymised presentation of respondents.



Figure 1. Frequency of words used by respondents to question 1.

## Respondent Rationale

<b>A</b>	‘...practitioners in Six Sigma are chosen and trained centrally, while Lean practitioners are often organically self-selected and may not have the right structure, training and information to integrate Six Sigma.’
<b>B</b>	‘The moot point is over the use of analysis tools, a Lean practitioner is likely to use data to determine root cause, but less likely to present it as thoroughly as a Six Sigma trained individual.’
<b>C</b>	‘We need to recognise that many professionals do not like statistics. Even if they recognise the importance of statistics – it scares them, and yet Six Sigma methodology can be used by them in a very easily accessible way of improving their processes.’
<b>E</b>	‘Lean methodologies are more focussed on instant improvement, leading to fast tangible results and are therefore ideal first steps for Six Sigma practitioners to apply before applying a more time consuming Six Sigma technique’
<b>F</b>	‘Six sigma researchers (from academia and industry practices) facilitate the integration of lean methods into DMAIC framework at a

	‘faster rate because Six Sigma practices facilitate process improvement in terms of defect reduction and process capability with Lean tools.’
<b>G</b>	‘My observation is that focus is given to silo benefits and not the big picture.’
<b>H</b>	‘I have seen Lean professionals ignore key system protocols prior to executing changes without fully vetting out the impact(s) on product/process applicational performance.’
<b>I</b>	‘I think the reason for this is that the tools and techniques associated with Six Sigma are perceived as being more complex than Lean.’
<b>J</b>	‘There is no theoretical rationale for this, except that Six Sigma came with high-profile publicity and more serious analytical tools. Hence people tend to know about Six Sigma first.’
<b>K</b>	‘The reason is simple, even at the early evolution stage of Six Sigma Body of Knowledge (BOK), Lean was considered as an important part of Six Sigma BOK and the methodology of Lean and that of Six Sigma are complimentary in nature.’
<b>L</b>	‘I personally perceive that ‘Six Sigma Strategy’ demands substantial statistical knowledge to identify and utilise the right statistical tools.’
<b>M</b>	‘Due to the scientific nature of Six Sigma it can be easier to traverse from a six sigma background into a Lean background.’
<b>N</b>	‘The reason is that Six Sigma practitioners are more likely quality experts and statisticians, and Lean practitioners are more likely value innovators and cost-saving experts. Generally quality experts want to be value innovators and cost-saving experts, which is the way to go for them. However, value innovators and cost-saving experts do not want to be quality experts and statisticians.’
<b>O</b>	‘Compared with Six Sigma, Lean is more like common sense in management and it's easier to be explained to and used by people.’
<b>P</b>	‘I think there are a couple of reasons: Six Sigma Methods tend to be more complex, not so easy to learn and apply. And if you look from a maturity level perspective, many organisations are on a low level of maturity in their Business Excellence Journey’
<b>T</b>	‘I think the reason for this is the structured approach to six sigma projects, this lends itself to the inclusion of lean tools at various stages within the project cycle. I think that perhaps this is harder to do if starting with lean and looking to adopt six sigma type practices.’
<b>U</b>	‘From my experience, Lean is more extended in managerial world in Spain, and managers are not generally interested in Six Sigma. However, Six Sigma managers are interested in more improvements,

	advances and practices, and consequently are more open to incorporate Lean.’
V	‘Lean methodology has always been part of the Six Sigma education and the opposite is not.’
X	‘it's basically because people think in LEAN as a compliment of Six Sigma, due that 6S is perceived as more complex in terms of execution and because of the data-driven approach. ‘

Table 2. Respondent rationales for Six Sigma acceptance and integration of Lean.

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<b>Component</b>	<b>Respondents</b>
<b>Business Process Design</b>	D
<b>Corporate Social Responsibility</b>	N
<b>Change Management</b>	X
<b>Culture</b>	A, I
<b>Data Analytics</b>	E, K
<b>Excellence Frameworks (EFQM, Baldrige)</b>	V
<b>External Focus</b>	H
<b>Leadership</b>	B, I
<b>Strategy</b>	A, M
<b>Training</b>	B

Table 3. Additional Components supporting Operational Excellence.

<b>Methodology</b>	<b>Respondents</b>
<b>Green</b>	F, L, N, R, S,
<b>Agile Enterprise</b>	D, E
<b>Artificial Intelligence (AI)</b>	A, O, U
<b>Robotic Process Automation (RPA)</b>	O, X
<b>Creating Shared Value</b>	N
<b>Data Sciences (Data mining and Big Data)</b>	E, I, Q, Y

Table 4. Additional methodologies which may integrate into Lean Six Sigma.



Figure 2. Frequency of words used by respondents to question 5.

**Country (No.)    Rationale**

<p><b>UK (4)</b></p>	<p>Six Sigma is more scientific and so easier to move to Lean</p> <p>People are scared of statistics and so avoid them although they can be easily applied</p> <p>It is moot, Lean practitioners still present statistics, just less thoroughly than Six Sigma practitioners.</p> <p>I think it’s because Lean is easier to do and many practitioners are lacking the SS skills, even though they claim to be GB / BB</p>
<p><b>Ireland (2)</b></p>	<p>Six Sigma practitioners are often centrally selected and trained, whereas Lean practitioners are often more organically self-selected.</p> <p>Six Sigma tools and techniques are perceived as more complicated.</p>
<p><b>US (2)</b></p>	<p>Organisations focus on silo benefits and not the big picture.</p> <p>Lean practitioners can ignore key protocols and not consider wider impacts prior to implementing change.</p>
<p><b>India (2)</b></p>	<p>Six Sigma practitioners use DMAIC which incorporates defect reduction through Lean tools.</p>

	Six Sigma demands significant statistical knowledge.
<b>China (1)</b>	Lean is incorporated into the Six Sigma Body of Knowledge.
<b>Singapore (2)</b>	Six Sigma was more publicised and is better known Lean is more like common sense and is more easily explained.
<b>South Korea (1)</b>	Six Sigma experts want to expand into Lean. Lean experts do not want to expand into Six Sigma.
<b>Netherlands (1)</b>	Lean is more focussed on instant improvement but is a first step for a Six Sigma practitioner.
<b>Germany (1)</b>	Six Sigma Methods tend to be more complex, not so easy to learn and apply. And if you look from a maturity level perspective, many organisations are on a low level of maturity in their Business Excellence Journey.
<b>Saudi Arabia (1)</b>	Lean methodology has always been part of the Six Sigma education and the opposite is not.
<b>Poland (1)</b>	people think in LEAN as a compliment of Six Sigma, due that 6S is perceived as more complex in terms of execution and because of the data-driven approach.
<b>Australia (1)</b>	I think the reason for this is the structured approach to six sigma projects....this lends itself to the inclusion of lean tools at various stages within the project cycle.
<b>Spain (1)</b>	However, Six Sigma managers are interested in more improvements, advances and practices, and consequently are more open to incorporate Lean.

Table 5. Rationales for Lean researchers being less likely to integrate Six Sigma by country of respondents.

**Country (No. of respondents) Methodology**

<b>UK (4)</b>	Data Sciences (1)
<b>Ireland (2)</b>	Artificial Intelligence Data Sciences
<b>US (3)</b>	Data Sciences (1)
<b>India (2)</b>	Green (2)
<b>China (1)</b>	None provided
<b>Singapore (2)</b>	Artificial Intelligence Robotic Process Automation
<b>South Korea (1)</b>	Green Creating Shared Value
<b>Netherlands (1)</b>	Agile Data Sciences
<b>Mexico (2)</b>	Agile (1)
<b>Germany (1)</b>	None Provided
<b>New Zealand (1)</b>	Green
<b>Greece (1)</b>	Green
<b>Australia (1)</b>	None Provided
<b>Spain (1)</b>	Artificial Intelligence
<b>Saudi Arabia (1)</b>	None Provided
<b>Poland (1)</b>	Robotic Process Automation

Table 6. Summary of methodologies that may integrate with Lean Six Sigma in the future.



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Reviewer's comments	Authors' response
<b>Reviewer 1</b>	
<p>Thank you for an interesting contribution on the evolution of Lean Six Sigma research. I suggest the following improvements to the paper before its publication:</p>	<p>Our thanks to the reviewer for taking the time to comment on our article. We have sought to answer each of the reviewer's comments in turn below.</p>
<p>Expand on the Literature Review section: currently it is quite brief and refer only a handful of studies. There are some other comprehensive Literature Review papers on Lean Six Sigma you may want to consider;</p>	<p>This was originally a deliberate choice by the authors as this is the second article in a series and the first article included a fuller literature review. However, we recognise the validity of the reviewer's comments when this article is considered alone and as such have expanded the literature review.</p>
<p>Choice of questions. Of the 5 questions asked, 2 came from the literature review, while the other 3 from the author(s), but there was only a couple of lines of explanation of why these particularly 3 were chosen (e.g. why Green LSS was mentioned and not LSS and Industry 4.0 for example?). It'd be good to elaborate a bit more on the rationale the author(s) had in choosing the questions;</p>	<p>Thank you, we have also expanded the rationale presented.</p>
<p>Expand on the practical/academic implications of the research, that are now just mentioned in passing within the 'limitations of research' paragraph</p>	<p>An expanded commentary on contribution has been added to the conclusion.</p>