Improving Long-Term Strategic Planning: An Analysis of STEEPLE Factors Identified in Environmental Scanning Brainstorms

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Abstract--**Given an understanding of factors that drive change in a firm's external environment is an important element of strategy development, some form of environmental scan to identify factors tends to be included. This paper presents findings from an analysis of environmental scans conducted by 76 manufacturing firms. Firm's senior decision makers brainstormed factors using the standard STEEPLE framework to prompt participants to consider social, technological, economic, ethical, political, legal, and environmental factors.**

The first finding reveals that participants' perspectives are dominated by events rather than trends. When the 886 responses were categorized as events, trends, requirements or uncertainties, over 70% of responses related to events. This finding is significant for advocates of systems thinking in strategy, and in addition the finding may provide quantitative evidence of cognitive bias in scanning.

Second, the brainstorms were found to vary significantly across two key dimensions: the breadth of factors identified within STEEPLE categories, and the number of factors identified in the most distant future time-period. Four brainstorm archetypes are suggested, and while the validity of the archetypes is subject to ongoing research work, the finding could aid workshop facilitators to tailor their approach to future scans.

I. INTRODUCTION

Decision maker's understanding the external environment is vital to developing sound corporate strategy. The study presented in this paper forms part of a broader study examining this understanding, specifically looking at how manufacturing firms scan and identify factors in the external environment. Decision makers' perception of external factors in the strategy development process is particularly important to study given the increasingly dynamic and complex environments in which firms operate [1], [2].

While the general field of environmental scanning is well covered in academic literature e.g. [3], [4], this study examines scanning from the perspective of assessing the quality of the outputs. The data set used for the analysis is unique, comprising 76 real world environment scans carried out by senior decision makers in small and medium sized manufacturing firms based in the UK between 2008 and 2011. The analysis reveals a notable diversity in the quantity and quality of outputs. Several measures were developed to determine quality, including the number of factors identified, the breadth and range of factors, the degree of articulation, and the type of factors identified.

Before reporting the findings from the analysis, literature relating to the field of environmental scanning is summarized, beginning with evidence of the importance of environmental scanning, with reference to authors in the fields of strategic planning and management.

A. The importance of environment scanning

Scanning the business environment is an essential part of corporate strategic planning. It is generally accepted that alignment between an organization and its external environment is essential for performance and strategy [5]–[9]. In particular the work of Andrews [5] has been influential in popularizing the idea that good strategy requires a fit between threats and opportunities that present themselves in the external environment and the firm's own strengths and weaknesses (i.e. SWOT).

Thus organizations tend to conduct an assessment of the external environment, typically termed an environment scan, at some stage in their strategy process in order to develop appropriate and successful strategy [10]. Environmental scanning is perhaps most simply described as the process which enables decision makers to make sense of current and potential future changes [11]. Others have defined it by the outcomes, Brown and Weiner described the process as "a kind of radar to scan the world systematically and signal the new, the unexpected, the major and the minor" [12, p. ix]. Aguilar [13] defined scanning in terms of its outcome, arguing that the systematic collection of external information (a) lessened the randomness of information flowing into the firm and (b) provided early warnings for managers of changing external conditions. Perhaps the most complete definition comes from Coates who linked the concept closely to foresight [14], [15]. In Coates' [16] view, environmental scanning entailed:

- detecting scientific, technical, economic, social, and political trends and events important to the institution
- defining the potential threats, opportunities, or changes for the institution implied by those trends and events
- promoting a future orientation in the thinking of management and staff
- alerting management and staff to trends that are converging, diverging, speeding up, slowing down, or interacting

B. The scanning process

There are having been a number of ways to conceptualize the process of scanning, and field studies have shown a wide diversity in the way decision makers gather information. Renfro and Morrison [17] perceived scanning to be either passive or active. Passive scanning is reading only for interest without using the information for strategic planning. The danger of this unsystematic approach is that information

which signals changes in the environment may be overlooked, especially given potentially relevant information can be scattered, vague, and imprecise [10]. The alternative is a more systematic active scanning approach where information is identified from a wide variety of sources covering the whole external environment [17]. Aguilar [13] witnessed four types of scanning in his study of the information gathering practices of managers in the field: undirected, conditioned, informal and formal.

- Undirected viewing consists of reading a variety of publications for no specific purpose other than to be informed.
- Conditioned viewing consists of responding to this information in terms of assessing its relevance to the organization.
- Informal searching consists of actively seeking specific information but doing it in a relatively unstructured way.
- Finally formal searching is a proactive mode of scanning entailing formal methodologies for obtaining information for specific purposes.

C. Defining and subdividing the environment

In defining the external environment, it has become common to break down this environment into two or three levels: the task environment, the industry environment, and the macro or societal environment [10], [11]. The task environment relates to the most immediate links the firm has in the external environment, while the industry environment relates to industry specific factors including shareholders, suppliers, employees/labor unions, competitors, trade associations, communities, creditors, customers, special interest groups, and governments. The macro or societal environment is the broadest level, where changes in social, technological, economic, environmental, and political factors affect the firm in less direct ways than the task or industry environment.

The subdivision of the macro business environment appears to originate from the 1960s. Aguilar [13] published 'Scanning the Business Environment' and suggested the mnemonic 'ETPS' to aid decision makers to consider and categorize the Economic, Technical, Political, and Social aspects of the external environment. Throughout the subsequent decades, further aspects have been suggested, including Legal, Environmental or Ecological, Ethical, and Infrastructure. A common framework currently used in scanning activities is STEEPLE, which considers Social, Technological, Economic, Ethical, Political, Legal, and Environmental factors.

The STEEPLE framework does however only provide a prompt in the brainstorming activity, helping decision makers to brainstorm important factors based on their own experiences into discrete categories. The framework itself does not make the task of understanding the external environment any simpler. Indeed the problems of gathering and analyzing information about the chaotic and complex external environment to create competitive insight have long been documented. Early research showed there existed little consistency in the information gathering process among firms [13] and that neither functional area not hierarchical level significantly related to the quality of scanning [18]. Globalization has contributed to a more complex and uncertain environment for firms [1], and as a result strategic long term planning decisions have become ever more difficult. While existing planning methods have long been criticized for their reliance on historical data, assuming that future changes were likely to be continuations of the direction and rate of present trends [19], the practice of environmental scanning has evolved little from the first incarnations of ETPS analysis five decades ago.

D. Triggering environmental scanning

Fahey and Narayanan [11] described how firms either engage in irregular, periodic, or continuous scanning. Irregular scanning tends to be crisis initiated, when a firm needs information to develop an immediate plan. Periodic scanning, in contrast, is scheduled to coincide with the strategic planning cycle. Firms can also engage in continuous scanning, however this requires considerable time and resources [11].

In reality, Mintzberg [20] discovered strategy formulation is rarely periodic, but tends to be an irregular and discontinuous process. Wheelan and Hunger [10] suggest there is a human tendency to continue on a particular course until some triggering event causes something to go wrong. For example Haigh and Griffiths [21] found surprising climatic events drove the inclusion of climatic trends into strategic planning by electricity suppliers. Indeed some empirical evidence suggests that most organizations tend to follow a particular strategic direction for between 15 to 20 years before making a significant change [22].

The equilibrium is typically punctuated by revolutionary periods, which Gordon *et al.* [23] posited were preceded by triggering events. These triggering events vary between firms, however some of the most common events documented by Gordon *et al.* [23] include the appointment of a new CEO, an external intervention, the threat of a change in ownership, and a gap between performance and expectations. Similarly, the term 'strategic inflection point' has also described triggers by Puffer [24], citing the examples of new technologies, a change in the regulatory environment, or a change in customer values and preferences.

E. Cognitive biases

It is appropriate to consider the role cognitive biases play in the scanning and brainstorming process [25], [26], especially considering the shear volume of information available to decision makers requires them to filter out information according to their own mental models [3], [27]. The understanding that decision makers have bounded rationality is now widely acknowledged following the work of Tversky and Kahneman [28] in the field of heuristics and cognitive biases. Their research challenged the idea of human

beings as rational actors and has guided almost all current theories of decision-making [29].

There is evidence to suggest that the triggering events described above contribute to cognitive biases in the brainstorming process. Studies show that vivid events can become strong anchors such that people overestimate the likelihood of certain well-publicized events while underestimating the risks of less dramatic ones [30]. A large body of evidence finds cognitive biases manifest automatically and unconsciously [31]–[33], such that even those aware of the existence of the phenomenon are unable to detect, let alone mitigate their manifestation solely via awareness. Two biases important to consider in relation to brainstorming are the attention bias and the availability heuristic.

- The attention bias is the tendency to pay attention to emotionally dominant stimuli in one's environment to the neglect of other relevant data [26].
- The availability heuristic is the tendency to overestimate the likelihood of events with greater "availability" in memory [25]. The availability in memory is influenced by how recent the memories are, or how unusual or emotionally charged they may be.

F. Varieties of external factors

A variety of different terms are used to describe factors in foresight and brainstorming activities. While the fields of environmental scanning and foresight have developed a long way from the insubstantial 'perspectives', as an emerging field with roots in many disciplines, there is a lack of consensus surrounding many of the terms. This ambiguity is compounded by the many practical applications of the research which often create their own usages irrespective of previous definitions.

Foresight and technology management literature tends to use the catch-all term 'trends and drivers' in the analysis of the strategic landscape for example [34], however little research in these fields has explored the implication of distinguishing between the diverse types of factors on the outcome of the strategic activity. In a recent study, Saritas and Smith [35] brought some clarity by devising a set of working definitions to differentiate between trends, drivers of change, wild cards/shocks, discontinuities and weak signals (summarized in Table 1). In their view trends and drivers are differentiated based on the nature of the influence in terms of time horizon and pervasiveness, and the ability for firms to exert influence on the factor. Wild cards are high impact low probability events, while discontinuities are situations where rapid change fundamentally alters existing or expected direction of policies, events and planning regimes. Weak signals are the early signs of possible, but not confirmed, changes in the environment.

TABLE 1 – WORKING DEFINITIONS DEVELOPED IN A RECENT STUDY IN AN EFFORT TO DIFFERENTIATE BETWEEN COMMONLY USED TYPES OF FACTORS IN FORESIGHT EXERCISES ADAPTED FROM [35, PP. 293–297]

Trends *Trends are those change factors that are experienced by everyone and often in more or less the same contexts. They create broad parameters for shifts in attitudes, policies and business focus over periods of several years that usually have global reach. Normally most firms can do little to change them as their causes are outside of the influence of individual firms, and often nation states as well. For example:* • Ageing population • Decreasing global nuclear warheads • Increasing greenhouse gas emissions
Drivers of Change *Drivers of change are those forces or events which may be amenable to changes according to one's strategic choices, investments, R&D activities or foresight knowledge and strategies. For example:* • Major technology developments and their societal impacts • Policy or regulatory changes that lead to changes in corporate actions or investments
Wild cards / shocks *Wild cards and shocks are those high impact surprise events and situations which could occur, but have a low probability of doing so. These situations tend to alter the fundamentals, and create new trajectories which can present additional challenges and opportunities that most stakeholders may not have previously considered or prepared for. For example:* • Gulf Stream shift • Nuclear disaster
Discontinuities *Discontinuities are those situations where change is rapid and fundamentally alters the previous pathways or expected direction of policies, events and planning regimes. While this is normal in most market places where the processes of creative destruction and products and services innovation are familiar, when discontinuities occur in society and government, the changes tend to be more significant because they can alter so many other domains. For example:* • Social media creating powerful forces that have altered the nature of business and social interactions, and personal information management. • Advances in nanotechnology, genomics and quantum computing, which if realised within the next decade, could fundamentally alter our ways of making materials, practicing medicine and computation-making calculations, with pervasive societal impacts.
Weak signals *Weak signals are the early signs of possible but not confirmed changes that may later become more significant indicators of critical forces for development, threats, business and technical innovation. They represent the first signs of paradigm shifts, or future trends, drivers or discontinuities. For example:* • In the 1980s the first mention was made of global warming • Nanotechnology was first described in the 1980s [36]

TABLE 2 – THREE TYPES OF FACTORS WHICH SHOULD BE CONSIDERED IN FORESIGHT EXERCISES IN ORDER TO CHALLENGE PARTICIPANTS TO IMPROVE THEIR UNDERSTANDING OF THEIR EXTERNAL ENVIRONMENT ADAPTED FROM [37, P. 168]

Events *What just happened?* Events are tangible and easily described, however tend to dominate people's attention.
Patterns/Trends *What is happening over time?* Examining patterns takes the understanding a little deeper, enabling people to examine patterns of change in the data over time.
Systematic Structures *What is driving these patterns or trends and how do they arise?* By beginning to untangle how the factors are related, an understanding of the system dynamics can be developed, working towards the ability to predict events.

Promoters of systems thinking argue that the distinction between these definitions is important to the outcome of a strategic exercise. Senge *et al.* [37] argue that most firms struggle to develop thorough insight into the behavior of factors in their external environment and the consequent impact on their firm. The authors argue that firms focus too heavily on events in the short term, ignoring less obvious and more complex trends and systematic structures, ultimately leading to myopic reactive strategic planning. Furthermore the authors argue that foresight exercises must challenge participants to identify these trends and structures that could fundamentally affect their firm and industry, defined in Table 2. In doing so, participants can develop an understanding of the deeper systematic structures operating in the external environment [37].

It is worth reflecting at this stage on what the literature reveals about environmental scanning before progressing to the data analysis and findings. It is widely acknowledged that scanning is considered vital to ensure a firm's strategy takes account of possible changes in the future. Scanning is the collection of information to help decision makers identify new or unexpected factors that threaten to alter the business context, ideally conducted in a systematic manner, however firms have been found to conduct scanning in variety of ways. Frameworks have been developed to help decision makers to brainstorm the external environment in a time constrained workshop settings, however cognitive biases may limit the quality of scanning; in particular attention bias and the availability heuristic can limit decision makers' perspective to recent vivid events at the expense of more complex factors such as trends. Finally, proponents of systems thinking argue that decision makers' awareness of trends is important in order to build an understanding of the systematic structures that shape changes in the external environment.

II. DATA ANALYSIS METHODOLOGY

A large volume of data was available for analysis from facilitated workshops held with small and medium size manufacturing firms located in the UK, from a diverse range of manufacturing sub-sectors. The firms' senior executives attended and conducted a variety of strategy development activities, including environmental scanning. The data set comprised the output of 76 workshops, held between 2008 and 2011, which followed a standard format of a series of activities in which participants contributed with hand written post-it notes [1]; the location and contents of which were subsequently recorded in digital form.

The data collected in this real world environment overcomes typical objections to the artificiality of non-field studies [38], however does present difficulties despite the standard format. Workshops varied in the number of participants attending, and the functional departments represented on a case by case basis. These limitations are discussed in the concluding sections of the paper.

The standard strategy workshops include four facilitated workshops, examining the firm's market, product, technology competences, before the final workshop was used to chart the outputs from the first three. Within the first workshop, focussing on the market, the external environment is explored as one activity of nine typically included in a half-day workshop [39]. The workshop includes standard strategy activities including a description of the firm's products and markets, developing a 'Stakeholder Influence Plot', considering possible 'Product Market Groups', completing a Boston Matrix (market growth vs share), and conducting a SWOT analysis.

Approximately 5 to 10 minutes is typically allocated for the environmental scanning activity, and participants are invited to brainstorm for factors and to consider in which of three future time periods they expect the factor to impact the firm. To aid the brainstorming the previously described STEEPLE framework is employed as a large poster placed on the wall, with seven rows for each of the STEEPLE categories and three columns for short, medium and long term time periods. A representation of the poster is shown in Figure 1. Post-it notes generated by the participants are placed on the poster, and the workshop output is a digital replica of the post-it notes' content and location. Factors are assigned to their individual STEEPLE categories, and either an individual or multiple time periods as best translated from the annotated post-it note.

[1] See Kerr *et al.* [44] for more information on similar workshop environments, including discussion on cognitive and social influence inhibitors, use of post-it notes, and the role of the facilitator.

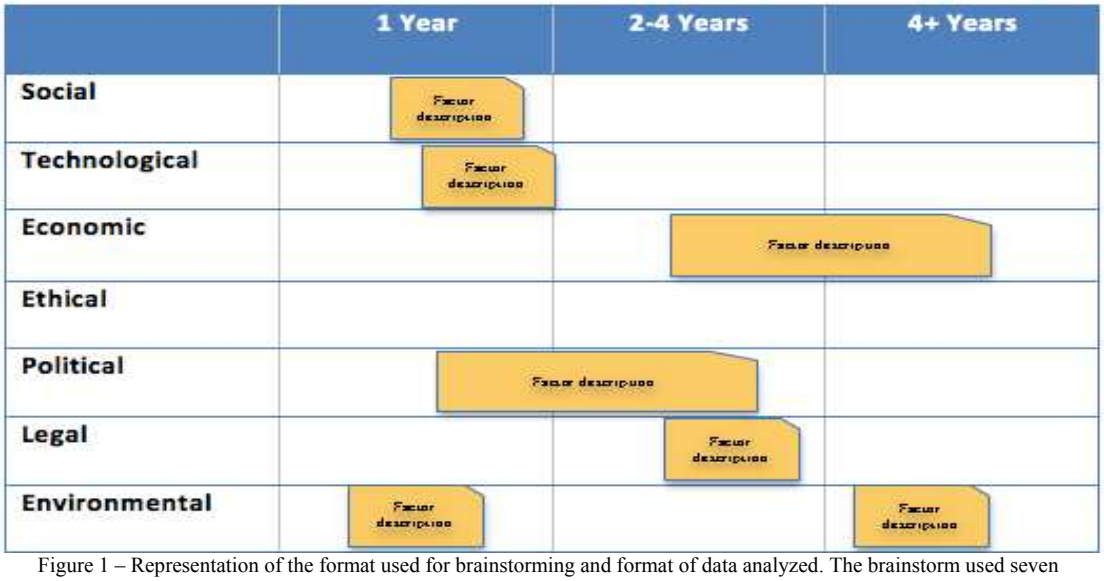

Figure 1 – Representation of the format used for brainstorming and format of data analyzed. The brainstorm used seven rows for the STEEPLE categories and three columns for future time periods.

A. Variable Analysis

The raw data files were processed and extracted into qualitative data analysis software (MaxQDA), and coded following best practice guidance [40], [41]. A total of 886 factors were extracted *in-vivo* from the 76 documents, and each factor was categorized according to the following variables:

- STEEPLE category
- Time period
- Level of articulation
- Type of factor

The STEEPLE category and time period were taken directly from the digital output, while the level of articulation and type of factor were qualitatively coded by the lead researcher according to the following principles:

- The 'level of articulation' was a variable created for the purpose of this analysis, with the factor categorized according to a four-level scale to indicate the quantity of detail recorded within the factor. Level 1 being for simple phrases with no detail to indicate the impact or change. In contrast, level 4 factors included quantified detailed descriptions. The four levels are summarized in Table 3 using real examples from the data set. Qualifying information is shown in *italics* for each level.
- The 'type of factor' variable distinguished between trends, drivers of change, uncertainties, and requirements. This categorization built upon the definitions developed by Saritas and Smith [35] in a similar study of factors. As described previously, in that study responses to a survey from attendees of a future studies conference were categorized into trends, drivers of change, wild cards / shocks, discontinuities, and weak signals. This study modified these categories slightly as expert knowledge in each sub-sector would have been required to differentiate accurately between weak signals, discontinuities, and wild cards / shocks. The definitions described in Table 4 were employed to categorize each factor by type.

TABLE 3 – LEVELS OF ARTICULATION EXPLAINED AND ILLUSTRATED WITH FACTORS EXTRACTED FROM DATASET

Articulation Levels	**Relating to '*skills*'**	**Relating to '*economic recession*'**
1. Topic phrase	"*skills*"	"*Recession"*
2. Topic with detail	"*shortage of* skills"	*"Recovery from* recession"
3. Indication of change over time	"*increasing* shortage of skills"	"Recovery from recession *may increase engineering"*
4. Quantify change	"*by 2016* increasing shortage of skills"	"Recovery from recession *in terms of price/value (2008 - £950, 2009 - £650, 2020 - £950)"*

TABLE 4 - DEFINITIONS USED TO DISTINGUISH BETWEEN TYPES OF FACTORS WITH EXAMPLES EXTRACTED FROM DATA SET FOR ILLUSTRATION

Type of Factor	Example from data set
Trends *Factors that arise from broadly generalizable change, experienced by everyone and often in more or less the same contexts insofar as they create broad parameters for shifts in attitudes, policies and business focus over periods of several years, and exist outside the influence of the individual firm.*	"Increased frequency of obesity" "Rise of E-books" "Trend to software as a service – need to change business model"
Events and forces *Events or forces that are more immediate and relevant to specific stakeholders. In contrast to trends that are longer term and pervasive, these events and forces can change from year to year and may be amenable to stakeholder actions or strategic choices.*	"Banks being difficult - taken overdraft away" "Restructuring of the NHS"
Uncertainties *Factors explicitly described as uncertain. These are often denoted with a question mark.*	"Currency – revalue ???" "Olympics – opportunities?"
Requirements *Factors that are identified as requirements or necessary for the firm.*	"Have to maintain system platforms for longer" "ROSHH compliance"

III. FINDINGS

Analysis of the data reveals ten findings of interest described in the following sub-sections. Firstly the number of factors identified in each brainstorm is presented, which suggests a notable diversity between firms' understanding of the external environment. Next the distribution of factors among the four variables described above is presented: the distribution amongst the seven STEEPLE categories, the distribution of the factors between the three future periods, the distribution between types of factor, and the distribution among the four levels of articulation.

A. Number of factors identified

There was a significant diversity in the number of factors identified in the brainstorms. The average number of factors identified was 11.6, however in three brainstorms only four factors were identified. In contrast, at the other end of the scale, six brainstorms identified over 20 factors. Figure 2 illustrates this diversity.

While the brainstorms were carried out using a standard process with around the same amount of time available for brainstorming, a number of other variables differed. At the participant level, the actual number of participants present in the brainstorm varied, along with their seniority in the firm. At the firm level, while all manufacturing firms, a number of different sectors were represented, and the size of the firms varied from micro firms with less than 10 employees to medium sized firms with up to 250 employee. Unfortunately many of these variables were not recorded, except for the sectors represented, and thus Figure 3 illustrates the average number of factors identified after firms are categorized by sector. The data presented in this way would suggest that participants in certain sectors, such as transportation, identify more factors, however the low sample size in each industry severely limits this conclusion. Nevertheless, the finding that there exists diversity in the number of factors identified between brainstorms is notable.

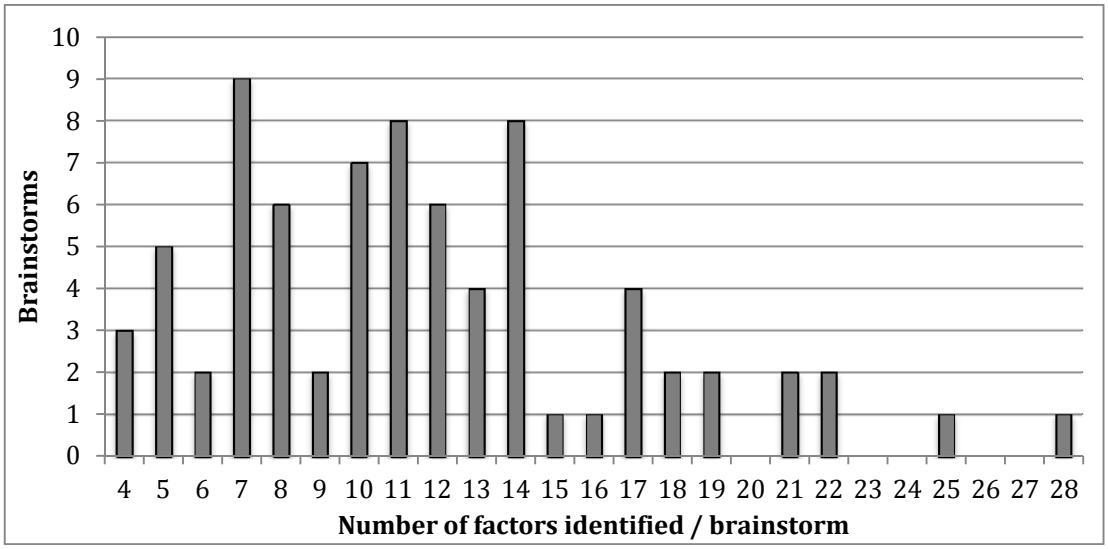

Figure 2 – Distribution showing the number of factors identified per brainstorm. A notable diversity in the distribution exists (standard deviation = 5.1) around the average of 11.6 factors per brainstorm.

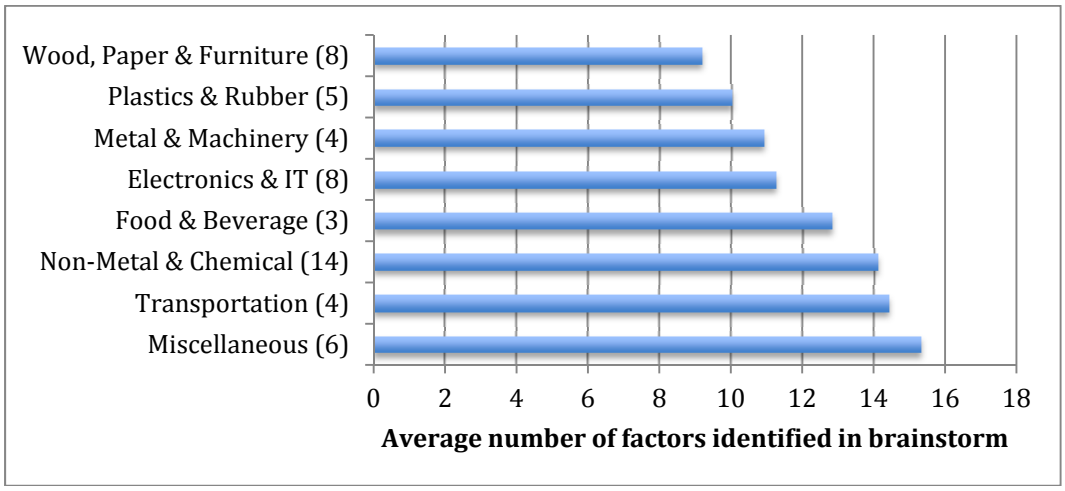

Figure 3 - Average number of factors identified in brainstorms distinguished by firm's industry, with sample size recorded in brackets. Presented in this way, the data reveals less diversity (standard deviation 2.25).

B. STEEPLE distribution

The distribution of factors amongst the seven STEEPLE categories is uneven, as presented in Figure 4. Economic factors were most likely to be identified (23% of the total), whereas in comparison ethical factors were the least likely. The three categories of social, technological and environmental issues were similarly populated at between 15-17%, while political and legal issues are less represented at 12% each.

Given the workshops were conducted in the wake of the global financial crisis, it comes as no surprise that economic factors dominated the participants' thoughts. Indeed this is reinforced in the language used, with a large proportion of the factors discussing the impact of the crisis.

A simplistic interpretation of the lack of ethical factors could be that the participants largely ignore ethical issues, or are even unethical. Whilst this could be true in some cases, experience interacting with the participants in the workshops would suggest otherwise. Another explanation may be that participants are not as familiar with considering ethical factors, given the ethical category is not typically included in more focussed forms of framework such as PEST or STEEPL. This explanation is borne out by examining the data in more detail, which reveals three dominant themes to the ethical factors identified (corporate social responsibility (CSR), natural environment, and resource exploitation), all of which are *also* identified in other STEEPLE categories. This suggests that firms do identify factors that can be considered ethical, but that these are recorded elsewhere, most often in environment, legal and social categories.

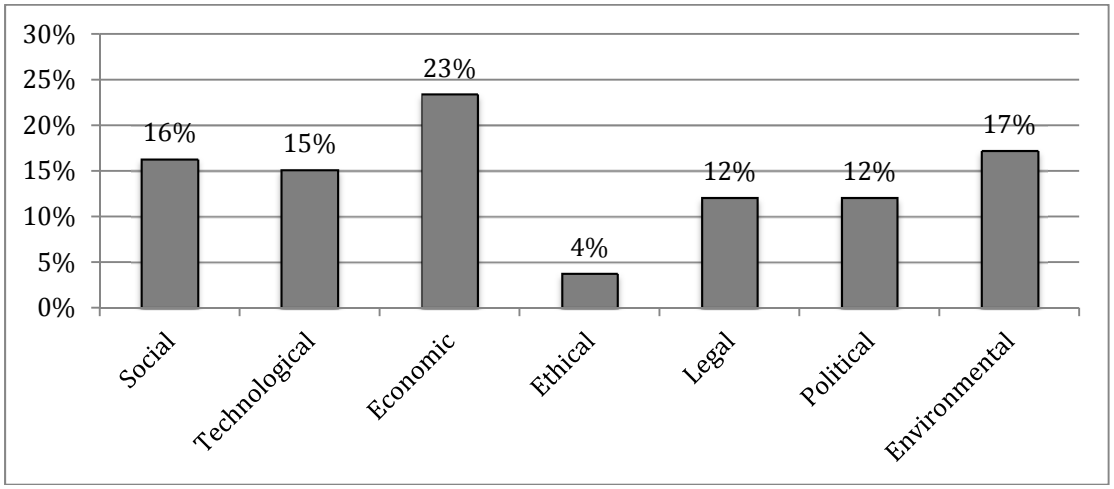

Figure 4 - Distribution of factors amongst STEEPLE categories

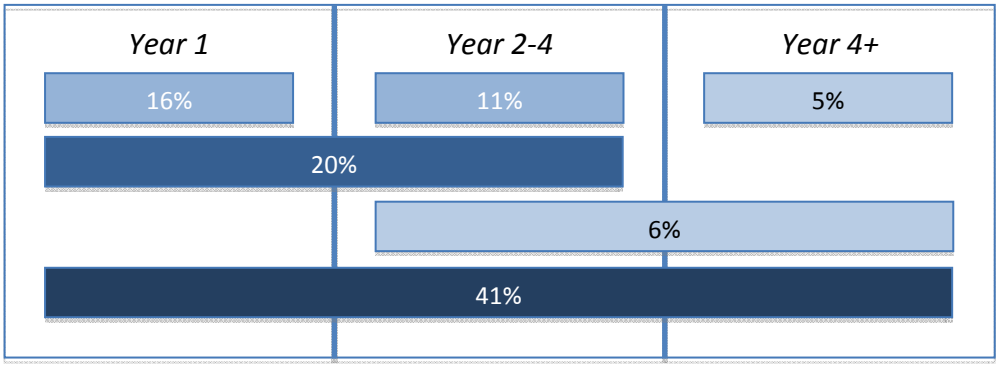

Figure 5 - Distribution of factors across three future time periods. It was most common to assign a factor to all three time periods, while participants rarely assigned factors to only the 4+ year period.

C. Time periods

The format of the environmental scan was such that each factor could be assigned to one or more of three future time periods. The distribution of factors among the time periods is visualized in Figure 5. The analysis reveals that two thirds of factors were assigned to multiple time periods, with 41% of the factors assigned to all three periods, 20% assigned to both the short and medium period, and 6% to the medium and long term. This finding most likely reflects uncertainty over long term factors, especially given the distribution of remaining factors assigned to only one time period. The long term 4+ year period was the least populated with only 5% of the factors, whilst the short term received over three times as many.

The number of time unspecific factors has implications for this study's conclusions, which is explored further in Section 4.3.

D. Types of Factor

The lack of distinction between terms used to describe external factors was highlighted in the review of literature, and in order to examine the degree of systems thinking in the brainstorms, the factors were categorized as trends, events/forces, uncertainties or requirements. Figure 6 presents the findings of this categorization and reveals the majority of factors can be considered as events and forces. Less than a fifth of factors were considered trends, with the remainder either uncertainties or requirements.

While Senge *et al.* [37] make no specific claims regarding the appropriate proportion of trends required to avoid 'knee-jerk' reactions, this analysis does present compelling evidence of a lack of systems thinking. Nearly a quarter (24%) of brainstorms identified no trends at all. These findings suggest the current STEEPLE brainstorming activity does not inspire systems level understanding of the external environment. This concern warrants more exploration, and so the next analysis explores the findings based on the four level scale to categorize factors based on their level of articulation.

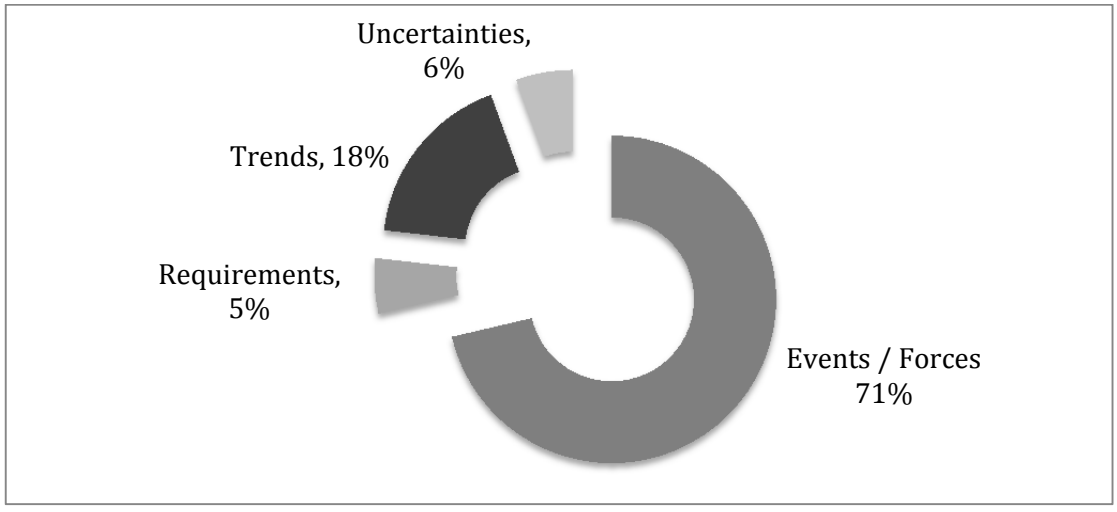

Figure 6 - Distribution of factors categorized as events / forces, trends, requirements or uncertainties. The majority of factors were deemed to be events or forces. The implications of this finding are significant considering the work of Senge et al. [37] into the danger of focusing on events over more complex patterns and structures.

E. Level of Articulation

As previously described, a four level scale was devised to quantify the articulation of participant's description of factors. Figure 7 presents the results of this categorization and reveals that few factors were considered to meet the highest articulation level. Nearly a quarter of factors were described with only a simple topic statement, for example 'oil', 'skills', or 'recession'. Over half of the factors were described with some further level of detail, for example: 'Recession – suppressed spending on alcohol". However only a quarter of the factors went further and described how the factor was changing over time, using adjectives such as 'increasing', 'declining', and 'constant'. Only 17 of the 886 factors, or 2%, quantified the change by quantifying the annual change, or providing a date by which some requirement is to be met.

Although the finding that only a quarter of the factors record information sufficient to describe a pattern of change provides further evidence of the lack of systems thinking, one crucial assumption limits the strength of this conclusion. It is assumed that the contents of the post-it note recorded the full extent of the conversation and knowledge of the participants. In reality, given the size of post-it notes and the time constraints in the workshop, the post-it notes are likely to provide only a summary of the discussion.

Nonetheless, the size of the post-it note does not prevent achieving the highest level of articulation. Conveying enough information to qualify for level 4 was possible even when limiting the description of the factor to less than eight words, as recommended by studies examining the most effective post-it notes for capturing other participant's attention [42].

F. Types of factors vary amongst levels of articulation

It is useful at this point to examine the relationship between the levels of articulation and the types of factors. The two variables are similar in nature but subtly different. While the levels of articulation refers to the level of quantitative detail provided, the type of factor distinguished between trends, drivers of change, uncertainties, and requirements. Examining the distribution of types within each level of articulation, Figure 8, shows that the two variables are not directly correlated, and that in fact the more articulated factors include the widest diversity of types, including events, trends and requirements. Level 1 & 2 factors are found to be dominated by events and forces, while at level 3 trends dominate.

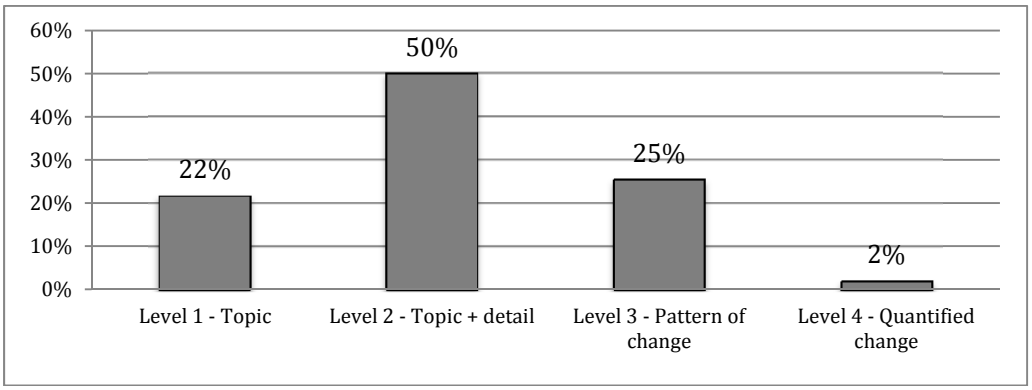

Figure 7 - Distribution of factors amongst four levels of articulation. The majority of factors are considered to include only a small amount of detail, a quarter describe how the factor is changing, while very few quantify the change.

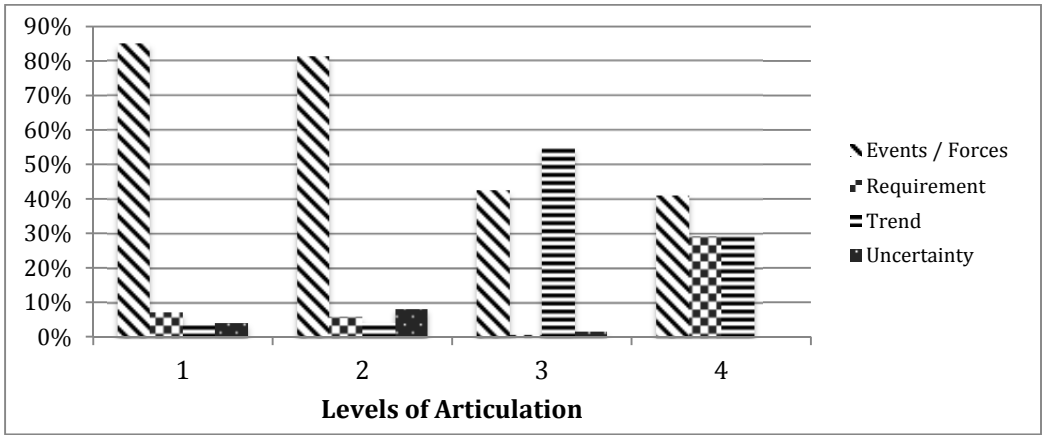

Figure 8 - Distribution of types of factors amongst the four levels of articulation. Events and forces dominate levels 1 & 2, while levels 3 & 4 also include trends.

The comparison between these two variables illustrates that the level of articulation is not directly related to the type of factor. The proportion of events and forces at level 4 shows that these can include complexity while still fulfilling the definition of an event or force, that is more immediate factors that can change from year to year and may be influenced by a firm's actions.

IV. ARCHETYPAL BRAINSTORMS

The findings thus far show there exists significant diversity among the brainstorms. Not only in the number and type of factors identified, but also the breadth of factors across the STEEPLE categories, and the range of foresight into the three future time periods. Some firms identified factors in many STEEPLE categories, demonstrating a broad knowledge of factors in the external environment, while others had more focus on just a few categories. Similarly some firms identified factors in the furthest time period of over four years, demonstrating foresight in their understanding of factors that could affect the firm in the future, while others concentrated their scanning effort on the short term. Taking these two dimensions into consideration, four archetypes are proposed to categorize brainstorms in terms of their STEEPLE breadth and range of foresight, see Figure 9. Each is named by means of an analogy:

- *Ostrich:* In these brainstorms, participants tend to identify factors in a limited number of STEEPLE categories, and few in the long term time period.
- *Polymath*: In contrast to Ostriches, Polymath brainstorms demonstrate a deep and broad knowledge of factors by identifying factors across many STEEPLE categories in both the short and long term.
- *Jack (of all trades):* Jack brainstorms exhibit a broad knowledge of factors in many STEEPLE categories, however do not demonstrate a 'mastery' in them by only identifying a limited number of long term factors.
- *Expert*: In contrast to Jacks, brainstorms are considered Expert when participants identify many long term factors but only in a limited number of STEEPLE categories.

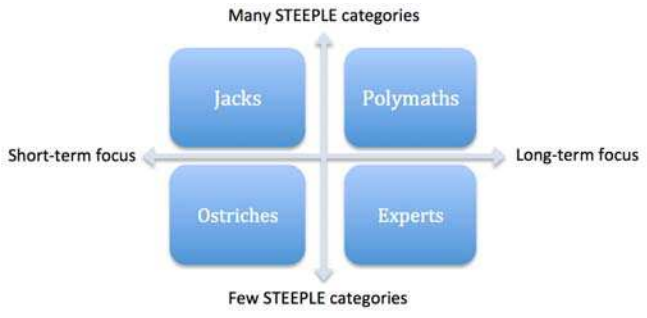

Figure 9 – Four brainstorm archetypes determined by the depth and breadth of factors identified. The vertical axis differentiates brainstorms based on the number of factors identified within STEEPLE categories. The horizontal axis differentiates brainstorms on the number of factors identified in the longest-term time period.

The archetypes were determined by evaluating variables in relation to the average for all the brainstorms analyzed. The average number of STEEPLE categories in which factors were identified was 5.3, while the average number of factors identified in the over four years period was 6. This differentiation resulted in the following distribution: 10 Expert, 12 Jacks, 22 Polymath, and 32 Ostrich brainstorms.

While this categorizing of brainstorms into four archetypes is novel, it is not to suggest that one archetype is superior to others. It may not be necessary for all workshops to have the depth and breadth of a Polymath brainstorm, indeed it may be a waste of valuable time and resources. However should the workshop participants or facilitator determine that a certain brainstorm type should be achieved, the archetypes provide a useful benchmark. It may be that participants struggle to identify long term factors, presenting the risk that the firm's strategy is short sighted. Similarly a brainstorm with too narrow a focus on certain STEEPLE categories may be at risk of ignoring changes in factors in previously unconsidered areas. In these cases, the facilitator may decide to devote more time to the brainstorm, or introduce other brainstorming aids.

The findings presented in the next sub-headings explore the relationship the archetypes have with the other variables already described. Significant differences are shown to exist between brainstorm archetypes across the variables, reinforcing the idea that facilitators should account for archetypes in order to tailor their design and approach to brainstorms.

A. Level of articulation differs between archetypes

The first insight comes from comparing the average level of articulation of factors identified by each archetype, Figure 10. The data reveals that factors identified in Polymath brainstorms are, on average, more articulate. While the difference is not large, there exists a recognizable improvement in the levels of articulation progressing from Ostrich through Jack, Expert and Polymath brainstorms.

This finding would suggest that there exists some relationship between the ability of participants to identify factors in many STEEPLE categories and in the long term, with the quality of the description recorded on the post-it note. One simple explanation for this finding could be the difference in time allocated to the activity. It could reasonably be expected that more time would not only increase the number of factors identified, but also allow time for more descriptive factors.

B. Different types of factors identified by archetypes

The second insight considered the types of factors identified by each of the archetypes. Figure 11 shows the relative proportion of factors identified by each archetype, and reveals that Polymath brainstorms identify a relatively higher proportion of trends compared to other archetypes. In Polymath brainstorms, 21% of factors are trends compared to 15% in Ostrich and Jack workshops, and 17% in Expert brainstorms.

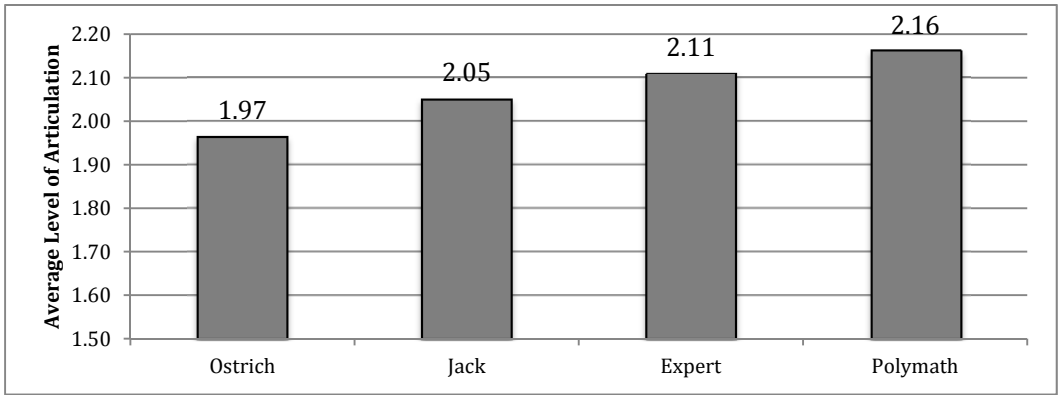

Figure 10 - Average level of articulation exhibited in each archetype. Although the difference is not substantial, there is a clear progression from the least articulate Ostrich brainstorms to Polymath brainstorms which tend to be the most articulate.

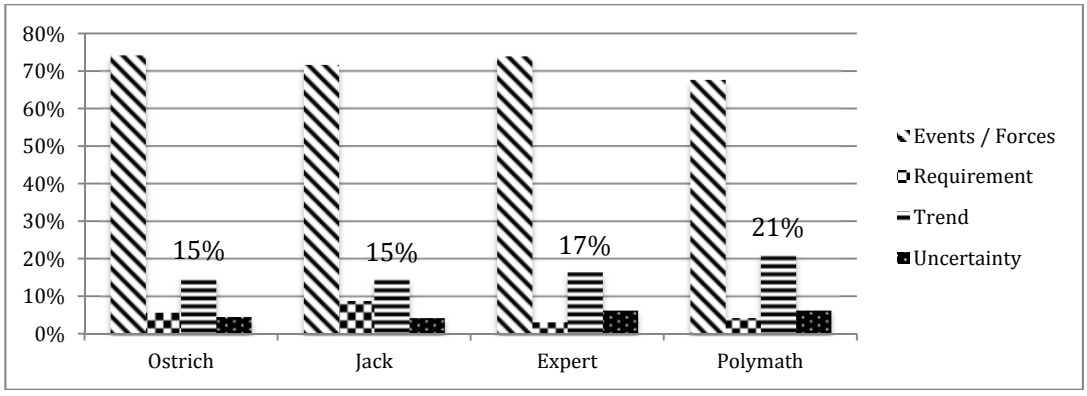

Figure 11 - Proportion of factor types identified by each archetype. Polymath workshops identify relatively more trends compared to other archetypes.

The finding confirms that those brainstorms in which long term factors are identified in many STEEPLE categories are also most likely to identify a higher proportion of trends than the other archetypes. Again, however, the difference is not large, and the simple explanation of more time allocated to the activity cannot be discounted.

C. Time specificity of factors

An intriguing correlation exists between the archetypes when considering the precision with which factors are identified across the time periods. The data reveals that Jack brainstorms are on average more specific when allocating factors to time periods. Figure 12 compares the specificity of the factors between archetypes, exposing that Polymaths and Experts are the least specific, typically indicating factors are important across 2.5 time periods.

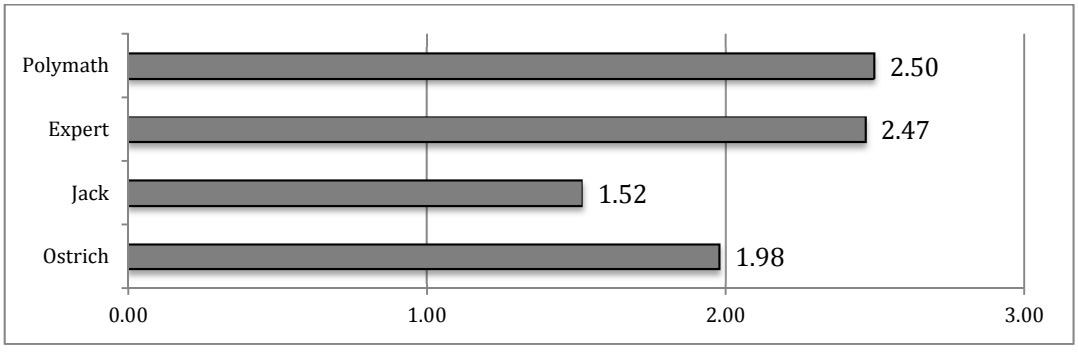

Figure 12 - Archetype specificity of factors to time periods, where higher values indicate factors are assigned to more time periods. Factors identified in Jack brainstorms were on average assigned to only 1.5 periods, compared to over 2 periods for expert and polymath brainstorms.

Unfortunately this finding brings into question the validity of the archetypes. The qualifying criteria for brainstorms to fall into both Polymath and Expert archetypes is the number of factors identified in the over four years time period, however it appears that as a result of factors with unspecific time periods, those brainstorms only appeared to have more foresight, but more likely are simply less time period specific. Further work is required to ascertain the implications of this finding, and is discussed further in the conclusions.

V. CONCLUSIONS

The study set out to analyze a large volume of data from 76 strategy workshops conducted with small and medium size manufacturing firms. The analysis concentrated on the outputs recorded from STEEPLE brainstorms with the aim to improve the understanding of the environmental scanning process. Participants brainstormed factors in the external environment, and recorded these onto post-it notes in facilitated workshops. This conclusion presents three contributions that arise from the analysis, and summarizes suggestions for future environmental scanning activities to improve long term strategic planning.

The first contribution is the set of findings from the analysis of the factors themselves. The rich dataset presented a unique opportunity to assess the distribution of factors amongst the STEEPLE categories, across the three future time periods, and to assess the types and articulation of factors identified by participants. The outputs of the brainstorms were analyzed in relation to these four variables, and despite a standard workshop process, the analysis reveals notable diversity in outputs. In some brainstorms, participants identified many factors broadly across the STEEPLE categories, while in others few were identified in a narrow focus. The analysis confirms the experiences described by the workshop facilitators that some participants struggle to identify factors in the external environment. The finding suggests that there exists the potential for the brainstorming process to be improved when participants struggle, as those firms that identify very few factors are at risk from unexpected changes in their external environment.

The second contribution is the novel evaluation of brainstorming data from the perspective of systems thinking. The depth of understanding of systematic trends and structures was tested by assessing each factor on a four scale measure of articulation, and categorizing each to distinguish events from trends, uncertainties and requirements. Analysis across both these variables suggests a general lack of systems thinking, which could be attributed to the participants themselves, or more likely the brainstorming process itself. The process is considered more likely to limit systematic thinking considering the significant diversity within the number of factors identified across the brainstorms, but the general lack of highly articulate factors and the focus on events. The implication of this lack of recorded detail is two fold. First the arguments made towards to the benefits of systems thinking in terms of competitiveness, but also the more practical consideration of due diligence. If the aim of the brainstorm is to capture the collective knowledge gathered in the room, then a poor record of the discussion on each factor limits the potential to review information and assumptions that contributed to the eventual strategy, should the strategy be revised in the future.

These suggestions for improvement must be tempered by the reality of the time constraints of the workshop. The facilitators face a significant challenge in completing all the activities within the half day workshop, and thus any improvement must be time efficient. Bearing this in mind, the third novel contribution is the identification of four distinct brainstorming archetypes. The archetypes can help workshop facilitators to recognize workshops in which participants struggle to identify long term factors, or to identify factors in a specific STEEPLE category. As part of further research project associated with this study, two workshop aids have been developed with the aim to help improve the brainstorming of long term factors or to broaden participants' thinking. The two aids are A4 sheets or presentation slides which can be quickly integrated into the workshop, each aiming to help broaden or extend participant's outlook:

- A summary of factors to consider that have been synthesized from factors identified in previous workshops.
- A summary of long term factors synthesized from the Future of Manufacturing report [43].

Given it may not be necessary for all firms to have the depth and breadth of a Polymath brainstorm, facilitators must apply their judgment in the use of these brainstorming aids. The two distinct summaries allow facilitators to decide whether the brainstorm needs to be broadened, extended, or both. Crucially the introduction of brainstorming aids has been found to be time efficient, helping firms identify factors in a short space of time. The validity of the archetypes and the benefit of the aids would benefit from further research, especially given the problem identified in the time period analysis in section 4.3. It may be that the archetypes are more clearly differentiated along other dimensions.

More generally, the findings and conclusions arising from this study would benefit from validation through further work. It would be worth considering the impact of variables unmeasured in this dataset related to the process and the firm. For example, while experience would suggest that participants tend to run out of ideas rather than time, the time available for each brainstorms should be measured. Similarly, recording firm specific data in further brainstorms would to help determine the influence of variables such as the number of participants, their seniority, and the maturity of the firm.

The nature of the qualitative data and analysis methods compel consideration of the study's limitations. First, it is worth considering that despite the data originating from workshops with a standard format, these were real workshops with countless variables affecting the output. Unfortunately many variables related to the process and the firm were

unrecorded, as already described. Second, the method of qualitative coding is well known to be influenced by researchers' biases. In particular for this study the categorizing of factor type and level of articulation. To limit such influence, factors were assessed and coded independent of other variables, and the results were discussed with practitioners to crosscheck findings with their practical experience. While these drawbacks can be expected to have had an impact on the findings, given the researchers' awareness of coding biases and the volume of data analyzed, the findings are believed to be strong enough to validate the limited conclusions drawn.

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Access to the underlying research data used in this publication, as required by EPSRC funding requirements, is restricted as it contains confidential information relating to the firms' strategy. In lieu of this data, the publication contains representative samples, and details the data analysis procedure in the methodology section.

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