Tool Fingerprinting: Characterising Management Tools

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***Abstract*--Academics have long been interested in understanding the nature of management tools such as roadmapping or scenario planning and to derive guidance on how they should be used. A typical approach to this challenge has been proposing rules and classifications to select and configure management tools. However, none of those proposed so far has been universally recognised. This paper argues that the characterisation of instances of tools implementation (tools-in-action) according to five key dimensions allows an easier and more robust approach to theoretically understand tools and to help practitioners with the configuration of toolkits. In order to highlight the advantages and the potential limitations of this characterization approach, a toolkit is examined.**

I. INTRODUCTION

Management tools and techniques such as roadmapping, portfolio management methods and scenario planning are considered useful for a variety business issues. In particular, they are deemed important to facilitate the management of innovation processes and increase the rate of development of new products [1]. The evidence of how management tools and techniques are adopted for innovation across the world is increasing (e.g. in Singapore [2], Turkey [3], the Netherlands [4]), but the data is still sparse as there is not yet an established way to review the uptake of tools.

Practitioners, on the other side, are confused by the increasing number of management tools and techniques available as scholars, managers and consultants develop ever newer ways to support firms. This is evident, for example, by considering the lists of existing management tools available in textbooks (e.g. [5]; [6]) and on websites:

- www.valuebasedmanagement.net
- www.ifm.eng.cam.ac.uk/dstools
- www.ifm.eng.cam.ac.uk/research/dmg/tools

Catalogues - i.e. collections of loosely grouped tools - are the most common attempt to put order in a challenging landscape, and to provide guidance to managers who need to learn, select, configure and combine various tools to respond to their particular business needs. These have been compiled by scholars and consultants, after a deep and long-standing observation of 'instances of tools-in-action' – i.e. approaches, methodologies, techniques etc. as deployed in the real word to support business needs. Several authors moved forward form simple catalogues towards the classification of tools, using criteria such as their visual appearance [7] or other dimensions such as their 'intrinsic' characteristics (e.g. qualitative-quantitative (e.g. [8]). The task for which tools can be used (e.g. innovation management tasks [9]) and/or the specific phase for each of these (e.g. 'mission statement' in strategic planning [10]) have also been used as criteria to classify tools. Tool catalogues and classifications in turn help practitioners to learn about management tools, choose the right one and configure it for their specific circumstances.

These processes are represented in Fig. 1 whereby, in one direction people work towards the abstraction of real examples of tools-in-action proposing generalizations and rules to use them, and in the other people use these abstractions to choose and implement tools, adapting them to the specific circumstances (application). In doing so, new instances of tools-in-action are generated.

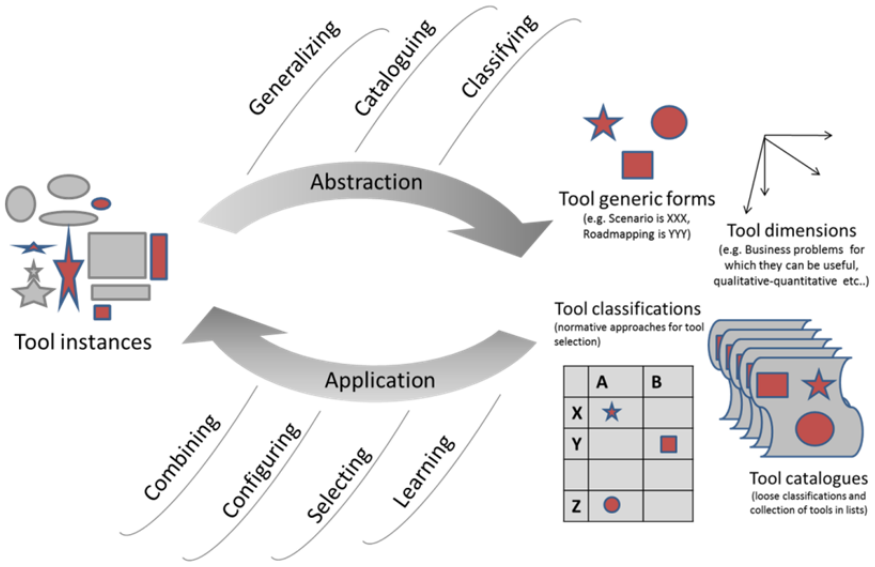

Fig 1: The cycle of abstraction and application of management tools.

As the abstraction processes originated from independent needs, epistemological backgrounds and/or the observation of a different set of tool instances, they have resulted in a proliferation of generic definitions, catalogues and classifications of tools. While these are equally valid, useful and supportable, they are not mutually exclusive, present inconsistencies and ambiguities and cannot provide a unique or 'universal' way to treat management tools. This has implications for both:

1) researchers who want to understand how tools are used and implemented, as the meta-analysis of the results of these studies is challenging, and
2) practitioners who need to learn, select and configure tools for their needs who might be confused and overwhelmed by the options available.

There is a need for a more stable platform to treat management tools [11] so that opportunities to configure and combine [12, 13] as well as integrate methods [14] might become easier.

In an attempt to address this issue, a route is proposed here which has its roots in the concept of family resemblances [15]. Wittgenstein made the point that certain phenomena (e.g. games in his example) do not have only *"one thing in common which makes us use the same word for all - but they are related to one another in many different ways"*. These similarities are characteristics known as 'family resemblances' (e.g. for games: "can be played in groups", "use cards", "use dice" etc..).

The route proposed here focuses on the definition of the family resemblances for the phenomenon 'management tools' and the subsequent characterisation of instances of tools-in-action (i.e. single instances of tools which have been configured in a specific way, for a specific purpose).

Accordingly, five dimensions (the family resemblances) were derived from the analysis of extant literature, which can concurrently describe any single instance of a tool (tool 'fingerprint'). These dimensions, we argue, provide the basis for a 'general' template for the analysis of each individual tool-in-action which could help both practitioners in the configuration of management tools / toolkits and academics in the analysis of trends in their use. A real case example of toolkit is analysed according to this logic to illustrate its practical advantages for both managers and researchers.

The remainder of this paper is structured as follows: firstly an overview of the literature on management tools as a whole is presented, showing some examples of the issues still unresolved. Following this, the new proposed approach is introduced and applied to an existing toolkit (as proposed and configured by Phaal et al. [13]), to show how this characterisation scheme can be employed both to assess existing tools and toolkits and to identify ways to improve and complement them with other tools. Finally, the paper concludes by reviewing the strengths and weaknesses of this approach for researchers and managers and areas for future research.

II. LITERATURE REVIEW

It has been shown that tools are useful for a wide variety of firms (manufacturing, high-tech, low-tech, service) for many management tasks. Hence, the research on management tools is not only important for innovation management but can be found scattered across many domains of management literature, including strategy and decision-making, foresight, innovation and technology management, new product development and operation management. Nevertheless, there is not yet a consolidated view of tools in any of them.

Across the management domains, the majority of papers on management tools relates to the analysis of single types of tools, either describing their general characteristics, theoretical foundations or methodological variants (abstraction), or by reporting case studies of single instances of tools-in-action (application). This literature is ever expanding. As an example, a special issue was recently dedicated to the advances and developments in scenario planning theory and application [16].

Instead, this paper fits with a relatively small part of the management literature across all domains which treats management tools as a group. These works, which mainly approach management tools in their generic form, also treat them in two ways:

1. **Reviewing their uses and implementation (Application)**. These studies use lists of generic tools, loosely classified, to survey the diffusion and adoption of management tools in various communities. For example, in the field of strategic management, many surveys have been carried out over the years to review how strategic planning tools are adopted in the Middle East (e.g. [17-19]), in Australasia [20], in the UK and other parts of the world (e.g. [21-23]). Others looked at how and why they are selected (e.g. [4, 8]).
2. **Proposing approaches to organise existing tools, explain their nature and attempt to resolve their complex variety (Abstraction).** These works discuss the nature of tools and attempt to understand how they can be viewed, combined and integrated [11-14, 24, 25]. Some of these scholars develop top-down classifications of 'generic tools' by using a particular characteristic of the tools as a criterion, for example a business tasks for which they can be used. These approaches are common (some examples are reported in Table 1) and respond to many of the needs of practitioners in that they provide order and structure in a very otherwise complex and diverse landscape. These classifications can be used as practical basis for training/learning and tool selection leading to the generation of new instances of tools (e.g. [5]). Despite their applicability and usefulness, the classifications of management tools are not universally valid, as discussed in the following sections.

TABLE 1: EXAMPLES OF TOP DOWN CLASSIFICATIONS OF TOOLS

Reference for classification	Domain	Number of tools and groupings	Criteria
[10]	General management	37 tools linked to 7 planning steps: - Mission statement, - Environment/competitive analysis; - Organisational analysis; - Planning assumptions; - Organisational priorities; - Action plans - Control systems.	Criteria for tool selection: Output, Input, Time, Resource requirements
[43]	Foresight	9 classes of tools: - Creativity, - Descriptive and matrices; - Statistical; - Expert opinion; - Monitoring and intelligence; - Modeling and simulation; - Scenarios; - Trend analyses; - Valuing/decision/economic.	Mixed criteria for classification: Tool purpose, Tool methodology, Tool type
[24]	Strategic Planning	28 tools in 4 classes based on the required level of preparation necessary to use each tool.	Classified by cluster analysis following a characterization approach based on generic toos: aim, level of preparation necessary.
[9] A similar approach is taken by Çetindamar et al. [5]	Technology and innovation management in general	10 classes of tools: - Knowledge management tools, - Market intelligence techniques, - Cooperative and networking tools, - Human resources management techniques, - Interface management approaches, - Creativity development techniques, - Process improvement techniques, - Innovation and project management techniques, - Design and product development management tools, - Business creation tools.	Criteria for classification: Business problems in the organisation
[32]	Technology and innovation management, New Product Development (NPD)	5 classes of NPD techniques: - Design techniques, - Organizative techniques, - Manufacturing techniques, - Information technologies, - Supplier involvement.	Criteria for classification: NPD process
[25]	Technology and innovation management in general	800+ matrix tools in 4 proposed four subclasses: - Matrices, - Grids, - Tables Scored profiles based on a combination of criteria: - Axes' categories (quantitative or qualitative, discrete or continuous) and the analytical purpose of the tool (e.g. evaluation of the relative position of options).	Criteria for classification: Axes' categories and the analytical purpose of the tool
[8]	Foresight	Classifying Foresight methods according to: - (Nature) Quantitative, qualitative and semi-quantitative - (Capabilities) Evidence or creativity based, expertise or interaction based	Criteria for classification: Nature of the method and capabilities required

A. Challenges encountered in management tool classifications based on business tasks

To create a classification involves organising a set of entities into groups based on criteria such as their nature, characteristics and possible relations [26]. 'Classifying' means to adopt a series of rules which allow the clear definition of classes so that the classified items belong to one group or another. The classes can then be linked by hierarchy.

Noy and Mcguiness [27] state that the first step in creating classifications is to define both the domain and scope the classification. In the literature there are differences with regards to the application domain in which management tools are considered. A great number of the studies on tools focus on strategic decision-making and technology and innovation management, although reviews and generalisations about tools in other management context can be found (see examples in Table 2).

TABLE 2. MANAGEMENT TOOL DOMAINS FOUND IN LITERATURE STUDIES

Domain	References
General management	[10, 34, 44, 45]
Technology and innovation management in general	[1, 3, 5, 11, 25, 33, 37, 46-48]
Front end of innovation	[49, 50]
New product development	[2, 4, 32]
Foresight	[8, 14]
Strategic planning	[17, 18, 20, 21, 23, 24, 30, 31]

However, as commented by Hidalgo et al. [9]:

> *'There is no one-to-one correlation between one firm's specific business problem and the methodology that solves it. As a result, it cannot be claimed that there is a closed set of developed and proven IMTs [Innovation Management Tools] for solving, one by one, the challenges faced by business as a whole. Furthermore, IMTs do not usually act in a deterministic, unique manner and the diversity of firms and business circumstances means that there is not a single ideal model for innovation management, although there are some principles of good practice.'*

In fact, the tools chosen to solve a business problem can be different depending on cultural factors linked to individual, organisational, industry and national influences.

Individual preferences were clearly demonstrated by Stenfors et al. [28] who showed that what constitutes an advantage of using a tool for one person is often a shortcoming for someone else. Gunn et al. [23] surveyed CEOs in UK and found that their background (e.g. personal education, business environment and tool training through universities or professional bodies) has an impact on the preference for one tool or another. Managers who received an academic induction to tools prefer those that have a theoretical basis, with those who have been educated in business schools showing a preference for particular tools such as the McKinsey 7 S framework. Scenario planning is often preferred by think-tanks and industry groups, whilst professionally trained managers favour SWOT analysis, benchmarking and balanced scorecards. The link between the uptake of tools and education has also been shown more recently by Jarzabkowski et al. [29].

Organisational culture also impacts on a tool's adoption, both positively by forcing the implementation of tools in agreement with management's preferences and negatively [30]. Nijssen et al. [4] found that tool adoption in Dutch firms in the context of new product development (NPD) depended on four factors: the level of interdepartmental communication, the number of stages in the NPD process, the company's NPD strategy, and the firm's prior adoption of tools and techniques. D'Alvano and Hidalgo [1] showed that innovation management tools are also associated to the level of innovativeness of the firm and that often activities and practices are more developed than the use of innovation management tools.

Glaister [31] argued that national culture impacts on the acceptance of tools outside the requirement for increased strategic activities. Glaister [31] hypothesised that UK firms adopt a wider range of tools than Turkish ones due to the greater familiarity with these instruments in the Anglo Saxon world, where tools are usually developed and implemented first. Similarly, Gonzalez et al. [32] observed that NPD techniques widely adopted in the US and proven to positively impact firms' performance in this context, do not bear positive results for Spanish firms. A potential reason for this unexpected result advanced by these researchers is that the implementation in Spanish firms might be incorrect or incomplete, due to the required changes in organisational structure and processes which may be countercultural to Mediterranean firms.

Therefore, it has been shown that it is improbable, if not impossible to identify univocal classification principles based on the business tasks they can be used for.

B. Challenges encountered in classifications based on the intrinsic characteristics of tools

A fundamental step in providing a classification is to define the objects to be classified. Across the literature it was noted that for management tools there are two problems with this approach, namely:

1) Identifying the boundary between management tools and everything else.
2) Defining the generalised unique underpinning 'essence' of the management tools and how they should be implemented.

One of the underlying issues is that the concept of 'management tool' is not clear. The existing definitions of management tools are overlapping and in practice, they cannot be easily used as a means to discriminate between tools and anything else. Past attempts to provide definitions show inconsistencies and disagreement. For instance:

- *Strategy tools can be described as concepts that assist strategic managers in making decisions* [21].
- A management tool is a *'document, framework, procedure, system or method that enables a company to achieve or clarify an objective'* [33].
- '*The term 'management tool' can mean many things, but often involves a set of concepts, processes, exercises, and analytic frameworks'* [34].

The strongest attempt to clarify the differences between all the terms used in the literature is provided by Shehabuddeen et al. [35] and later used by Phaal et al. [11]. Their taxonomy provides clear definitions and relationships between the terms most commonly found in the literature (*paradigm, system, framework, map, model, process, procedure, technique and tool)*. However, although strong in theory, their approach to define these terms might be hard to use in practice to elicit what is a tool and what is not. In fact, they also admit that: *'the boundaries between the various forms of representations and approaches are not distinct, and hybrid forms are indeed common'* [11].

This discrepancy in definitions is reflected in the types of tools considered by researchers whilst carrying out surveys of

TABLE 3: LIST OF TOOLS INCLUDED BY MORE THAN 50% OF STUDIES IN THE SURVEYS

		Rigby 2001	Adelaahyat 2008	Ghamdi 2005	Elbanna 2007	Khan 1992	TTFG 2004	Stenfors 2007	Gunn 2007	Hidalgo 2008	Lisinski 2006	Frost 2003	Clark 1999	Clark 1997	Glaister 2007	Chai 2006	Knott 2008	Gonzalez 2002	Nijssen 2000	Webster 1989	Frequency of tools in studies reviewed
	Appl. Domain →	Mgmt.	Strategy	Strategy	Strategy	Strategy	Forecast.	Strategy	Strategy	Innovation Mgmt.	Strategy	Strategy	Strategy	Strategy	Strategy	NPD	Strategy	NPD	NPD	Strategy	[%]
Name	Other names↓																				
Key/critical success factors analysis	Critical success factor		Analysis of key (critical) success factors	Critical success factors analysis	Analysis of critical success factors				Critical success factors		Key Factors for Success Analysis	Critical success factors	Critical success factors	Critical success factors	Analysis of “key” or critical success factors					Critical success factors	58
	Key success factor											Key success factors									
Competences/Capability and skills analysis	Critical skills analysis											Critical skills analysis									68
	Core Compe-tency	Core Compe-tency	Core capability/ compe-tency analysis						Core Compe-tency	Compe-tency Mgmt		Core Compe-tency		Core Compe-tency			Core Compe-tency				
	Core capabil-ity							Enterprise resource planning	Resource capability analysis			Company capability profile analysis			Core capabilitie s analysis		Org. capability assess.				
Benchm arking		Bench-marking		Bench-marking	Bench-marking				Bench-marking	Bench-marking		Bench-marking		Bench-marking		Bench-marking	Bench-marking			Bench-marking	53
Life cycle analysis	S-curve			Product life cycle analysis	Product lifecycle analysis	Product life cycle analysis	Sustainability analysis [life cycle analysis]	Life cycle analysis	Lifecycle analysis		Industry Life Cycle Analysis	Life cycle concepts							Product life cycle	Product life cycle analysis	53
Porter's five forces analysis	Industry structural analysis		Porter’s five-forces analysis	Porter's five-force analysis	Porter’s five-forces analysis				Porter’s five-forces		Porter's Five Forces Model	Industry structural analysis (Porter's vulnerability analysis - 5 factor models)		Industry analysis /Porters five-F’s model	Porter’s five-forces/ industry attractive-ness analysis		Five forces			Competit or analysis (Porter)	53
Portfolio analysis	Portfolio analysis		Portfolio analysis (e.g. BCG, growth share)	Portfolio analysis	Portfolio analysis					Project portfolio Manag.	Portfolio Matrix Analysis	Portfolio analysis		Portfolios	Portfolio matrices					Portfolio Analysis	63
	BCG matrix				Boston consulting group matrix or General Electric matrix	The growth share matrix (BCG)											BCG matrix				

Scenario planning	Scenario planning	Scenario Planning	Scenario Construct.		Scenario Construct. /analysis		Scenarios [scenarios with consistency checks scenario Mgmt.]	Scenario planning	Scenario planning		Scenario-based Analysis	Scenario planning		Scenarios	Scenario Construct.		Scenario and contingen -cy planning			Multiple scenarios	68
	Scenario simulation						Scenario-simulation [gaming; interactive scenarios]														
Stakeholder analysis	Stakehol. analysis			Stake-holder analysis	Stake-holder analysis	Directiona l policy matrix	Stake- holder analysis [policy capture, assumptio-nal analysis]		Stake-holder analysis					Stake-holder analysis	Stake-holder analysis					Stake-holder analysis	53
	Stakehol. mapping								Stakehol. mapping		Stakehol. mapping										
SWOT				SWOT analysis	SWOT analysis	SWOT analysis		SWOT analysis	SWOT		SWOT Analysis	SWOT, TOWS matrix		SWOT	SWOT analysis		SWOT			Situationa l analysis (SWOT, TOWS)	58
Value chain analysis			Value chain analysis	Value chain analysis	Value chain analysis			Value chain analysis	Value chain analysis		Value chain analysis	Value chains		Value chain	Value chain analysis					Value chain analysis	53

tool adoption. By comparing 18 studies, we could identify a condensed list of 218 tools. Table 3 represents a small percentage of these which appear in more than half of the surveys. The most commonly encompassed tools in these surveys are scenario planning and core competencies/capability analysis and they appear across the management literature. Competency/capability analysis is in about 70% of the surveys, in particular in the field of strategy, but is not present in all. It is missing in Kahan and Al-Buarki [36] and Stenfors et al. [28].

Hence, as surveys review different management tools and it is proven that there is a varied understanding of management tools and how they are applied [30, 37-39], the meta-analyses of these surveys' results are questionable. Although the original conceiver of the tool (of the catalogue or survey) might have a specific idea of what s/he means with any specific tool and what they are/are not, several contingent factors impact on the general implementation and configuration of tools in firms. Each tool (e.g. roadmapping) can be found in a number of differing manifestations (e.g. 'roadmapping' could be used for business, product and technology strategy) and can be implemented in various ways, for example qualitatively, using workshop-based approaches [12] or through software tools which employ more quantitative techniques (e.g. [40]).

Further, the 18 researchers of the surveys listed in Table 3 regrouped the tools/techniques in various ways. For example the Boston Consulting Group Matrix and portfolio analysis are two different entries for Elbanna [18], whilst they are treated together in other studies such as Aldehayyat and Anchor [17]. This implies that the affinities between tools are not universally accepted.

Taking into account the problems illustrated in developing an approach to treat generic management tools and the pragmatic need to understand how to configure and integrate tools, this paper attempts a new approach based on the characterisation of instances of tools-in-action. This approach tries to respond to the need for rigour in developing general design rules to navigate the vast complexity of tools in existence and to help to consolidate a universal basis to build toolkits comprising of tools which could be integrated and configured [11].

III. A CHARACTERISATION SCHEME FOR TOOL CHARACTERISATION AND CONFIGURATION

In consideration of the limitations of the approaches so far advanced, we propose a methodology which breaks free from many of the constraints previously listed.

This approach pays attention to particular cases of tools-in-action, rather than to their generalizations. It replaces explanatory generalizations of the whole tool with the description of *aspects* derived from their specific practical use in line with the theory of 'family resemblances' first advanced by Wittgenstein [15].

The advantage of this approach is twofold:

1) This characterisation step will lead eventually to a more robust classification of management tools. By being more objective in the assessment of tool instances it will be possible to develop a language across disciplines to compare tools and to collate coherent data of real instances of tools-in-action. Eventually, by applying robust methods (e.g. cluster analysis) it would be possible to develop a strong and universally accepted classification (See Fig. 2a).
2) The approach can also provide practical help to managers to improve the configuration of toolkits (see Fig. 2b), as illustrated by the case example in the next section.

The first step of this approach is a conscious decision not to be overly concerned with crystallising a definition or restraining the field of what we consider to be management tools at the outset. Speculatively, and deliberately against the mainstream tendency, we start from the proposition that we could consider to be management tools anything (concepts and their practical embodiment) that firms use to support their business needs.

The second step is to propose a multifaceted characterisation system based on the idea that several characteristics are concurrently needed to define each tool in an instance of use. This leads to a tentative list of tool's key dimensions (section 3.1). We obtained such a list via the analysis of past literature of management tools and for each of these dimensions we identified options which can describe their variability.

These dimensions were then included in a characterisation scheme that can be used to map and analyse each tool instance or application. The characterisation scheme was tested by analysing a real example (section 4). The analysis, which provided an overall 'toolkit fingerprint', is evaluated in section 5, discussing its advantages and limitations.

Description of universal characterization scheme for tools

So, what are the dimensions of an individual tool? The literature reviewed here covering the use of tools in companies suggests that a first tentative list seeking to describe an individual case application of a tool has five areas. These are discussed below and illustrated in the accompanying tables (Tables 4-8). They describe the:

1) Business task for which the tool is used (Application Domain – AD).
2) Tool aims (Functions – F).
3) Implementation techniques (IT).
4) Time frame and internal/external context considered (Business Aspects Considered - BAC).
5) Implementation metrics (IM).

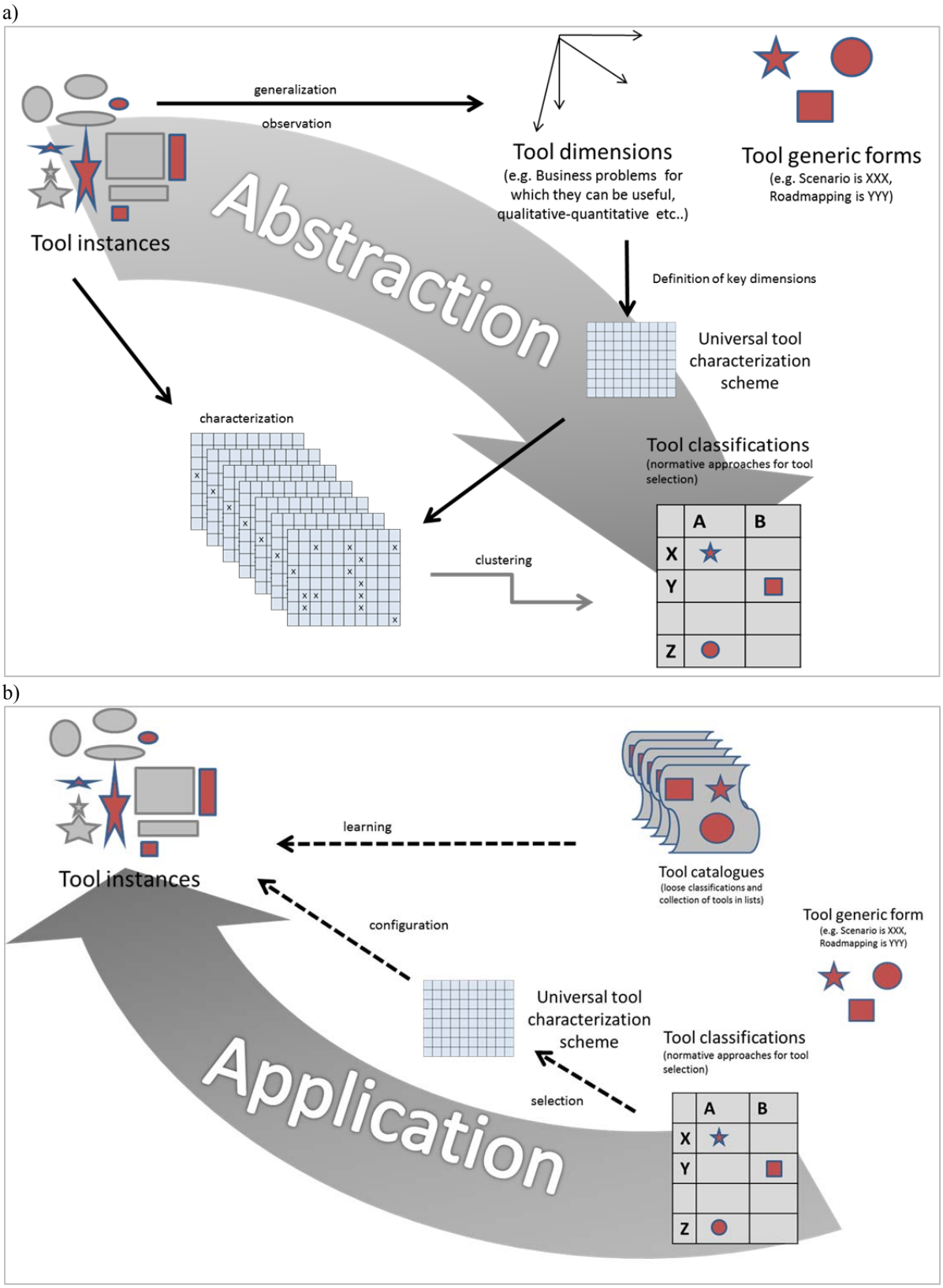

Fig. 2: a) Proposed process of abstraction and generalization of management tools, based on characterization and clustering; b) Practical process to make use of management tools with the proposed characterization scheme

A. Application Domain (AD)

Tools can be applied to a great number of management decisions. In the strategic management literature, following Stenfors et al.'s list [28], these can be divided in 'Corporate and business unit strategy' and 'Functional strategy'. These can be subdivided respectively as indicated in Table 4. In particular, the individual framework describing the corporate and business unit strategy was originally developed by Clark and Scott [22].

Here we stop at the strategic level and conveniently adopt an established strategic process, however other types of application domains can be added, such as knowledge management or human resources management tasks (see for example [9]).

B. Functions (F)

Tools are applied to help achieve certain aims, i.e. 'actions' (e.g. to compare different options, to quantify, to visualize etc.). We can assume that these represent the 'functions' of tools. An initial list from the literature is reported in Table 5, where an indication is also given of where these have been previously reported. We tentatively impose a hierarchy and organise these functions as primary, secondary and social functions of tools.

C. Implementation Techniques (IT)

Tools rely on techniques to be implemented as listed in Table 6. The techniques refer to the methodology which can be used, ranging from people-based qualitative techniques such as workshops, to numerical simulation and modelling.

D. Business Aspects Considered (BAC)

Each tool can be configured to encompass several aspects related to the business. We identified the following (see Table 7):

1) Time (from past, to present to short & medium- to long-term future);
2) Internal aspects ("resources" in Clark [21]);
3) External aspects ("operating and remote environments" in Clark [21]).

TABLE 4: LIST OF TOOL APPLICATION DOMAINS (AD)

Corporate & Business Unit Strategy [21, 22]	1) Audits	a. Current direction (where are we going?)
		b. Strategy audit (where are we now?)
	2) Trends	a. What are the trends? (micro and macro)
	3) Strategy development	a. Development of alternatives
		b. Evaluation of alternatives
		c. Selection of alternatives
	4) Strategy implementation	a. Communicate
		b. Monitor
		c. Control
Functional strategy [28]	5) Planning & production, logistics and purchasing	
	6) Quality and process development	
	7) R&D	
	8) Sales and marketing	
	9) Human resources	
	10) Process, (product) development	
	11) Project management	
	12) Finance	

TABLE 5: TOOL FUNCTIONS (F)

Primary functions of tools (linked with business aims)	1) Explore [38], activate [28], stimulate [51]	
	2) Evaluate (compare, contrast, classify) , select (rank, prioritize, filter) [22], normative [38]	
	3) Combine, integrate, align, identify links and path dependency [25]	
	4) Review, audit, identify gaps [20], test, validate	
	5) Forecast, predict, back-cast [43]	
Secondary functions of tools	6) Simulate, model [43]	
	7) Map, visualise, summarise [52]	
	8) Optimise, quantify [28]	
Social functions of tools	9) Learn [38]	a. Individual
		b. Organisational
	10) Plan [22]	a. Develop plan
		b. Implement plan
	11) Communicate and agree [28]	
	12) Coordinate [51]	
	13) Collect [51], Capture	

TABLE 6: TOOL IMPLEMENTATION TECHNIQUES (IT)

1) Interviews [43]
2) Workshops [43]
3) Numerical simulation [43]
4) Statistical analysis [28]
5) Narrative [53]
6) Modelling [20]
7) Role playing [54]
8) Analogies [20]
9) Heuristics [22]
10) Synectics [4]
11) Morphological analysis [4]

TABLE 7: BUSINESS ASPECTS CONSIDERED BY TOOLS (BAC)

Time horizon	1) Past
	2) Present
	3) Short to Medium-term future
	4) Long-term future
External aspects (Environmental analysis in [21, 22])	5) Competitors
	6) Suppliers and customers
	7) New entrants
	8) Policy and regulators
	9) Geography (markets)
	10) Sector
	11) Context (PESTLE)
Internal aspects (Organisational analysis [21, 22])	12) Market
	13) Product
	14) Technology
	15) Finance
	16) Corporate
	17) Human Resources

E. Implementation Metrics (IM)

Scholars agree that there is variability of implementation of tools across firms. A collection of the implementation metrics and their variability is represented in Table 8, which also indicates the original references.

IV. APPLICATION OF THE APPROACH TO THE ANALYSIS OF AN EXISTING STRATEGIC MANAGEMENT TOOLKIT

The characterisation scheme developed in the previous section, we believe, has the strong potential to help researchers to improve the understanding of tools (See Fig. 2a). The approach has also a very practical use to help managers configure toolkits (See Fig. 2b). To demonstrate its latter potential, it was tested by using it to analyse a specific instance of a toolkit. For the purposes of this analysis, we decided to use the toolkit described by Phaal et al. [13] comprising 8 tools overall, labelled TK1-8 (see Fig. 3).

TABLE 8: TOOL IMPLEMENTATION METRICS (IM)

	Metrics		**Variability**
Adoption [2]	1) Frequency of use [51]		Continuous – periodic - ad hoc
	2) Number of tools used [2]		Single tool – Combination of tools
	3) Intensity of use [51]		High – Low
	4) Thoroughness [2]		Following standard guidelines – not
	5) Codification [51]		Formal – Informal
	6) Diffusion [2]	a. How many users [51]	Everyone – Someone – No one
		b. Types users [23]	Public - private; Manufacturing - Services; Individual (desk based) - Community (consensus)
	7) Understanding [51]		Shared – Unshared
Resources required for adoption	8) Identification of tools	a. Search for new tools [28]	Easy – Difficult
		b. Identification through training [23]	Business schools and academic training – professional bodies and consultancies
	9) Use friendliness [2]	a. Learning of tool [2]	Easy - Difficult
		b. Implementation and maintenance of tool [28]	Easy - Difficult
	10) Familiarity with tool [22]		Don't know - Heard of - Know and use
	11) Cultural match	a. Top management support [4, 22, 32]	Yes - No
		b. Acceptance [51]	Enthusiasm - Resistance
Usefulness of tool [2]	12) Benefits specificity [2]		Specific benefits – Generic benefits
	13) Proven record [2]		Effective in other firms – Not
	14) Emphasis [31]		On tool process – On results

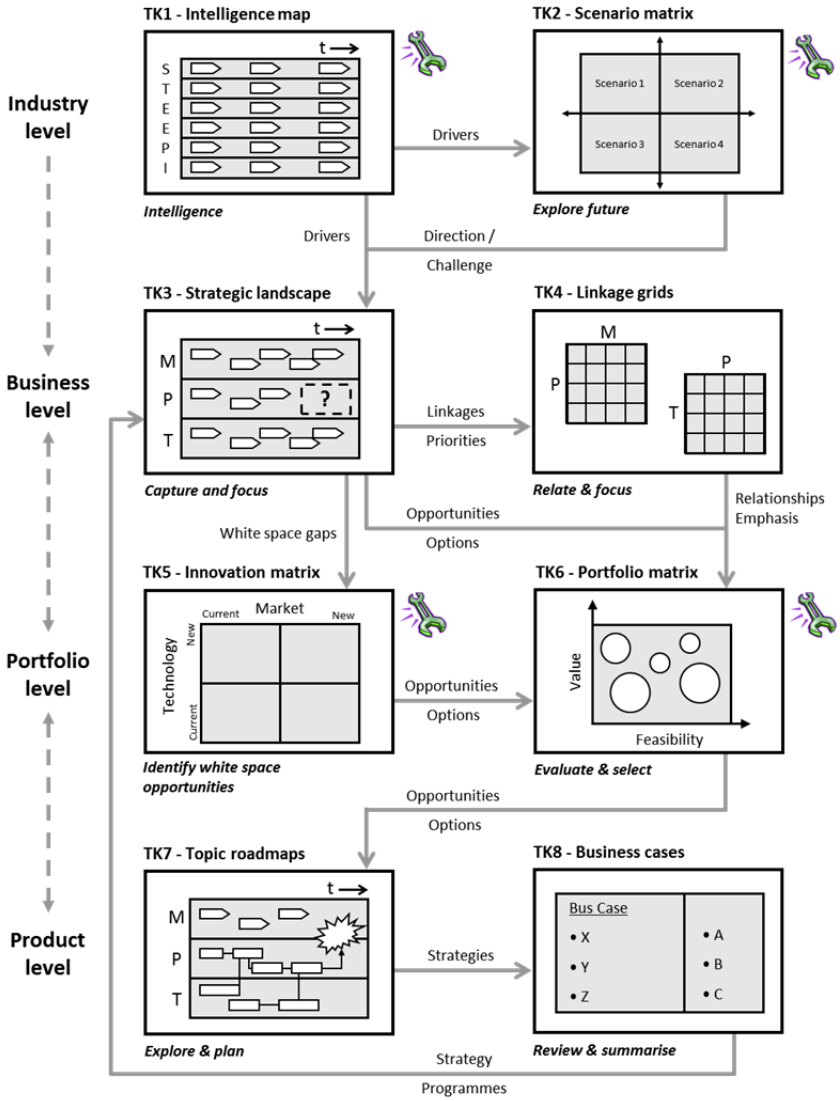

Fig. 3: Description of the toolkit as in Phaal et al. [13]

The toolkit was developed on the basis of more than 200 applications and a range of diverse sectors. Each tool component (module) is represented in its generic form, with the need to configure the toolkit for each particular application context. This modular architecture ensures flexibility, allowing additional tool modules to be added as required, enabled by the roadmapping platform at the heart of the toolkit. Phaal et al. [13] do not present data regarding the follow-on implementation of the toolkit in firms; nor do they present individual case studies (instances) of the application of the toolset (tools-in-action). This, we are aware, is a compromise which deviates from our original ambition to use the characterization scheme for tools-in-action only, but nevertheless still provides a basis for testing the proposed scheme for tools and toolkits in their aggregate form.

This example was chosen for pragmatic reasons, firstly because it illustrates the combination of a high number of tools (similar examples are rare in literature). Secondly as the paper [13] provides an 'objective' (in that it is written) basis for this analysis. This was an important determinant of our choice as we could criticise the literal description in Phaal et al. [13] and not the generic idea of the tools described (i.e. the generic potential that the tools or toolkit have, if configured, and applied differently to cover other aspects which were not explicitly described in the example used). Hence, the resulting comments are not to be taken as critiques of tools (e.g. of portfolio or roadmap) but only as an example of evaluation of the characteristics of the specific case as described in Phaal et al. [13]. Further, the authors have a detailed, first-hand knowledge of the toolkit in action, potentially helpful in the evaluation of the outcomes of this characterisation approach.

Characterisation of Phaal et al.'s [13] toolkit

The characterization is illustrated in Table 9 and described below. This snapshot or 'fingerprint' gives a quick visual overview of the coverage of the toolkit.

TABLE 9: REPRESENTATION OF THE TOOLKIT DESCRIBED BY PHAAL ET AL. [13] THROUGH OUR DIMENSIONAL ANALYSIS

Application domains (AD)

		Toolkit							
AD	**1a**			TK3				TK7	
AD	**1b**			TK3				TK7	
AD	**2**	TK1	TK2	TK3				TK7	
AD	**3a**			TK3				TK7	
AD	**3b**			TK3				TK7	
AD	**3c**			TK3	TK4	TK5	TK6	TK7	
AD	**4a**			TK3	TK4	TK5	TK6	TK7	TK8
AD	**4b**								
AD	**4c**								
AD	**5**								
AD	**6**								
AD	**7**					TK5	TK6	TK7	TK8
AD	**8**								
AD	**9**								
AD	**10**					TK5	TK6	TK7	TK8
AD	**11**								
AD	**12**								

Functions (F)

		Toolkit							
F	**1**		TK2	TK3				TK7	
F	**2**	TK1	TK2	TK3	TK4	TK5	TK6	TK7	
F	**3**			TK3	TK4			TK7	
F	**4**		TK2					TK7	
F	**5**		TK2						
F	**6**								
F	**7**	TK1		TK3	TK4	TK5	TK6	TK7	
F	**8**						TK6		
F	**9a**								
F	**9b**								
F	**10a**							TK7	
F	**10b**								
F	**11**			TK3	TK4	TK5	TK6	TK7	TK8
F	**12**								
F	**13**	TK1	TK2	TK3	TK4	TK5	TK6	TK7	TK8

Implementation techniques (IT)

		Toolkit							
IT	1								
IT	2	TK1	TK2	TK3	TK4	TK5	TK6	TK7	TK8
IT	3								
IT	4								
IT	5								
IT	6								
IT	7								
IT	8								
IT	9								
IT	10								
IT	11								
IT	12								
IT	13								

Business aspects considered (BAC)

		Toolkit							
BAC	1								
BAC	2	TK1		TK3				TK7	
BAC	3	TK1		TK3				TK7	TK8
BAC	4	TK1	TK2	TK3				TK7	TK8
BAC	5	TK1	TK2	TK3				TK7	TK8
BAC	6	TK1	TK2	TK3				TK7	TK8
BAC	7	TK1	TK2	TK3				TK7	TK8
BAC	8	TK1	TK2	TK3				TK7	TK8
BAC	9	TK1	TK2	TK3				TK7	TK8
BAC	10	TK1	TK2	TK3				TK7	TK8
BAC	11	TK1	TK2	TK3				TK7	TK8
BAC	12				TK4	TK5	TK6	TK7	TK8
BAC	13				TK4	TK5	TK6	TK7	TK8
BAC	14				TK4	TK5	TK6	TK7	TK8
BAC	15							TK7	TK8
BAC	16							TK7	TK8
BAC	17								TK8

Implementation metrics (IM)

		Toolkit
IM	1	
IM	2	
IM	3	
IM	4	
IM	5	
IM	6a	
IM	6b	
IM	7	
IM	8a	
IM	8b	
IM	9a	
IM	9b	
IM	10	
IM	11a	
IM	11b	
IM	12	
IM	13	
IM	14	

TK1: Market intelligence map: A template used to capture, assess and filter strategically important information (on external social, technological, economic, environmental, political and legal factors that has a high potential impact on future success, including industry, competitor and customer knowledge) as input to the strategic landscape.

Based on this definition, this tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy – Trends (AD2)
b. Primary Functions: Collect (capture) (F13), Filter and assess (Select) (F2), Map (F7)
c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Time: Present (BAC2), Short & Medium-term future (BAC3), Long-term future (BAC4), External – Context (PESTLE) (BAC 11), industry, competitor and customer knowledge (BAC5, BAC6, BAC,7, BAC8, BAC9, BAC10)

TK2: Scenario matrix: Matrix comprised of two axes, representing key external trends and drivers that have high levels of impact and uncertainty. Used either as an input to the strategic landscape to establish context and goals for a series of roadmaps (to explore), or at the end of the process to test the roadmap developed.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy – Trends (AD2)
b. Primary Functions: Explore (F1), Filter and assess (Select) (F2), Test (F4), Forecast and predict (F5), Collect (capture) (F13),
c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Time – Long-term future (BAC4), External – Context (PESTEL) (BAC 11), industry, competitor and customer knowledge (BAC5, BAC6, BAC,7, BAC8, BAC9, BAC10)

TK3: Strategic landscape: A tabular structure, based on roadmapping principles, to capture, assess and communicate prioritised market and business drivers, and priority product, service and technology developments, and associated resource requirements.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy – Audit (AD1a, AD1b), Trends (AD2), Strategy development – Development, evaluation and selection of alternatives (AD3a, AD3b, AD3c), Strategy implementation – Communicate (AD4a)
b. Primary Functions: Collect (capture) (F13), Explore (F1), Prioritise (F2), Review and audit (F3), Map (F7), Communicate (F11),
c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Time - Present (BAC2), Short & Medium-term future (BAC3), Long-term future (BAC4), External – Context (PESTLE) (BAC 11), industry, competitor and customer knowledge (BAC5, BAC6, BAC,7, BAC8, BAC9, BAC10)

TK4: Linkage grids: A set of two matrices used to formally map the relationships (link) between the layers of the landscape, mapping market to product, and product to technology. The approach is used to prioritise the importance of particular product and technology areas in terms of their contribution to market drivers and business strategy. Such information is input to the topic roadmapping activity, to ensure that these relationships are included in the more detailed roadmaps produced during this stage.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy: Strategy development –selection of alternatives (AD3c), Strategy implementation – Communicate (AD4a)
b. Primary Functions: Collect (capture) (F13), Prioritise (F2), Align (Identify links) (F3), Map (F7), Communicate (F11),
c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Internal – Market (BAC 12), Product (BAC13), Technology (BAC14)

TK5: Innovation (Ansoff) matrix: A matrix comprised of two axes (level of novelty of market application and level of novelty of capability (technology)). It is used to identify and generate potential innovation opportunities and position them on the matrix.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy: Strategy development –selection of alternatives (AD3c), Strategy implementation – Communicate (AD4a). Functional strategy: R&D (AD7), Process/product development (AD10)
b. Primary Functions: Prioritise (F2), Map (F7), Communicate (F11), Collect (capture) (F13)
c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Internal – Market (BAC 12), Product (BAC13), Technology (BAC14)

TK6: Portfolio matrix: Matrix comprising two axes (value (market size) and feasibility of an opportunity (technological and other capabilities)) used to assess the relative merits of potential innovation opportunities (to rank them).

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy: Strategy development –selection of alternatives (AD3c), Strategy implementation – Communicate (AD4a). Functional strategy: R&D (AD7), Process/product development (AD10)
b. Primary Functions: Prioritise (F2), Map (F7), Quantify (F8), Communicate (F11), Collect (capture) (F13)

c. Implementation Techniques: Workshop (IT2)
d. Business Aspects Considered: Internal – Market (BAC 12), Product (BAC13), Technology (BAC14)

TK7: Topic roadmaps: A tabular structure, incorporating layers representing market drivers, business strategy (corporate), product, service, system and technology developments and associated resources which are plotted against time. It is used to explore selected innovation opportunities, to develop outline strategies and associated actions (plan) and to identify key knowledge gaps and learning points.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Corporate and business strategy – Audit (AD1a, AD1b), Trends (AD2), Strategy development - development, evaluation and selection of alternatives (AD3a, AD3b, AD3c), Strategy implementation – Communicate (AD4a). Functional strategy: R&D (AD7), Process/product development (AD10)
b. Primary Functions: Explore (F1), Prioritise (F2), Identify links and path dependency (F3), Identify gaps (F4), Map (F7), Develop plan (F10a), Communicate (F11), Collect (capture) (F13)
c. Implementation Techniques: Workshop (IT2)
e. Business Aspects Considered: Time - Present (BAC2), Short & Medium-term future (BAC3), Long term future (BAC4), External – Context (PESTLE) (BAC 11), industry, competitor and customer knowledge (BAC5, BAC6, BAC7, BAC8, BAC9, BAC10). Internal – Market (BAC 12), Product (BAC13), Technology (BAC14), Finance (BAC15), Corporate (BAC16)

TK8: Business case templates: Customised templates used to capture the narrative associated with the topic roadmaps in a consistent and structured fashion. Aspects included: the type and scale of the opportunity (i.e. Product (service), technology); the market and competitive environment; the key product and service features, functions and performance; key and enabling technologies; financial and human resources; enablers and barriers; milestones and decision points (i.e. plans); and knowledge gaps. The templates include a summary section.

This tool can be translated into the dimensions listed in Section 3 as:

a. Application Domain: Strategy implementation – Communicate (AD4a). Functional strategy: R&D (AD7), Process/product development (AD10)
b. Primary Functions: Communicate (F11), Collect (capture) (F13)
c. Implementation techniques: Workshop (IT2)
f. Business aspects considered: Time – Short & Medium-term future (BAC3), Long-term future (BAC4), External – Context (PESTLE) (BAC 11), industry, competitor and customer knowledge (BAC5, BAC6, BAC7, BAC8, BAC9, BAC10). Internal – Market (BAC 12), Product (BAC13), Technology (BAC14), Finance (BAC15), Corporate (BAC16), HR (BAC17).

V. DISCUSSION

A. Analysis of the toolkit

This approach, based on characterisation, allowed us to analyse the toolkit example as presented in the paper and to make some observations and recommendations about other tools which might be included to complement the existing ones.

Beyond the lack of data on the implementation of the toolkit discussed in section 4, we could observe that the toolkit reviewed appears quite complete, covering most of the aspects highlighted in the dimensions checklist. However, some potential gaps or areas for potential improvement were identified via this detailed review. Such as:

- As expected by the definition, the toolkit is skewed towards the development of a strategy, rather than other application functions. However, some parts of strategy (i.e. implementation - strategy monitor (AD4b) and strategy control (AD4c)) are not supported explicitly in the toolkit described in Phaal et al. [13]. Some complementary tools could be inserted to cover for these tasks and support the social functions of 'learn' and 'coordinate'.
- The toolkit deliberately encompasses only tools which are delivered through workshops, following a particular philosophical stance [12]. As a result, the toolkit poses a great emphasis on the social functions performed by the tools of 'agree' and 'communicate'. As such, people should be aware that this sequence of tools favours these aspects but might have intrinsic biases induced by interpersonal dynamics [41]. Other tools and techniques might be inserted to mitigate for these biases. For example, the overall process of this toolkit might be complemented with tools which could help to quantify, model and simulate either as inputs to this sequence of tools or subsequently to develop and test its outputs further.
- The only business aspect not explicitly included in the configuration of tools reviewed is the 'past'. This is understandable considering that the toolkit is projected into the future and its key goal is to develop future strategies. However, without a revision of the past experience, there is the risk of neglecting to learn from the past and to overlook the firm's traditional biases and weakness during the development of the future strategy. Accordingly, tools to deliberately add this aspect could be encompassed.

B. Implications of the universal characterisation scheme and further work

This paper has attempted to push forward the current discourse on how to treat management tools by attempting to

develop a basis for a general characterisation scheme to review each tool/toolkit's specific instance along several key dimensions. These are: 1) Application Domain; 2) Functions; 3) Implementation Techniques; 4) Business Aspects Considered and 5) Implementation metrics.

We think this approach has strong theoretical validity in that it is based on a recognised philosophical approach of 'family resemblances' (Wittgenstein, 1953) and provides scholars with a more objective way to study tools and toolkits, compared to current approaches. It is, for example, useful for researchers interested in understanding the uptake of tools in firms in that we hope it could provide stronger ways to develop surveys whose results could be better compared and meta-analysed. Further, it could eventually provide the basis for an improved understanding and ultimately a more stable and classification of management tools. In fact, if this approach was to be applied systematically to evaluate a large number of instances of tools-in-action, a classification approach could eventually be carried out by cluster analysis (See Fig. 2a) in a similar way to that illustrated by Moherle [42] in his study on TRIZ. This type of analytical classification approach could lead to identify classes of management tools accepted more widely, based on the real dimensions of the tools in application, rather than on dimensions derived from generic descriptions (such as in [24]).

We think this approach can also be particularly helpful for practitioners. By using the tool-in-action approach, discussions could be avoided regarding what is meant by the words 'roadmapping' or 'portfolio management'. Similarly, speculations and assumptions with regards to what tools are meant to do could be avoided. Clearly seeing the fingerprint of each tool provides strong foundation for configuring and planning of toolkits and for communicating their benefits and characteristics. This analysis clarifies the strengths of certain tools compared to others, or their potential similarities, and could highlight which gaps need to be covered by additional tools. These benefits could be clearly important for consultants planning their range of services or for company managers who are trying to design and implement their innovation management activities.

Although theoretically strong and beside these advantages, we note that the characterisation scheme needs further development. Some potential weaknesses were highlighted regarding the initial list of dimensions developed from literateure, for instance:

1) There were similarities and redundancies in the tool configuration, in particular, across these three groups: TK1, TK2, TK3 – TK4, TK5, TK6 – TK7, TK8. However, these tools have been assembled empirically, addressing real industrial needs (applied and tested many times in real cases), and have been found to be complementary during company interventions. These nuances are not easily discernible through the scheme described in this paper which needs to be improved accordingly. We realise that although interesting as a start, the five dimensions which have been derived from the available literature, might not be complete or sufficient to describe the toolkit fully and further work should be directed to improve the lists developed for each dimension, checking that they are exhaustive and that prioritization and simplification is not needed to distil the unique traits of a toolkit.
2) The links (inputs and outputs) and the order described for the toolkit in Phaal et al. [13] could not be mapped via the analysis of these single dimensions. Further work should improve the tool characterisation scheme to encompass elements such as 'type of data needed', 'input' and 'output' such as suggested in Webster [10] and to refine and test the implementation characterisation dimension.
3) Last, but not least, we can see how the characterisation scheme proposed could be difficult to use in practice, due to the lengthy list of dimensions. This problem will become even more significant if the list of dimensions is destined to increase. An appropriate visualisation could be helpful to support the application of this approach and its uptake in practice.

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