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Why this paper might be of interest to Alliance Partners:

This paper explores the characteristics of service complexity. It identifies 76 potential factors that distinguish a complex from a simple service across the dimensions of: markets & products, technologies, production processes, administration & management, ecosystem. The paper introduces four different types of service complexity - identified based on the nature and the source of complexity - and uses these types to interpret and analyse the 76 potential dimensions of complexity. The paper proposes a detailed breakdown of the meaning of complexity in services, specifically targeted at supporting the development of tools and methodologies that managers can use to measure and manipulate the complexity embodied by their service businesses.

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Abstract

Drawing on a systematic review of literature, this paper analyses the characteristics of service complexity. In particular, the paper proposes an interpretative framework that maps the potential factors that make a service complex, and provides a general taxonomy to distinguish the characteristics of the complexity in a service.

Introduction

Defining and understanding complexity has long been of interest to scholars from a wide range of disciplines. Although the term has been used to mean different things in different circumstances, the notion of complexity has been seized upon by looking for common properties among diverse kinds of systems, including physical, biological, and social systems. In relatively recent times, complexity thinking and complexity research have started to be applied also to management science (Robertson, 2004). It has indeed become almost commonplace to observe that increasing levels of complexity are being incorporated into organisations. The process is seen as a main challenge by managers and researchers, and is described as involving corporate as well as governmental organisations (Keeney, 1979; Child et al., 1991). This paper focuses on the specific context of firms and management, and on the complexity that arises around a particular type of business activities: the provision of services.

There are three main reasons for this focus. First, the authors of this paper are actively studying the decision of many manufacturing firms to integrate increasing degrees of service contents into their offerings, the so-called 'servitization of manufacturing' trend. Service complexity is often cited in the field as a factor that importantly affects the rewards and challenges associated with the adoption of a servitization strategy (Gebauer et al., 2008; Benedettini and Neely, 2010; Raddats and Easingwood, 2010); yet there is no clear definition of what a complex service is. Authors have used their independently developed distinctions between simple and complex services, and very limited attempts have been made at either conceptually or empirically substantiating the proposed classifications. Second, definitions of complexity commonly used in the organisational domain are often tied into the concept of a system. The logic of complexity science is straightforwardly applied, which suggests that a system is complex when it consists of many parts that interact in ways that heavily influence the probabilities of later events, often resulting in emergent properties (e.g. Nunes Amaral and Uzzi, 2007; Sargut and Gunter McGrath, 2011). This perspective appears to the authors of this paper as being too narrow to capture the meaning of complexity in services. Clearly service systems can be very large and have emergent properties (e.g. metropolitan hospitals, public transport in large urban areas, provision of utilities). However, it must be considered that complexity in services can originate from many other sources than the service system. Third, the service-dominant (S-D) logic is becoming a mainstay in management research. Within the S-D logic, service represents the common denominator of all exchange processes; service is what is always exchanged with products becoming mere vehicles for service provision (Vargo and Lusch, 2004; Barile and Polese, 2010).

Thus, considerations regarding complexity in services may be usefully extended to other areas of the organisation and support widespread complexity management.

The purpose of this paper is to provide a thorough representation of the meaning of complexity in service contexts. In particular, the paper seeks to identify and integrate the various factors that differentiate a complex from a simple service within a coherent framework appropriate for both academic and empirical research. The structure of the paper is as follows. First, in Section 2 the research methodology is detailed and the results of the data collection are organised and presented. By collating this information with further input from the literature, Section 3 develops the theoretical formulation of the service complexity framework. Section 4 then illustrates how the framework works in practice. Finally, Section 5 concludes the paper with final remarks and directions for future research.

Research approach

The study was grounded in a literature review, which was aimed at a comprehensive appraisal of current knowledge on the potential aspects that contribute to service complexity. In order to achieve a rigorous assessment of these aspects, a systematic review approach was adopted. The systematic approach entails following a particular stepwise process to conduct the review, and devising a review protocol that provides an explicit description of the principles, criteria and methodology applied at each step. The review strategy is necessarily subjective, due to the need to adapt the general systematic approach to the particular requirements of the subject study; yet use of a replicable, scientific and transparent process makes the search more objective and less biased compared to the traditional narrative approach.

The literature was explored by posing the following research questions: 'How can complexity in services be defined? What would be a list of the potential factors that make a service complex?' The purpose of these questions was to guide the review, that is the definition of the search strategy for the identification of relevant studies, the subject areas interested by the search, the sources of material accessed, and the criteria for inclusion and exclusion of studies in the review.

The focus of the review was to capture concrete and practical features of service complexity rather than reviewing and discussing theoretical definitions of the concept, as pragmatic features build upon theoretical definitions and can, in addition, embody empirical evidence. Thus, the following domains were sampled: product design, marketing, operations management, organisational design, information processing. Other disciplines that have studied complexity, but are not directly linked to the scope of the review, like physics, biology, social sciences, politics, chemistry, geology, were excluded. On the same basis, general-level discussions of complexity provided by chaos theory, complexity theory and complexity science were also excluded.

Potentially relevant publications were identified by constructing search strings that combined the keyword 'complex*' with a different range of terms and phrases. Wildcard symbols were often used to reduce the number of search strings since, for example, 'complex*' could return hits for 'complex', 'complexity' and 'complexities'. The search first focused on servitization research as the most explicit source of material referring to the service complexity experienced by manufacturing firms. Database searches were carried out by combining the keyword 'complex*' with the terms 'servitiz*' (as well as alternative spellings, i.e. 'servitis*', 'serviciz*' and



'servicis*'), 'product-service*' and 'service* AND manufactur*'. Further search strings were constructed to investigate the types of services more commonly offered by manufacturing firms, based on the key phrases 'product-support service*' and 'industrial service* OR business service*'. In parallel, the mainstream service field was also explored. An initial search was run for the keywords 'complex*' and 'service*' appearing within two words of each other. Supplementary searches focused on specific areas where, according to their knowledge of the field, the authors believed that complexity may be grounded. Here, search streams were created that associated the generic search terms 'service*' and 'complex*' with particular keywords indicating the area of interest. This meant that, for instance, the two search strings (i) 'complex*' and 'service* process*' and (ii) 'process* complex*' and 'service*' were employed to search for papers that defined complexity relative to the service process. Analogous search strings were constructed based on the area keywords 'system* OR network*', 'production OR delivery', 'market*', 'environment*', 'techn*', 'ecosystem', 'information', 'pric*', 'value', 'transaction*', 'structur*', 'customer* OR client', 'product*', 'supply', 'organisation* OR organization*', 'task*', 'buying situation'. In addition, the search terms 'task complexity', 'product complexity' and 'supply chain complexity' were searched for in combination with 'review'. A total of 45 search strings were identified. These were submitted to a panel of academics from different disciplines (performance measurement, operations management, strategic management, industrial engineering, marketing, service management), which was formed to validate the review protocol.

Four databases were consulted – Business Source Complete (EBSCO Host), Scopus (Elsevier), ABI/Inform Complete (ProQuest) and Web of Knowledge (Thomson ISI) – ensuring coverage of a leading collection of scholarly journals, periodicals, and quality web contents. The searches excluded feed news from sources searched within the ABI/Inform database (as this source was returning a very large number of hits and these were clearly not relevant to the review) and included all available sources for the other databases. The searches were limited to the abstract field. Abstract search option was not available for the Web of Knowledge database and therefore, for this particular database only, the topic field had to be used, which includes abstract, title and keywords.

The searches yielded a total of 26,989 hits. This large number was inevitable given the general nature of some of the search terms. For example, a large number of studies emerged from the keyword search on the grounds that they tackled some complex scenario or some inherently complex problem, yet such studies were clearly not relevant to the review. The citations identified were first analysed through searching for the word 'complex' within titles and abstracts. In many cases, this was sufficient to identify lack of fit with the review objective. If there was some doubt, the full paper was downloaded. Particular attention was devoted to those studies that focused on testing the impact of service complexity on some dependent variable (e.g. customer choices, costs, organisational practices) as these papers had necessarily adopted some operational measure for service complexity. A total of 889 unique papers were downloaded and reviewed. Judgement about inclusion was made by means of assessing if the papers provided an explicit definition of complexity. By virtue of the distinction between products and services often being blurred (e.g. Araujo and Spring, 2006), papers from the product-related literature were considered akin papers from the service field, provided that they proposed types of complexity that were applicable also to the service domain. As the focus of the review was to capture as many views as possible around service complexity, rather than tracking the most relevant evidence on the subject, a quality appraisal, as used in previously

published systematic reviews, where the value of references is determined by assessing the quality of the research methodology, was felt not to be appropriate in this case. In line with Birkin and Bowman (2007), quality was instead established in relation to the clarity of the contribution of the papers to the review questions and, hence, apart from such aspects as robustness of the research strategy or significance of the results. Eighty-four papers were identified at this stage. Furthermore, 21 papers were also deemed to be relevant, which, although not explicitly defining the concept of complexity, clearly assumed a specific meaning for it. These were, however, collected in a separate list of references and ranked less highly in terms of relevance. Cross-referencing yielded other articles, 18 of which were identified as suitable for inclusion. Finally, 4 papers were manually included in the review based on references previously accessed by the authors, bringing the final list to 127 papers.

Given the nature of the criteria used to select these papers, each of them contained the indication, either explicit or implicit, of some operational definition of complexity that could be applied in service contexts. The definitions were captured from the text and collected in a unique document. If two or more papers had adopted the same definition of complexity, the definition was clearly not repeated in the document, but a map was outlined indicating the papers that had adopted each definition. On the contrary, in the case where one paper introduced a definition of complexity that combined or built upon complexity factors suggested by other papers, a distinct record was introduced in the document for the paper. The definitions were ordered in the document, so as to bring near to one another those that focused on similar areas of complexity, and were examined in turn. The examination consisted of drawing those factors that were used in the definitions to characterise complexity. One or, if appropriate, multiple complexity factors were drawn from each definition. The factors were sometimes rephrased in order to increase clarity and avoid overlaps. However, the possibility of overlaps between factors was in some instances accepted, as this was considered preferential to adopting general factors capable of absorbing the overlaps. In the end, this process led to the identification of 76 potential factors (or dimensions) of service complexity.

What was needed at this stage was a tool to group together and organise the various dimensions of service complexity emerging from the literature, so that these could be appropriately compared and contrasted. The approach followed was to adopt the analytical tool proposed by Von Tunzelmann (1995). Von Tunzelmann developed a tool for business processes analysis based on assuming four categories of functions that characterise a firm, namely (i) markets and products, (ii) technologies, (iii) production processes, (iv) administration and management. While products and technologies are identified as the two main functions of the firm, production and administrative processes are necessary to relate technologies to products: the former for actually producing the products, and the latter for ensuring the viability of operations. We obviously interpreted products in von Tunzelmann's categorisation as both material artefacts and service products. In addition, we propose a further function that characterises the existence of a firm. This is the ecosystem, which we defined as the wider network of stakeholders that influence the way the firm creates and captures value through the provision of products or services. All of the 76 potential complexity factors fell within the 5 categories above. Figure 1 proposes the potential complexity factors identified from the literature specified in terms of these five categories, a first notable contribution of this paper to research on service complexity.

Figure 1. Service complexity factors emerging from the literature

Markets and products

1. The service is highly individual.
2. The service has low commodity content.
3. The service is offered according to many differentiated options.
4. The needs and wants for the service are very heterogeneous among the firm's customers.
5. The customer requirements for the service are difficult to interpret.
6. The customer requirements for the service are subject to change.
7. The timing and level of customer demand for the service are uncertain.
8. The customers tend to look for new offerings for the service all the time.
9. The service delivers many different functions / addresses a wide range of customer requirements.
10. The service delivers sophisticated functions / addresses sophisticated customer needs.
11. The service is infrequently purchased.
12. The service has a short life cycle.
13. The service has a high risk of obsolescence.
14. The service contains a high number of sub-services.
15. The service contains very heterogeneous sub-services.
16. The service contains highly interrelated sub-services.
17. The service involves an ongoing interaction between the customer and the service, so that the customer can make decisions.
18. The service requires a high degree of customer knowledge.
19. The outcome of the service is difficult to predict.
20. The outcome of the service is difficult to monitor.
21. The service is affected by information asymmetry between the client and the service provider.
22. The service organisation offers many different services.
23. The market for the service is highly competitive.
24. The service is new.
25. The service entails some innovation that is perceived as being difficult to understand and use.
26. The process of service innovation involves suppliers and customers.
27. The service is delivered at many different locations (geographical dispersion of the firm's domain).
28. The service is delivered across multiple channels.
29. The service is offered to many different groups of customers (heterogeneity of the firm's domain).
30. The customer will purchase the service based on credence qualities, i.e. supplier reputation and relationship with supplier.
31. The service is difficult to understand for the customers.
32. A large amount of information is needed to specify the attributes of the service in enough detail to allow potential buyers to make a selection.
33. The customers lack the technical knowledge to evaluate the service.

Technologies

34. The service is offered according to sophisticated options, e.g. with the purchase of new technology, more advanced infrastructure.
35. The service uses new and sophisticated technologies.
36. The service uses rapidly developing technologies.
37. The service delivery involves several different technologies.
38. The service incorporates a variety of distinct knowledge bases, skills and competencies.

Production processes

39. The service requires a high number of interactions between the service provider and the customer during the service delivery process.
40. The service involves a high interrelation of activities taking place between the service provider and the

customer during the service delivery process.

The service requires the customers to be in the system for a high percentage of the time it takes to serve them, i.e. high customer contact.

41. The service needs to be carried out cooperatively with the customers, i.e. high customer involvement.
42. The service is delivered in a process that is to be tightly integrated into the business processes of customers (industrial services only).
43. The service is delivered through assembling sub-services offered by a pool of seller candidates, which provide complementary as well as substitutive services.
44. The service is delivered through a network consisting of a complex web of direct and indirect ties between various actors, all delivering value either to their immediate customer or to the end customer.
45. The delivery network for the service comprises actors each of whom might be involved with multiple other delivery networks, each with their own demands.
46. The delivery network for the service involves different parties that depend on each other to accomplish their tasks.
47. Material and data flows exchanged between partners in the service delivery network are affected by uncertainty.
48. A high number of steps are required to produce the service.
49. The service is produced through a high number of steps.
50. Highly interrelated steps are required to produce the service.
51. The service is produced through highly interrelated steps.
52. The service process requires intensive input of human labour.
53. The input of human labour in the service process is predominantly intellectual.
54. The cost and quality of the service, i.e. the relationship between input and service output, are affected by changes in the environment.
55. Tolerance on the time it takes to produce the service is low.
56. The service requires a variety of inputs.
57. The provision of the service involves use of shared resources.
58. Operations relative to the service involve a high number of people.
59. The process of service production may need to adapt non-routine procedures and methods.
60. The service does not rely on established bodies of knowledge, yet it requires new solutions.
61. The provision of the service is based on judgement as the service involves tacit, as opposed to codifiable, information.
62. The service can be produced according to a number of alternative paths.
63. The service involves a great deal of specialised knowledge to undertake the service tasks.
64. The production and delivery system for the service involves a high number of feedback loops.
65. The service is difficult to provide in a cost-effective and efficient manner.

Administration and management

66. The service requires intensive investments.
67. The service has a high cost.
68. The service involves complicated commercial arrangements, such as stage payments, penalty clauses, and performance bonds.
69. Management takes responsibility for the entire task of providing the service through a performance-based contract.
70. The contractual relationship between the service provider and the customer is highly individual.
71. A variety of pricing structures are available for the service or different pricing structures exist for different customer groups.
72. The pricing structure for the service changes frequently.

Ecosystem

73. The value network of the service comprises a high number of actors with which the service provider has to manage a relationship.
 74. The service involves conflicts between multiple stakeholders.
 75. The service is subject to a pressing regulatory environment.
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Framework development

The purpose of the framework sought in this paper was to define conceptual directions that could enable interpretation and analysis of the various dimensions of service complexity presented in Figure 1. Based on the expectation that a core set of interrelated assumptions regarding the meaning of complexity should underpin the different approaches to service complexity embodied in the literature, the investigation focused on generic definitions of complexity. An obvious starting point for developing the framework was hence to look in a dictionary. The *Oxford English Dictionary* defines as 'complex' something (i) '*Consisting of many different and connected parts* (e.g. a complex network of water channels)' or (ii) '*Not easy to analyse or understand; complicated or intricate* (e.g. a complex personality)'. An analysis of the literature revealed the presence of numerous formal definitions of complexity built around this perspective. In particular, Jacobs (2008) identifies complexity as a property that stems from the characteristics of multiplicity (high number of components) and relatedness (high degree of interconnection between components). Further, Jacobs recognises the presence of a third element of complexity, that of difficulty in understanding (high level of resources, mental or otherwise, required to achieve comprehension of the item in question). However, his line of reasoning is that difficulty in understanding is a consequence of multiplicity and relatedness, and therefore it does not come into defining principles of complexity. Wang and Tunzelmann (2000) and Özman (2007) propose that, in scientific fields, complexity is manifested by breadth and depth properties. While breadth complexity is the case of a subject that involves many different areas, depth complexity refers to a subject that is analytically sophisticated. Breadth and depth properties are similar, respectively, to the characteristics of multiplicity and difficulty in understanding discussed by Jacobs (2008). However, a main difference is that complexity of depth is not necessarily an outcome of complexity of breadth, i.e. a subject can be analytically sophisticated, and hence complex, even if its development does not involve the investigation of a wide range of areas. Nevertheless, complexity of breadth is more concerned with the heterogeneity between subject areas rather than the sheer number of subject areas involved.

A first parameter for analysing the practical dimensions of service complexity emerging from the literature was defined in the framework based on the conceptualisations of complexity introduced above. The parameter entailed the distinction between two types of complexity: *complicatedness* and *difficulty*. Complicatedness was defined as embodying both properties of multiplicity and relatedness discussed by Jacobs (2008). The opportunity of adding diversity as a third dimension of complicatedness was also considered. However, because the meaning of diversity appeared to be implicitly represented by multiplicity, this was eventually avoided. Complicatedness may lead to difficulty, which includes, but is not limited to, difficulty in understanding and sophistication. Specifically, difficulty was associated with significant material or immaterial resources being required/employed in order to achieve a desired outcome. In addition, difficulty was also intended to reflect uncertainty, which was defined in the framework as inability to predict accurately or rely on something. The approach of Wang and Tunzelmann (2000) and Özman (2007) was followed in assuming that difficulty is not necessarily a function of complicatedness. In this regard, in the interest of avoiding overlaps between types of complexity, we prioritised complicatedness over difficulty – i.e. it was decided that, in those instances when difficulty is a reflection of complicatedness, the relevant property had to be only complicatedness.

A second parameter of analysis was introduced in the framework to distinguish between *general complexity* and *individual complexity*. General complexity was defined as complexity intrinsic to the service. As a consequence, in the case of general complexity, the same level of complexity is presented to all the firms that offer one particular type of service. On the contrary, individual complexity was defined as a type of complexity emerging around the individual firm. Hence, individual complexity results in the different levels of complexity faced by different firms that offer the same type of service. In addition, individual complexity may be due to either: (i) decisions made by the firm; or (ii) characteristics of the environment where the firm operates.

Both general and individual complexities are intended to embody objective complexity. This is defined in the mainstream literature as complexity based on individual attributes of an entity, as opposed to subjective complexity that instead reflects the perceptions of individual subjects (e.g. Campbell, 1988). Recognising this difference in the context of the framework implies, in practice, emphasising that sometimes general and individual complexities can be manipulated by the individual firm, and hence subjective complexity, i.e. the complexity that is actually suffered by the firm, can be reduced. Therefore, a service that has to be targeted at the individual customer (factor #1 in Figure 1) is an example of general-level complexity, even though the individual firm might be able to customise the service by differently combining standardised service components and thus reduce the level of actual complexity. Similarly, in the case of a service that is based on rapidly evolving technologies (factor #31 in Figure 1), a service provider can endeavour to reduce actual complexity through outsourcing, or rather shift part of the complexity out-of-doors.¹

Figure 2. Definition of the framework parameters

Type of Complexity		Definition
Nature of Complexity	COMPLICATEDNESS	<ul style="list-style-type: none"> • Multiplicity: high number of components (AND/OR) • Relatedness: high level of interaction between components.
	DIFFICULTY	<ul style="list-style-type: none"> • Significant material or immaterial resources required/employed in order to achieve an outcome (AND/OR)* • Uncertainty: inability to accurately predict or rely on something.*
Source of Complexity	GENERAL COMPLEXITY	<ul style="list-style-type: none"> • Complexity intrinsic to the service. The same level of complexity is presented to all the firms that offer one particular type of service.
	INDIVIDUAL COMPLEXITY	<ul style="list-style-type: none"> • Complexity emerging around the individual firm. Different levels of complexity faced by different firms offering the same type of service. Due to either: <ul style="list-style-type: none"> (i) Decisions made by the firm; (OR) (ii) The environment in which the firm operates.

* When not due to complicatedness

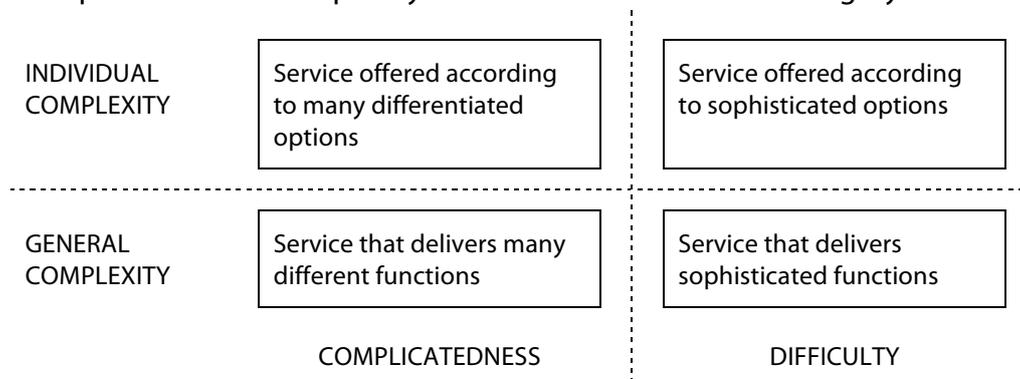
¹ Note that reducing actual complexity often introduces individual complexity of the type due to a firm's decisions. Using outsourcing to reduce technology challenges, for example, will increase the number of actors in the service delivery network, which in turn can generate complexity (e.g. factors #45, #46, #47 in Figure 1).

In synthesis, while complicatedness and difficulty reflect the nature of complexity, general and individual complexities capture the source of complexity. A summary of the definitions of the framework parameters is provided in Figure 2, with the next section showing the framework in practice.

The framework in practice

By combining the dimensions of complicatedness and difficulty with those of general and individual complexity, the framework identifies four categories of complexity that may apply to a service. Figure 3 provides examples of complexity factors falling within each category from the list of 76 potential factors that emerged from the literature review. Indeed, when ‘a service delivers many different functions’, the aspect of multiplicity can be recognised and hence the characteristic of complicatedness applies. Because the complexity affects in the same way all the potential providers of the service, it is of a general type. ‘A service that is offered according to many differentiated options’ is still complex because of complicatedness but the type of complexity is individual rather than general, as the individual firm might in principle decide to offer only a limited range of options. Moving from a service offered according to many differentiated options to ‘a service offered according to sophisticated options’ (like, for example, the purchase of new technology or advanced infrastructure), the nature of complexity changes from complicatedness to difficulty. The complexity is still individual as simpler options for providing the service can be envisaged. Finally, a service that delivers sophisticated functions introduces general-level difficulty, as the sophistication depends on the service itself.

Figure 3. Examples of service complexity factors in each framework category



All of the 76 service complexity factors identified were coded according to the 4 framework categories. The coding was performed by one of the members of the research team and, in order to ensure reliability, also by a second ‘novice’ coder. The second coder attended a training session in which he was briefed on the objectives of the research and the framework explained. The coder was given the definitions in Figure 2 as a guide for what he should look for in assessing the complexity factors against the framework categories. The examples in Figure 3 were also illustrated before the coder proceeded with the actual analysis of the complexity factors. Both coders coded all the 76 service complexity factors. The novice coder was asked to re-code the first few factors a second time after he analysed the whole list, so as to ensure consistency in his coding. The final results of the coding, after the differences between the two coders were resolved (92 per cent agreement was obtained in the first instance), are illustrated in Figure 4.

Figure 4. Classification of service complexity factors according to the framework categories

INDIVIDUAL COMPLEXITY	3, 4, 22, 27, 28, 29, 44, 45, 46, 47, 50, 52, 58, 71, 72	21, 34, 48, 69, 70, 73
GENERAL COMPLEXITY	1, 9, 14, 15, 16, 17, 26, 37, 38, 39, 40, 42, 43, 49, 51, 57, 59, 63, 65, 74, 75	2, 5, 6, 7, 8, 10, 11, 12, 13, 18, 19, 20, 23, 24, 25, 30, 31, 32, 33, 35, 36, 41, 53, 54, 55, 56, 60, 61, 62, 64, 66, 67, 68, 76
	COMPLICATEDNESS	DIFFICULTY

(Factors indicated as numbered in Figure 1)

Conclusion

This paper provides a detailed breakdown of complexity in services. It addresses complexity across dimensions, including markets and products, technologies, production processes, administration and management, and ecosystem. It further enables differentiation between different types of complexity according to the nature and source of the complexity. The research methodology has been based on a systematic review of the literature that has overlooked the theoretical definitions of complexity proposed, for example, by complexity theory and complexity science, in order to capture the more concrete and practical features of complexity. Future work will be devoted to determining the characteristics of complexity especially relevant to specific types of service and at investigating whether the proposed framework categories can be used to identify appropriate practices for complexity management. However, the immediate value of the paper is in the development of an evidence-based picture of complexity, specifically targeted at collating different ways in which complexity can be experienced, embodied by service businesses.

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