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Complexity in services: an interpretative framework

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Complexity in services: an interpretative framework[1]

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.

Keywords: service complexity, framework

1.   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 sized 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 to also management science (Robertson, 2004). It has become indeed almost a commonplace to observe that increasing levels of complexity are being incorporated in organisations. The process is seen as a main challenge by managers and researchers, and is described to involve 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. Firstly, 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 to 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 in 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 for capturing 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 inputs 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.

2.   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 explicit description of principles, criteria and methodology applied at each step. The review strategy is necessary 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 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 that 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 one another. 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 relatively 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) that 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 26989 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 keyword search on the ground 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 being often blurred (e.g. REFS), 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. 84 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 where ordered in the document, so that to bring near to one another those that focused on similar areas of complexity, and were examined in turn. The examination consisted of drawing the 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 preferred rather than 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 Tulzelmann'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 eco-system, 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 five categories above. Figure 1 proposes of 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 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 short lifecycle
13. The service has 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 on-going 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 organization 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 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 high interrelation of activities taking place between the service provider and the customer during the service delivery process
41. The service requires the customers to be in the system for a high percentage of the time it takes to serve him, i.e. (continued)
    high customer contact
42. The service needs to be carried out cooperatively with the customers, i.e. high customer involvement
43. The service is delivered in a process that is to be tightly integrated into the business processes of customers (industrial services only)
44. The service is delivered through assembling sub-services offered by a pool of seller candidates which provide

complementary as well as substitutive services

45. 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 the end customer
46. The delivery network for the service comprises actors each of whom might be involved with multiple other delivery networks, each with their own demands
47. The delivery network for the service involves different parties that depend on each other to accomplish their tasks
48. Material and data flows exchanged between partners in the service delivery network are affected by uncertainty
49. A high number of steps are required to produce the service
50. The service is produced through a high number of steps
51. Highly interrelated steps are required to produce the service
52. The service is produced through highly interrelated steps
53. The service process requires intensive input of human labour
54. The input of human labour in the service process is predominantly intellectual
55. The cost and quality of the service, i.e. the relationship between inputs and service output, are affected by changes in the environment
56. Tolerance on the time it takes to produce the service is low
57. The service requires a variety of inputs
58. The provision of the service involves use of shared resources
59. Operations relative to the service involve a high number of people
60. The process of service production may need to adapt non-routine procedures and methods
61. The service does not rely on established bodies of knowledge, yet it requires new solutions
62. The provision of the service is based on judgement as the service involves tacit as opposed to codifiable information
63. The service can be produced according to a number of alternative paths
64. The service involves a great deal of specialised knowledge to undertake the service tasks
65. The production and delivery system for the service involves a high number of feedback loops
66. The service is difficult to provide in a cost-effective and efficient manner

Administration and management

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

Eco-system

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

3. Framework development

The purpose of the framework sought in this paper was to define conceptual directions that could enable interpreting and analysing 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 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 to 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 accurately predict 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. With 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 a *general complexity* and an *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 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 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 which is actually suffered by the firm, can be reduced. Therefore, a service that has to be targeted on 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[2].

Figure 2   Definition of the framework parameters

|	Type of Complexity	Definition
Nature of Complexity	COMPLICATEDNESS	• Multiplicity: high number of components (AND/OR) • Relatedness: high level of interaction between components
	DIFFICULTY	• 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	• Complexity intrinsic to the service. Same level of complexity is presented to all the firms that offer one particular type of service
	INDIVIDUAL COMPLEXITY	• Complexity emerging around the individual firm. Different levels of complexity faced by different firms offering the same type of service. Due to either: (i) Decisions made by the firm; (OR) (ii) The environment where the firm operates

* When not due to complicatedness

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.

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[2] Note that reducing actual complexity often introduces individual complexity of the type due to 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).

4.   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 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, 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

INDIVIDUAL COMPLEXITY	Service offered according to many differentiated options	Service offered according to sophisticated options
GENERAL COMPLEXITY	Service that delivers many different functions	Service that delivers sophisticated functions
	COMPLICATEDNESS	DIFFICULTY
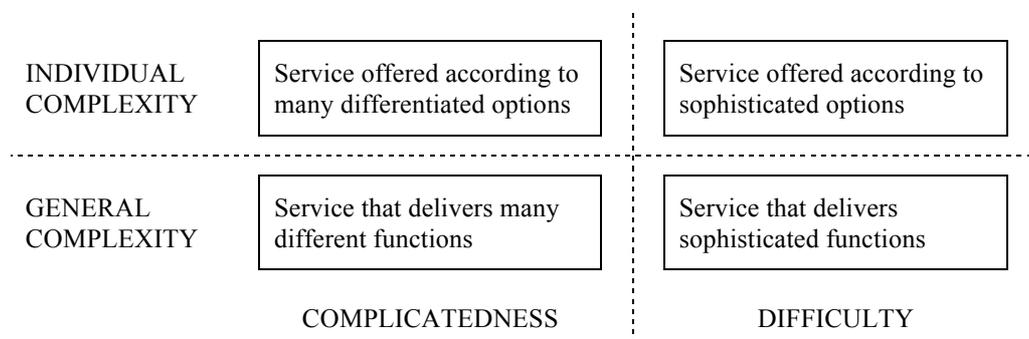
All of the 76 service complexity factors identified were coded according to the four framework categories. The coding was performed by one of the members of the research team and, in order to

ensure reliability, by also a second 'novice' coder. The second coder attended a training session in which he was briefed on the objectives of the research and explained the framework. 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 that to ensure consistency in his coding. The final results of the coding, after the differences between the two coders were resolved (92% percentage of agreement obtained in the first place), 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)

5.   Conclusions

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 eco-system. It further enables differentiating between different types of complexity according to the nature and the source of the complexity. The research methodology has been based on a systematic review of the literature that has overlooked theoretical definitions of complexity proposed, for example, by complexity theory

and complexity science, in order to capture more concrete and practical features of complexity. Future work will be devoted at determining the characteristics of complexity especially relevant to specific types of services 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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