

Factors Influencing Service Complexity: The Perspective of Servitized Manufacturers

Ornella Benedettini, Andy Neely

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Why this paper might be of interest to Alliance Partners:

The shift of manufacturers into services has been described as a process that involves the provision of services of increasing complexity. This paper analyses the characteristics of the suggested complexity. By assessing the multiple determinants that the business and management literature have proposed for service complexity from the perspectives of six servitized manufacturers from three different industrial sectors, the study develops insights into the concrete and practical features of complexity in the context of the service offerings of manufacturing firms. Results show that, while manufacturers deal with relevant complexity in their services, this complexity appears to be mainly related to service delivery issues that require the development of new and service-specific skills. Overall, manufacturers appear to be quite cautious about adding complexity to their service businesses. Finally, results indicate that the complexity of the product served and the context in which the services are offered can be more important determinants of complexity than the service itself. The study builds on previous work from the same authors, also included in the Cambridge Service Alliance monthly papers series (June 2012)

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Factors Influencing Service Complexity: The Perspective of Servitized Manufacturers

*Ornella Benedettini (ob256@cam.ac.uk)
University of Cambridge, UK/Politecnico di Bari, Italy*

*Andy Neely
University of Cambridge, UK*

Abstract

Many manufacturing firms are shifting towards services. While it has become axiomatic to make this claim, the process is described as increasingly encompassing the provision of complex services. However, the definition of complexity is rarely provided and it is not clear how complex services should be identified. This paper investigates the factors that differentiate a complex from a simple service in the context of the service offerings of manufacturing firms. Results indicate that the complexity of the product served and the context in which the services are offered can be more important determinants of complexity than the service itself.

Introduction

Expanding into services is the emerging business logic in manufacturing. Combined product/service solutions are replacing product-centred offerings, to the point that products are no longer necessarily at the core of the firm's value proposition or even of the business model (Kindström, 2010; Gebauer et al., 2011). While it has become almost axiomatic to say that manufacturing firms are shifting towards services, the servitization trend is described as increasingly encompassing the provision of complex services. However, the definition of complexity is rarely provided and it is not clear how complex services should be identified. Some have identified complex services as services supporting clients' actions in relation to the supplier's product (Eggert et al., 2011), others as services that are more intangible and often customised at each assignment (Lindberg and Nordin, 2008), and others still as services wherein the supplier takes responsibility for providing the customer with a desired outcome (Neu and Brown, 2008). These classifications have been developed rather independently by the authors, and often lack sufficient conceptual or empirical foundations. Nevertheless, they tend to focus on specific aspects of complexity, and very little attempt has been made to collate and contrast the various dimensions that distinguish a complex from a simple service.

The purpose of this paper is to analyse thoroughly the meaning of complexity in the context of the service offerings of manufacturing firms. In particular, the paper seeks to contribute to substantiating better the distinction between a complex and a simple service by assessing, from the perspective of six servitized manufacturers, the multiple determinants that the wider business and management literature have proposed for service complexity.

Methodology

The study was grounded in recent work by the authors (Benedettini and Neely, 2012), which, based on a systematic review of literature, analysed the possible meanings of complexity in service contexts. This work captured a list of 76 potential factors that differentiate a complex from a simple service, classified into 5 domains of relevance: (i) Markets & Products; (ii) Technologies; (iii) Production Processes; (iv) Administration & Management; and (v) Ecosystem (Figure 1). The 76 factors were developed around a generic concept of service, i.e. avoiding boundaries regarding specific types of service (B2B, B2C, etc.). Thus, they resulted in being appropriate for use also in mapping the potential complexity in the service offerings of manufacturing firms.

Figure 1 – The potential service complexity factors (Benedettini and Neely, 2012)

Markets and Products	
1. The service is highly individual.	18. The service requires a high degree of customer knowledge.
2. The service has low commodity content.	19. The outcome of the service is difficult to predict.
3. The service is offered according to many differentiated options.	20. The outcome of the service is difficult to monitor.
4. The needs and wants for the service are very heterogeneous among a firm's customers.	21. The service is affected by information asymmetry between the client and the service provider.
5. The customer requirements for the service are difficult to interpret.	22. The service organisation offers many different services.
6. The customer requirements for the service are subject to change.	23. The market for the service is highly competitive.
7. The timing and level of customer demand for the service are uncertain.	24. The service is new.
8. The customers tend to look for new offerings for the service all the time.	25. The service entails some innovation that is perceived as being difficult to understand and use.
9. The service delivers many different functions/addresses a wide range of customer requirements.	26. The process of service innovation involves suppliers and customers.
10. The service delivers sophisticated functions/addresses sophisticated customer needs.	27. The service is delivered at many different locations.
11. The service is infrequently purchased.	28. The service is delivered across multiple channels.
12. The service has a short life cycle.	29. The service is offered to many different groups of customer.
13. The service has high risk of obsolescence.	30. The customer will purchase the service based on credence qualities, i.e. supplier reputation and relationship with supplier.
14. The service contains a high number of sub-services.	31. The service is difficult to understand for the customers.
15. The service contains very heterogeneous sub-services.	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.
16. The service contains highly interrelated sub-services.	33. The customers lack the technical knowledge to evaluate the service.
17. The service involves ongoing interaction between the customer and the service, so that the customer can make decisions.	
Technologies	
34. The service is offered according to sophisticated options, e.g. with the purchase of new technology, more advanced infrastructure.	37. The service delivery involves several different technologies.
35. The service uses new and sophisticated technologies.	38. The service incorporates a variety of distinct knowledge-bases, skills and competencies.
36. The service uses rapidly developing technologies.	
Production Processes	
39. The service requires a high number of interactions between the service provider and the customer during the service delivery process.	53. The service process requires intensive input of human labour.
40. The service involves high interrelation of activities taking place between the service provider and the customer during the service delivery process.	54. The input of human labour in the service process is predominantly intellectual.
41. The service requires the customers to be in the system for a	55. The cost and quality of the service, i.e. the relationship between

high percentage of the time it takes to serve them.	input and service output, are affected by changes in the environment.
42. The service needs to be carried out cooperatively with the customers.	56. Tolerance about the time it takes to produce the service is low.
43. The service is delivered in a process that is to be tightly integrated into the business processes of customers (industrial services only).	57. The service requires a variety of inputs.
44. The service is delivered through assembling sub-services offered by a pool of seller candidates, which provide complementary as well as substitutive services.	58. The provision of the service involves use of shared resources.
45. The service is delivered through a network consisting of a complex web of direct and indirect ties between various actors, all of which deliver value either to their immediate customer or the end customer.	59. Operations relative to the service involve a high number of people.
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.	60. The process of service production may need to adapt non-routine procedures and methods.
47. The delivery network for the service involves different parties that depend on each other to accomplish their tasks.	61. The service does not rely on established bodies of knowledge, yet it requires new solutions.
48. Material and data flows exchanged between partners in the service delivery network are affected by uncertainty.	62. The provision of the service is based on judgement as the service involves tacit, as opposed to codifiable, information.
49. A high number of steps is required to produce the service.	63. The service can be produced according to a number of alternative paths.
50. The service is produced through a high number of steps.	64. The service involves a great deal of specialised knowledge to undertake the service tasks.
51. Highly interrelated steps are required to produce the service.	65. The production and delivery system for the service involves a high number of feedback loops.
52. The service is produced through highly interrelated steps.	66. The service is difficult to provide in a cost-effective and efficient manner
Administration and Management	
67. The service requires intensive investments.	71. A variety of pricing structures is available for the service, or different pricing structures exist for different customer groups.
68. The service is high cost.	72. The pricing structure for the service changes frequently.
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 The contractual relationship between the service provider and the customer is highly individual.	
Ecosystem	
73. 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 is subject to a pressing regulatory environment.
74. The service involves conflicts between multiple stakeholders.	

The present study examines three manufacturing sectors: (i) IT; (ii) industrial equipment; and (iii) aerospace & defence. These sectors have been chosen on the basis of involving substantial and consolidated servitization initiatives. Two firms were targeted for each sector. The selection criteria were that the firms had to be extensively engaged in offering services. For each firm, the authors identified a respondent (who had in-depth knowledge of service activities) to contribute to the study. They asked these interviewees to indicate the importance of each of the 76 potential complexity factors to their organisation. Being aware that different programmes or business units may be responsible in the same firm for different services, the authors asked the interviewees to take the perspective of the particular services offered by their programme/business unit. A scoring mechanism was developed, according to which these respondents were invited to indicate the degree of importance of each complexity factor on a 0–4 Likert scale (0 = ‘no importance’, 1= ‘low importance’, 2= ‘moderate importance’, 3= ‘high importance’, 4= ‘very high

importance'). Data were collected through an online questionnaire. In addition to tick-boxes for the choice of the degree of relevance of the potential complexity factors, the questionnaire also included comment boxes. For some respondents, comments were also collected through follow-up phone interviews.

Data were collected in March–April 2012 and analysed during the period up until May 2012. Results are summarised in the following sections.

Understanding the main factors of complexity

Of the 76 potential complexity factors proposed, the 6 firms interviewed identified on average 40.83 factors (53.73%) as being either highly important or very highly important. Factors of no or low importance were also on average 13.83 (18.20%), suggesting that manufacturing firms remarkably offer complex services.

A more detailed picture is provided in Table 1, which highlights that considerably more factors, among those that the firms identified as highly or very highly important, fall in the Markets & Products (34.70%) and in the Production Processes (40.00%) domains than in the Administration & Management (10.20%), Technologies (9.80%) and Ecosystem (5.31%) domains. In some ways this is not surprising given the higher number of potential factors in the Markets & Products and Production Processes domains (33 and 28 v. 5, 7 and 3 respectively); yet it raises an interesting question. What do we mean by 'service complexity'? The survey data indicate that the service product is less important than the service production process in determining total complexity. Stated differently, it seems that a very relevant part of the complexity faced by the firms interviewed is not actually due to the service, but to the various aspects surrounding the provision of the service, production and delivery in particular. Therefore, we suggest that it would perhaps be appropriate to rename the complexity that manufacturers encounter when they servitize from 'service complexity' to 'complexity in services'.

Table 1 – Service complexity by domain

Domain	No. of factors with importance ≥ 3 (i.e. 'high' or 'very high')*	%	Total No. of factors
Markets & Products	14.17	34.69	33
Technologies	4.00	9.80	5
Production Processes	16.33	40.00	28
Administration & Management	4.17	10.20	7
Ecosystem	2.17	5.31	3
*Average for the six firms in the sample	40.83	100	76

The most relevant dimensions of complexity (Figure 1) appear to refer to: (i) services that require a high degree of customer knowledge (factor #18); (ii) services that are delivered at many different locations (factor #27); (iii) services that are offered according to sophisticated options (factor#34); or (iv) services that have to be carried out cooperatively with the customers (factor#42). Clearly, the firms interviewed appear to face many different factors of service complexity, but what is more interesting to observe is that three of the four most commonly important factors (ii, iii, and iv) deal with service delivery. This is an interesting outcome when compared to the mainstream servitization literature, which prioritises other challenges of servitizing, such as service design and innovation, competition, or need for investments. These

aspects have been included in the study (e.g. factors #23, #4, #5, factor#6, #26, #67, #68), yet they are not felt to be the most important by the firms interviewed. However, it must be noted that the complexity factors identified above (factors ii, iii, and iv) involve competences, skills and abilities that, while being service specific, cannot simply be acquired or purchased; they need to be developed. Important dimensions of complexity might hence be linked to the product background of the firms. According to the data in Figure 1, customer-related factors are also an important element of the complexity faced by the firms (factors i and iv). This is consistent with the customer-centricity that is often emphasised in services, and suggests that the ability to offer complex services involves a strong relationship and integration with the customers – and once more takes time to develop.

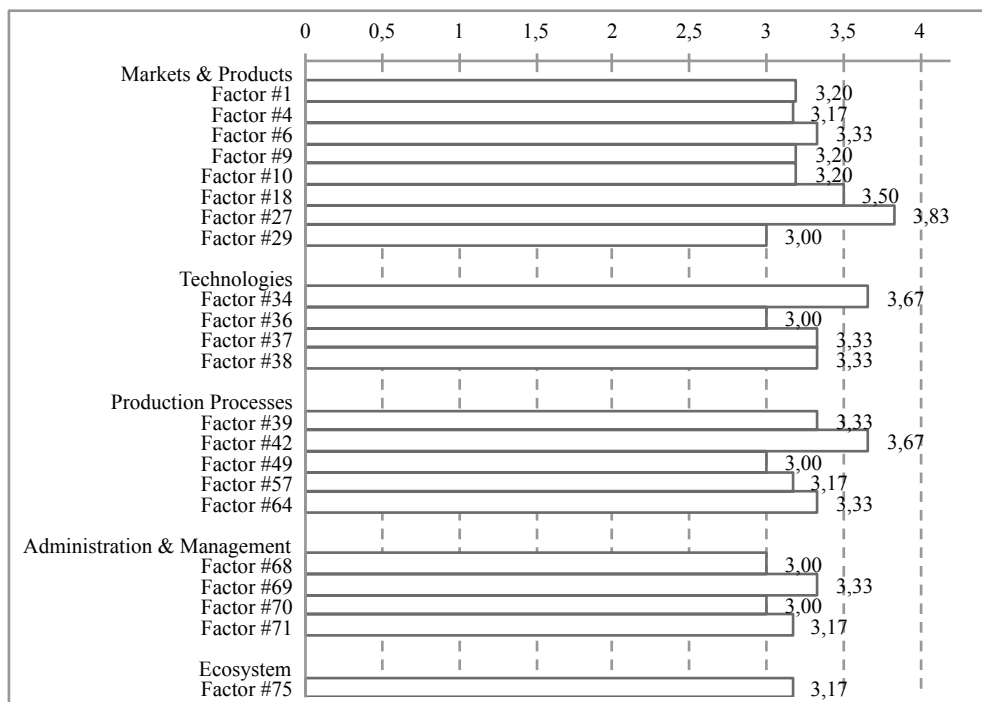


Figure 1 – Average importance of complexity factors (main factors only)

Exploring the differences between industrial sectors

Table 2 explores the impact of the potential service complexity factors in more detail, breaking down the analysis at the level of industrial sectors. While IT and aerospace & defence firms appear to face similar levels of complexity (48.5 and 47 factors respectively identified on average as 'highly' or 'very highly' important), substantially lower complexity emerges for industrial equipment firms (27 factors).

The main differences appear to be in the impact of Markets & Products (15.5 and 17 factors for IT and aerospace & defence firms v. 10 factors for industrial equipment firms) and Production Processes (21.5 and 17.5 v. 10 factors). One possible way to explore this result is to look at the individual factors that are highly relevant to both IT and aerospace & defence firms, yet not equally to industrial equipment firms. In terms of Markets & Products, the firms in the first two sectors importantly face customer requirements that are very heterogeneous (factor #4) and subject to change (factor #6). The services also tend to be highly individual (factor #1), require a high degree of customer knowledge (factor #18), deliver many different (factor #9) and sophisticated (factor #10) functions, and contain many interrelated sub-services (factor #16). On the Production Processes side, conversely, the main differences arise from the need for a great

deal of specialised knowledge to undertake service tasks (factor #64), a high number (factor #49) of interrelated steps to produce the service (factor #51), and a high number of interactions with the customers (factor #39). The Markets & Products factors above reflect the offering of more customised and high-value services by IT and aerospace & defence firms. Production Processes factors are also consistent with this view. Hence, our investigation suggests that differences in the levels of service complexity faced by manufacturers in different sectors may actually be due to different degrees of customisation and value intensity: customised and high-value services appear to be more complex to design and target to the customers and, indeed, to deliver.

Table 2 – The profile of service complexity by industry sector

Domain	No. of factors with importance ≥ 3 *			Factors with importance ≥ 3 **		
	IT	Ind. Eq.	Aer. & Def.	IT	Industrial Equipment	Aerospace & Defence
Markets & Products	15.5	10.0	17.0	1, 4, 6, 9, 10, 16, 17, 18, 22, 27, 29, 32	26, 27, 29	1, 4, 5, 6, 9, 10, 11, 14, 15, 16, 18, 19, 21, 25, 27
Technologies	5.0	3.5	3.5	34, 35, 36, 37, 38	34, 36, 38	34, 37, 38
Production Processes	21.5	10.0	17.5	39, 40, 41, 42, 43, 46, 47, 49, 51, 52, 54, 57, 60, 62, 64, 65	42	39, 42, 48, 49, 51, 55, 58, 59, 64, 66
Administration & Management	4.5	2.0	6.0	68, 69	–	67, 68, 69, 70, 71
Ecosystem	2.0	1.5	3.0	74, 75	–	74, 75, 76
	48.5	27.0	47.0			

* Average between the two firms in the sector, ** Importance ≥ 3 for both firms in the sector

To explore how the characteristics of service complexity differ between industrial sectors, the authors also applied the theoretical framework developed in their already cited paper (Benedettini and Neely, 2012) to the survey data. This framework identifies four types of service complexity based on the nature and source of complexity. Nature of complexity can be either: (i) complicatedness; or (ii) difficulty. Complicatedness refers to the presence of many different and/or interrelated components, whereas difficulty applies to outcomes that require/rely on the use of significant resources (material or immaterial) to be achieved, or are affected by uncertainty. Source of complexity can instead be either: (i) general; or (ii) individual. General complexity is an intrinsic characteristic of the service, and hence it is presented to all firms that offer a certain service. On the contrary, individual complexity originates around the individual firm, because of decisions made by the firm or because of its immediate environment. These dimensions of complexity have been developed based on the same 76 potential service complexity factors used in this study, and hence the authors' original paper (Benedettini and Neely, 2012) also codifies the factors according to the four framework categories. Some examples are given in Figure 2.

The authors analysed the amount of complexity that the firms in each sector identified in the different categories. For each industrial sector, Figure 3 indicates the level of complexity faced in each of the four categories as a percentage of maximum complexity. Complexity faced was

determined as the sum of the scores (on the 0–4 Likert scale) that the firms had given to the factors in that category; maximum complexity was obviously calculated as four (i.e. maximum score) multiplied by the number of factors in the category. Industrial equipment firms appear in Figure 3 to show the lowest levels of complexity in all framework categories. Levels of complexity are not substantially different between framework categories, for industrial equipment as well as IT firms (the maximum differences are 9.56% and 13.73% respectively). On the contrary, aerospace & defence firms seem to face relevantly higher complexity in the difficulty–individual category (87.5%) than in the other categories (79.76%, 60.83% and 63.6%). Hence, aerospace & defence firms seem to deal with greater sophistication and greater risk-taking in their services (difficulty nature), due to their own decisions and business settings (individual source). This might actually result from the pursuing of more aggressive market strategies, yet it cannot be excluded that the reason why this happens is that these firms are exposed to greater pressures from external forces, which may more often lead/force them to introduce complexity into service activities.

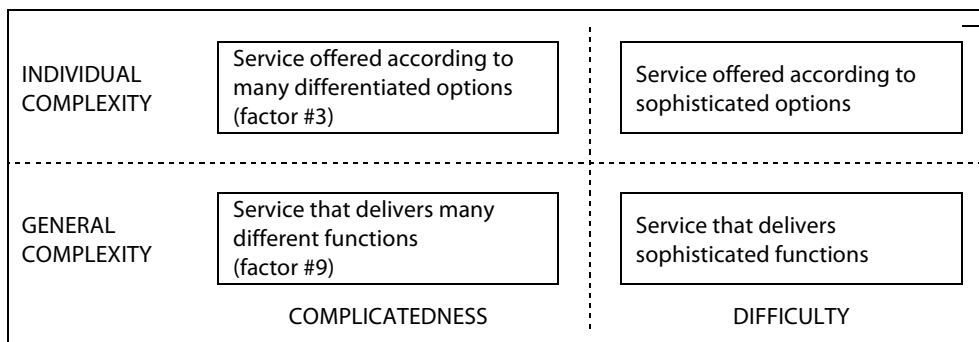


Figure 2 – Examples of factors in each category of complexity (Benedettini and Neely, 2012)

INDIVIDUAL COMPLEXITY		75,83%	72,92%
		(20,82%)	(8,01%)
GENERAL COMPLEXITY		79,17%	65,44%
		(30,43%)	(40,73%)
	COMPLICATEDNESS		IT
		DIFFICULTY	
	58,33%	62,5%	60,83%
	(20,71%)	(8,88%)	(17,30%)
	55,95%	52,94%	79,76%
	(27,81%)	(42,6%)	(31,75%)
	Industrial Equipment		Aerospace & Defence

Figure 3 – Distribution of complexity among framework categories

However, perhaps the most interesting outcome from this analysis relates to the numbers in brackets in Figure 3. These show how the scores given by the firms to the potential service complexity factors are distributed between the four categories of complexity. Although amount of complexity is different between industrial equipment and the other industrial sectors, the data suggest that the complexity faced by firms in different sectors is distributed in the same way between categories. One particularly noteworthy point is that, for all three industrial sectors, over

70 per cent of total complexity has 'general' source. This means that manufacturers actually tend to face the complexity that is presented and imposed on them, rather than deliberately introducing complexity. On the one hand, this suggests a cautious behaviour, i.e. manufacturers tend to avoid adding unnecessary complexity to their service businesses (Child et al., 1991). However, on the other hand, it might also be that these firms are missing important opportunities because they are not good at exploiting complexity. Complexity is, indeed, increasingly seen in management science as being an important strategic variable. One can just think about the degree to which many firms have enlarged choices offered to customers in many product and service markets, or have infused technology in their activities. The upcoming challenge for organisations seems to be to understand the drivers and costs of complexity, i.e. to introduce complexity that significantly improves competitiveness while, at the same time, properly managing this complexity in such a way that 'subjective' (e.g. Campbell, 1988) complexity (i.e. complexity actually suffered by the firm) can be reduced. Hence, the results of our analysis might actually indicate that manufacturers need to become more familiar with complexity, and learn how better to use it in order to support their service business.

Going back to the question of how service complexity appears to manufacturers in different sectors, we have implicitly assumed in our previous analysis that the type of services offered plays an important role in defining the relevant features of complexity. The rest of the paper does in fact verify this contention, and examines how the specific type of services offered may have affected the complexity experienced by the individual firms interviewed.

The impact of the type of service

So far, the literature has not produced a definite typology of the services offered by manufacturing firms. However, several authors (e.g. Boyt and Harvey, 1997; Lindberg and Nording, 2008) have regarded consultancy, research, and design services as being the most complex kinds of potential service to offer. The two IT firms interviewed offer consultancy services for sale and implementation of enterprise software. Hence, one would expect these firms to deal with higher levels of complexity than the industrial equipment and aerospace & defence firms, which, instead, offer maintenance and support services on vehicle systems. Stated differently, if, as the literature would suggest, consultancy services are more complex than maintenance and other technical support services, then why do aerospace & defence firms appear in the survey to be exposed to the same level of complexity (e.g. Table 2, Figure 3) as IT firms?

The authors believe that there are a few considerations that should be made. First, the level of complexity of the product can be different. Notwithstanding that enterprise software (especially in large corporations) can be very complex, it is not always that complex. Aerospace & defence vehicles are, instead, inevitably highly complex products, involving many different and highly integrated subsystems. The services supporting these products require high skill levels, incorporate a variety of technologies and knowledge-bases, and hence are necessarily complex themselves. Second, maintenance and support services are certainly more traditional services for manufacturers, yet in some settings they may be difficult to standardise. Although one of them also has other lines of business, the two aerospace & defence firms interviewed both answered the questionnaire relative to services in support of military assets. In the market of military assets, firms clearly deal with few but very large customers with very specific needs and strong buying power, which makes it difficult to segment customers and standardise services. Heterogeneity and level of customisation necessarily increase, especially because customisation needs to be

realised upstream in the service design processes. As a consequence, a whole range of activities, like measuring service performance, controlling service costs, or pricing services, become more challenging. Nevertheless, the service requires wider cooperation and value co-creation with the customer, which creates a greater dependence on success of the service from the participation of the customer.

These considerations lead to an important conclusion. The complexity in the service offerings of manufacturing firms depends not only on the type of services that they offer; important determinants of this complexity are also the complexity of the product served by the services and the context in which the services are offered. Comparing data between the individual firms interviewed also reinforces this conclusion. Table 3 shows the average scores that the individual firms in each sector indicated for the 76 potential complexity factors. There is an interesting difference between the complexities faced by the two industrial equipment firms (average scores are 1.68 and 2.76 for firms 3 and 4 respectively). In particular, the average resulting complexity for firm 4 is aligned with the complexity indicated by the IT and aerospace & defence firms (ranging from 2.72 to 2.97). Firm 4 offers comprehensive technical support for power and automation equipment products used in industrial plants of different industries, while firm 3 offers maintenance and optimisation of specific machinery. The market setting of the two firms is clearly different: while firm 3 serves many different customers with the same product, firm 4 is likely to serve few customers on plants that are all different from one another.

Table 3 – Importance of complexity factors for individual firms

	IT		Industrial Equipment		Aerospace & Defence	
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6
Average relevance of all factors	2.97	2.78	1.68	2.76	2.82	2.72
Main differences (Factors #)*	2, 8, 15, 25, 45, 48, 61, 66	11, 13, 20, 56	7	1, 6, 9, 17, 19, 21, 31, 32, 37, 47, 49, 50, 51, 52, 55, 58, 64, 65, 66	13, 28, 46, 60, 65	31, 29, 22, 50, 52, 54
* Importance ≥ 3 (i.e. 'high' or 'very high') for the firm and ≥ 1 (i.e. 'no' or 'low') for the other firm in the sector						

Table 3 also shows the factors that have been acknowledged as 'highly' or 'very highly' important by each firm, while being of 'no' or 'low' importance by the other firm in the same sector. Factors #1 (service highly individual), #6 (customer requirement for the service subject to change), #17 (customer that makes decisions in an ongoing interaction with the service supplier), #19 (service outcome difficult to predict) suggest more customised services for firm 4. Of the remaining factors, factors #37 (services that involve several different technologies), #64 (great deal of specialised knowledge to undertake the service task), #65 (many feedback loops in service production and delivery processes) may well originate from the greater complexity of the product. Intriguingly, the higher number of services offered by firm 4 (factor#27) doesn't appear in Table 4, suggesting a further conclusion: offering more services does not necessarily increase complexity when these services are in the same range.

Conclusions

Clearly this is a small study, and there is more work to be done to validate and triangulate the data. However, some interesting points emerge from the analysis so far. First, manufacturing firms deal with relevant complexity in their services. Service delivery issues that require the development of new and service-specific skills appear to be particularly important sources of complexity. Second, manufacturing firms appear to face different levels of complexity in different industrial sectors. Complexity appears to be a characteristic of the services offered, rather than a consequence of the different approaches to complexity that may be taken by individual firms. The data suggest that, overall, manufacturers tend to be quite cautious about adding complexity to their service business, perhaps because they need to become more familiar with it. Third, service complexity cannot be identified based only on the type of service. There are other elements, like the complexity of the product served or the context in which the services are offered, which can be more important determinants of complexity than the type of service itself.

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