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R&D MANAGEMENT

Dynamic capabilities for service innovation: conceptualization and measurement

Matthijs J. Janssen[1,2,3], Carolina Castaldi[1] and Alexander Alexiev[4]

[1]School of Innovation Sciences, Eindhoven University of Technology, Den Dolech 2, IPO 2.04, 5600 MB Eindhoven, The Netherlands. C.Castaldi@tue.nl
[2]Dialogic Innovatie en Interactie, Hooghiemstraplein 33-36, 3514 AX Utrecht, The Netherlands. Janssen@dialogic.nl
[3]Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands. M.j.janssen@uu.nl
[4]VU University Amsterdam, De Boelelaan 1105, 5A-35, 1081 HV Amsterdam, The Netherlands. A.S.Alexiev@vu.nl

Although the development of new services is becoming a major concern for firms throughout the entire economy, there is only little insight in the organizational antecedents of service innovation. It is widely acknowledged that engaging in R&D is relatively uncommon for service providers, but there are also indications that the R&D concept is poorly applicable to service innovation in the first place. Therefore, attention is shifting toward the actual capabilities that allow a firm to source ideas and convert them into marketable service propositions. This paper provides the operationalization of a set of dynamic service innovation capabilities (DSICs) that is general enough to be relevant across different sectoral contexts. While the selected framework is found to consolidate earlier works on the specificities of service innovation, it also captures broad insights on the evolutionary properties of the creation of novel solutions. Thereby, it exemplifies how DSICs can be conceptualized according to the so-called synthesis approach to service innovation. We operationalize a refined version of such DSICs and develop a measurement scale, using two multi-industry subsamples from a dataset of 391 Dutch firms. The measured capabilities are found to correlate to different extents with performance measures. Our main contribution, a validated scale for five complementary DSICs, opens the way to comparative analyses regarding firm abilities for creating innovative services.

1. Introduction

The provision of novel services is increasingly regarded as a source of competitive advantage for firms from virtually all industries (Vargo and Lusch, 2004) and as a driver for economic change (Gallouj and Djellal, 2010). Innovation management scholars have investigated service innovation as part of service innovation businesses strategies (Sawhney et al., 2004; Berry et al., 2006), as the outcome of service innovation processes and R&D (Miles, 2007; Perks et al., 2012) and new service development (Zomerdijk and Voss, 2011), and more recently as core element in service-based business model innovation (Suarez et al., 2013; Visnjic Kastalli and Van Looy, 2013).

Characteristic for the various lines of inquiry is the consensus that service innovation follows a different logic than product innovation.[1] Because services are intangible, heterogeneous, non-stockable and coproduced with clients, also service innovation dynamics are marked by a number of peculiarities (Gallouj and Djellal, 2010). Especially the intensive interaction with customers and the tendency to fulfill actual needs (instead of providing artifacts) make that service innovation can be seen as an innovation mode in which challenges differ from the ones encountered in product innovation (D'Alvano and Hidalgo, 2011). How managers should respond to this is a question asking for in-depth insight in firms' service innovation activities. Since there is only a limited understanding of how service innovation comes about, more detailed research into the organizational antecedents of service innovation has frequently been urged for (Miles, 2007; Den Hertog et al., 2010; Gallouj and Djellal, 2010; D'Alvano and Hidalgo, 2011).

Typically, investigation of an organization's ability to generate and recombine knowledge starts by looking at its R&D efforts (Nerkar and Paruchuri, 2005). One of the key problems in the service innovation context is that the notion of R&D is only limited applicable to the development of new solutions and experiences (Miles, 2007). Compared with strictly technological R&D, the search for new service solutions is hardly organized in a formalized manner, which can for example be concluded from the fact that R&D budgets are scarce among service industries (Miles, 2005). Rather, the development of services often occurs through implicit and possibly non-systematic ways (Thomke, 2003).

Apart from being modestly relevant for service innovation, R&D figures alone are also a very poor indication of how much an organization is engaged in staying adaptive and renewing its output. In fact, such figures hardly give any insight in a firm's strengths or weakness with respect to the different types of activities that are required for generating and implementing new products. Hence, scholars have embraced the idea of examining a firm's capabilities for processing knowledge and seizing opportunities (Teece et al., 1997). As a response to critiques that such dynamic capabilities are hard to measure, recent contributions to the dynamic capability view (DCV) have pointed at the importance of looking at the *microfoundations* of *common sets of capabilities* (Teece, 2007). Contrary to studies aimed at identifying firm-specific capabilities, this modern approach enables interfirm comparison of processes related to knowledge sourcing, transformation and exploitation (Barreto, 2010).

The DCV is heavily rooted in evolutionary theories of novelty creation, and according to a Schumpeterian perspective services constitute one of the forms novelty can take (D'Alvano and Hidalgo, 2011). Yet just like in the wider innovation literature, most capability studies tend to focus on capabilities for (product) innovation specific to manufacturing firms (Hogan et al., 2011). This is regrettable, considered that looking at dynamic capabilities might be a promising alternative for gauging an organization's ability to develop and implement new services (Leiponen, 2012; Teirlinck and Spithoven, 2013).

Starting from the ubiquitous but ill-understood nature of service innovation, this paper aims to operationalize a set of dynamic capabilities for service innovation meeting two criteria: it should allow the identification of capabilities that are specific to service innovation, but general enough to be conceptually relevant for all types of firms. Our claim here is that this can be achieved by conceptualizations capturing the salient evolutionary properties (Teece, 2007) of individual firms' innovation efforts.

In the following sections, we first show how the conceptual framework of dynamic service innovation capabilities (DSICs) by Den Hertog et al. (2010) has the aforementioned properties and how it relates to earlier attempts to capture dynamic capabilities in service contexts. Using two subsamples of a multi-industry survey, we then separately purify and validate an actual measurement scale. The capabilities are also found to correlate to different extents with performance measures.

The proposed measurement scale, which is our main contribution, captures to what extent firms possess DSICs that are relevant for different processes concerning the creation and implementation of new services. For researchers, such a common measure opens the way for comparative analysis across firms and sectors, whereas for managers (and policy makers) the scale offers a prescriptive tool to strengthen capabilities for service innovation.

2. Theoretical background: dynamic capabilities for service innovation

Reflecting the need for more research into the antecedents of service innovation, several recent studies have aimed to define relevant sets of capabilities (e.g. Kindström et al., 2013; Hogan et al., 2011). After such an initial proliferation of capability conceptualizations, it is essential that the literature consolidates and capitalizes on previous research in a structured way (Barreto, 2010, p. 277). Our attempt to do so is based on two key criteria.

First, we search for a micro-founded conceptualization that provides detailed information on the activities a firm needs to perform in order to enact a certain capability. Only a selected number of the available conceptualizations meet the current methodological standards of the DCV. These standards contend that capabilities can only be meaningfully operationalized, and measured across different firms, by studying the actual microfoundations, i.e. the organizational routines that allow for the execution of certain common capabilities (Eisenhardt and Martin, 2000; Teece, 2007; Foss, 2011). Conceptualizations that do provide a basis for grounded and comparative analysis of firms' abilities to generate and implement new services are shown in Table 1.

Second, we follow the urge to study service innovation not only in service firms, but in manufacturing firms as well. Conceptualizations can be categorized regarding the scope of dynamic capabilities they distinguish, namely whether they are only specified for product innovation, for service innovation or for both. The different attempts so far have followed patterns similar to the application of other innovation theories to the case of services. We recognize three approaches, reflecting how the thinking on service innovation has evolved over the past decades: *assimilation*, *demarcation* and *synthesis* (Gallouj, 1994; Coombs and Miles, 2000). In Table 1, we grouped the selected micro-founded conceptualizations according to these three approaches. Below we discuss the scope of their conceptual foundations and of their microfoundations.

The *assimilation* approach assumes that service innovation can be analyzed with concepts and tools developed in the context of innovation in mainly manufacturing sectors. In this vein, Fischer et al. (2010) as well as Kindström et al. (2013) identify microfoundations that are particularly relevant for manufacturing firms turning toward service development and delivery. By regarding service innovation processes as similar to product innovation ones, identification of just service-specific innovation routines concerns 'details' rather than the key constructs (Eisenhardt and Martin, 2000). Indeed, the assimilation-like conceptualizations are directly based on Teece's (2007) set of capabilities for sensing, seizing and reconfiguring. Although this set itself is praised for its potential to shed light on the organizational abilities required for acquiring and applying knowledge, conceptualizations like the ones above are found to be too general to capture accurately the peculiarities of service innovation processes (Salunke et al., 2011). Conceptualizing service innovation capabilities from a manufacturing or technological R&D perspective thus brings the risk of a myopic view, in this case by restricting the scope of which microfoundations to include.

The *demarcation* approach includes studies and theories addressing the specificities of services and service innovation processes. Instead of searching for microfoundations that can be grouped into an existing framework of dynamic capabilities, studies in this approach introduce service particularities in the capabilities themselves. Thereby, they stress the fundamentally different nature of service innovation (as opposed to innovation in goods). The examples in Table 1 concern sets of dynamic capabilities that are specific for a single type of service, e.g. professional services (Hogan et al., 2011) or 'elevated service offerings' (Agarwal and Selen, 2009). Thereby, the conceptualizations are well suited to capture routines that are idiosyncratic for service innovation processes in these contexts, but limited in their further applicability to other sectoral contexts. Moreover, the theoretical underpinnings diverge from the evolutionary inspired processes prominent in the original DCV.

Finally, the *synthesis* approach refers to theories and frameworks in which insights from the previous two approaches are integrated into a novel, more integrated view on innovation (Metcalfe, 1998). Although our literature survey does not pretend to be exhaustive, we hardly encountered a conceptualization of DSICs that fits within the emerging synthesis approach. An exception is the conceptual framework by Den Hertog et al. (2010), in which six complementary capabilities are proposed as a representation of a firm's capacity to acquire and apply new knowledge in novel services.

Compared with conceptualizations from the assimilation approach, the extended set of capabilities by Den Hertog et al. (2010) is better suited to grasp the idiosyncrasies of innovation in intangibles. At the same time, it avoids putting emphasis on capabilities that would only be relevant for a single type of ('pure') service providers. This scope fits exactly with our second requirement for the selection of a conceptualization. Moreover, the complementarities between the capabilities offer an exceptionally suitable basis for studying evolutionary dynamics. As a service-based extension of the original set by Teece (2007), all capabilities can be conceptually associated with the evolutionary mechanism through which entrepreneurial experimentation leads to novelty creation and determines firm evolution (Metcalfe, 1995; Salvato, 2003). 'Sensing user needs and (technological)

Table 1. Overview of conceptualizations of dynamic capabilities for service innovation

Approach	Key properties of dynamic capability view		Example of conceptualization in services		
	Foundation of conceptualization	Scope of microfoundations	Authors	Identified capabilities	Sector
Assimilation	Product innovation-based set of capabilities, associated with evolutionary mechanism[1]	Service-specific translation of product innovation-based capabilities	Fischer et al. (2010)	Sensing, seizing, reconfiguring	Servicizing organizations
			Kindström et al. (2012)	Sensing, seizing, reconfiguring	Servicizing organizations
			Gebauer et al. (2012)	Sensing, seizing, reconfiguring	Small-/medium-sized suppliers
Demarcation	Service-specific set of dynamic capabilities, not associated with evolutionary mechanism[1]	Idiosyncratic (service-specific) innovation routines	Agarwal and Selen (2009)	Customer engagement, collaborative agility, entrepreneurial alertness and collaborative innovative capacity	Collaborative services
			Salunke et al. (2011)	Episodic learning, relational learning, client-focused learning and combinative capability	(Entrepreneurial) Project-oriented service firms
			Hogan et al. (2011)	Client-focused, marketing-focused and technology-focused innovation capability	Professional service providers
Synthesis	Extended set of dynamic capabilities, associated with evolutionary mechanism[1]	Wide range of innovation routines	Den Hertog et al. (2010)	Sensing user needs and technological options, conceptualizing, (un)bundling, coproducing and orchestrating, scaling and stretching, and learning and adapting capability	(All sectors)

[1]Association with evolutionary mechanism refers to conceptualizations in which the capabilities match distinct but complementary processes through which firms source, convert and exploit knowledge (Teece, 2007; Barreto, 2010).

options' provides ideas for new or altered propositions.[2] 'Conceptualizing' and '(un)bundling' both correspond to capabilities essential for selecting an idea and developing it into a detailed proposition (possibly composed of recombined or isolated service concepts). Finally, '(co)producing and orchestrating', as well as 'scaling and stretching', are related to efforts in which a new service is actually delivered to the market. Being a meta-capability, 'learning and adapting' corresponds less with the evolutionary mechanism of consecutively generating ideas, converting them into propositions and exploiting them on the market (see Section 3.1).

When introducing their framework, Den Hertog et al. (2010, p. 506) state that it can only be used as a prescriptive tool once empirically tested, which is what we will do in the remainder of this paper. In particular, we will test on the basis of an extensive survey whether the six dynamic capabilities as distinguished by Den Hertog et al. (2010) can indeed be identified empirically in firms engaging in service innovation.

3. Developing a measurement scale

Table 2 shows the research methodology and research design we follow in our scale development and testing process (Churchill, 1979; Anderson and Gerbing, 1988). Using recent insights from the management literature on dynamic capabilities, we start by refining the selected conceptualization. We then perform an exploratory analysis to assess which items could be included in our measurement scale, followed by confirmatory analysis for validity and reliability checks.

3.1. Refining the selected conceptualization

The theoretical foundations developed in recent contributions to the DCV allow us to refine and operationalize the selected set of dynamic capabilities for service innovation. Specifically, they guide us in the choice of which capabilities of the conceptualization by Den Hertog et al. (2010) to include or exclude, and how to formulate items for their measurement.

First, we consider the requirement that conceptualizations entail a multidimensional set of common but empirically distinct capabilities (Eisenhardt and Martin, 2000; Teece, 2007; Barreto, 2010). Since learning and adapting is explicitly defined as a meta-capability that helps an organization to reflect upon (and improve) the other capabilities, it is not a separate dimension of the same order as the others. Indeed, Den Hertog et al.'s (2010) expectation that learning is linked to all of the other dimensions also implies that it cannot be measured as a distinct capability.

Second, we checked whether each capability can be disaggregated into several constituting microfoundations (Eisenhardt and Martin, 2000; Foss, 2011). On this basis, we also excluded (un)bundling, since it does not reflect a dynamic capability that can be related to observable activities. The capability, as described by Den Hertog et al. (2010), essentially indicates whether an innovation is recombined or not: it is actually a property of innovation and thus a result of the strategic use of dynamic capabilities. Treating information about the outcome of an innovation process as a capability would lead to causal ambiguity, of which the DCV is frequently accused (Williamson, 1999).

Table 2. Research design for development of measurement scale

Phase	Step	Actions
Theoretical grounding	1. Identify constructs	Literature review
	2. (Re)define constructs	Use key properties of DCV to refine the selected framework
Instrument design	3. Generate scale items	Formulate items by identifying microfoundations (literature review and convergent interviewing)
	4. Test and revise scale items	Deploy pilot survey: interview respondents for ensuring clarity and validity of items
Data analysis	5. Exploratory analysis	Principal component analysis: identification of items that load well on the associated construct (use random half of data)
	6. Confirmatory analysis	Confirmatory factor analysis: assessing reliability, as well as convergent and discriminant validity (use other half of data)
	7. Correlation analysis	Estimate structural paths between constructs (using SEM)
	8. External validity	Assess relation with performance measures

DCV, dynamic capability view; SEM, structural equation modeling.

3.2. Instrument design

Given the abstract nature of dynamic capabilities, their operationalization provides a considerable challenge (Zahra et al., 2006). We developed multi-item 7-point Likert scales, which respondents rated from 'strongly disagree' to 'strongly agree', for each of the four remaining service innovation capabilities. The scales consisted of statements regarding the presence of particular firm activities, reflecting microfoundations at the level of concrete processes and structures (Teece, 2007). Since we are interested in a measurement scale that allows for comparative analysis, focusing on such routines is of greater use than exploring the various ways individuals execute them.

With respect to the development of actual items for the multi-item scale of each capability, the theoretical underpinnings of the original framework discussed at length in Den Hertog et al. (2010) and our own additional refinements discussed above guided us in ensuring content validity, i.e. the requirement that the items truly reflect the constructs they are supposed to measure (Churchill, 1979). Additionally, the dynamic capabilities' constructs had a prominent role in nine in-depth case studies of firms that varied in the degree to which they could consistently and continuously develop and implement service innovations. Convergent interviewing based on a semi-structured interview protocol enriched our understanding of organizational processes that may be part of the respective capabilities for service innovation.

After formulating our initial set of items, face-to-face interviews with researchers and pretests with respondents from various organization types and sizes delivered useful comments on how to improve the clarity and validity of the scales. Comments concerned unknown words, unclear phrases and queries about what to do when a question was not relevant to the respondent's situation. The final phrasing of the resulting 18 items, as well as the codes used in the remainder of this analysis, can be found in Table 3. In the design of our questionnaire, we followed procedural precautions, like guaranteeing respondent anonymity (Podsakoff et al., 2003).

Table 3. Survey items

Construct with underlying items	Item code
Sensing user needs and (technological) options	
• We systematically observe and evaluate the needs of our customers.	SensingA
• We analyze the actual use of our services.	SensingB
• Our organization is strong in distinguishing different groups of users and market segments.	SensingC
• Staying up-to-date with promising new services and technologies is important for our organization.	SensingD
• In order to identify possibilities for new services, we use different information sources.	SensingE
• We follow which technologies our competitors use.	SensingF
Conceptualizing	
• We are innovative in coming up with ideas for new service concepts.	ConcepA
• We find it hard to translate raw ideas into detailed services.[1]	ConcepB
• Our organization experiments with new service concepts.	ConcepC
• We align new service offerings with our current business and processes.	ConcepD
Coproducing and orchestrating	
• Our organization has problems with initiating and maintaining partnerships.[1]	CoprOrchA
• Collaboration with other organizations helps us in improving or introducing new services.	CoprOrchB
• Our organization is strong in coordinating service innovation activities involving several parties.	CoprOrchC
Scaling and stretching	
• We are able to stretch a successful new service over our entire organization.[1]	ScaleStretchA
• In the development of new services, we take into account our branding strategy.	ScaleStretchB
• Our organization is actively engaged in promoting its new services.	ScaleStretchC
• We introduce new services by following our marketing plan.	ScaleStretchD
• We find it difficult to scale up a successful new service.[1]	ScaleStretchE

[1]Item removed from final version of the scale.

3.3. Sampling profile

To test the newly developed scale empirically, we drew a sample from multiple industries, warranted by the broad reach of the service innovation phenomenon (Drejer, 2004; Gallouj and Djellal, 2010). Data were collected through a survey of single-business firms or business units, each with more than 10 full-time employees. Using databases from Bureau van Dijk, we retrieved the contact information of Dutch firms located in the Northern Randstad, the broad central region of the Netherlands where most national economic activity and population are concentrated. The questionnaire was sent to 8,054 firms and addressed to the chief executive officers or senior executives to ensure that the respondents were knowledgeable about the key firm processes under investigation in this study (Miller et al., 1998). The questionnaire was administered by mail with the option to be filled in via the web if preferred. We obtained complete responses on our scale from 391 firms, or a 5% response rate, which is common for similar types of research. There were only minor differences in the firm and demographic profiles of respondents versus non-respondents; the majority of respondents were small (84%) or medium-sized firms (13%), mostly stemming from services (76%), industry (11%) or construction sectors (8%).

3.4. Data preparation

Since the constructs we aim to measure have only been developed conceptually in earlier works (Den Hertog et al., 2010), our operationalization required an exploratory step (Gerbing and Hamilton, 1996). Following Anderson and Gerbing (1988), we used a two-stage process for the exploration and validation of the factorial structure of questionnaire items. In order to do so, we split our dataset into two equal parts of randomly chosen cases. Dataset 1 ($n = 196$) was used for principal component analysis (PCA), whereas dataset 2 ($n = 195$) was used for the subsequent confirmatory factor analysis (CFA).

4. Data analysis

4.1. Item reduction for measurement purification (exploratory analysis)

Our measurement scale was constructed as follows. We entered all 18 items in a PCA on dataset 1. A dataset of 196 responses was sufficient to test all the constructs at once, given the fulfilled requirement of a 5 to 1 ratio of sample size to the number of estimated parameters (Shook et al., 2004). The Kaiser–Meyer–Olkin measure (0.84) for sample adequacy was sufficient and above the critical value of 0.50.

The varimax-rotated PCA reproduced the anticipated structure of factor loadings reasonably well. However, the items for sensing user needs and (technological) options appeared to load on two distinct factors. The first three items can be associated with the intelligence unction focused at what customers want, whereas the second set of three items mainly relate to sensing possibilities for producing a new offering. The observation that keeping up-to-date with market developments consists of two (sub)capabilities concerning demand and supply matches the ‘customer orientation’ and ‘competitor orientation’ by Menguc and Auh (2006).

Furthermore, four items were dropped from the analysis: three reverse-coded items (ConcepB, CoprOrchA, ScaleStretchE) loaded on none of the five factors, and one item (ScaleStretchA) loaded on three of the five factors, with factor loadings below the critical threshold of 0.60 (Flynn et al., 1994). Table 4 shows the component structure for the remaining set of items. The items showed also strong internal consistency with Cronbach’s alphas above 0.70 (Nunally, 1978).

4.2. Assessing reliability and validity (confirmatory analysis)

Reliability and validity of the resulting scale were then reassessed by performing CFA on the second dataset ($n = 195$) using AMOS 18 (IBM Corporation, Armonk, New York, United States).

Table 5 lists the measures for estimation of the model fit, indicating that the five-factor measurement model fits our data rather well. The chi-square/degrees of freedom (χ^2/df), the goodness-of-fit index, the Tucker-Lewis coefficient, the normed fit index, the comparative fit index and the root mean square error of approximation were all above the respective acceptance levels commonly used in the literature (Hair et al., 1998).

According to the composite reliability measures in Table 6, all above the 0.70 standard, the measurement items sufficiently represented their respective constructs (Bagozzi and Li, 1988). Moreover, the percentages of average variance extracted exceeded 0.50, indicating that for each construct a sufficient amount of variance is accounted for by the items rather than by measurement error (Fornell and Larcker, 1981).

Apart from supporting construct reliability, Table 6 also provides evidence for convergent validity. The standardized factor loadings of the items

Table 4. Results from principal component (five factors) on dataset 1 ($n = 196$), after removing inversely framed items

Items (code)	Factor loadings				
	F1	F2	F3	F4	F5
SensingA				0.724	
SensingB				0.761	
SensingC				0.666	
SensingD			0.804		
SensingE			0.759		
SensingF			0.760		
ConcepA		0.729			
ConcepC		0.827			
ConcepD		0.695			
CoprOrchB					0.815
CoprOrchC					0.881
ScaleStretchA	0.436	0.409			0.446
ScaleStretchB	0.716				
ScaleStretchC	0.734				
ScaleStretchD	0.800				
Cumulative % of total variance explained	40.07	50.00	58.109	65.30	71.07
Cronbach's alpha	0.748	0.813	0.776	0.753	0.748

Notes: Loadings below 0.4 are suppressed. Cronbach's alpha is calculated on the basis of items loading above 0.6.

Table 5. Model fit values of CFA on five-factor model

	Value	Acceptable level of excellent fit	Acceptable level of reasonable fit
df	67		
χ^2	122.6		
χ^2/df	1.83	< 3	< 5
GFI	0.921	> 0.95	> 0.90
TLI	0.934	> 0.95	> 0.90
NFI	0.901	> 0.95	> 0.90
CFI	0.952	> 0.95	> 0.90
RMSEA	0.065	< 0.05	< 0.10

Note: Results are based on dataset 2 ($n = 195$).
CFA, confirmatory factor analysis; CFI, comparative fit index; GFI, goodness-of-fit index; TLI, Tucker-Lewis coefficient; NFI, normed fit index; RMSEA, root mean square error of approximation.

were all significant ($P < 0.05$) and generally above the critical value of 0.60 (Eisenhardt, 1988).

Finally, the discriminant validity of our measurement scale can be assessed with the values in both Tables 6 and 7. With the exception of one pair of constructs, the correlations between the capabilities were below the square root of variance extracted for each of them (Table 7). This indicates that, in general, the items of a dimension are more related to each other than to other dimensions (Fornell and Larcker, 1981). Sensing (technological) options and conceptualizing shared a relatively high amount of variance, but their correlation exceeded the square root of the average variance extracted for each of those respective constructs only minimally (Table 6). Moreover, both the maximum shared squared variance and average shared squared variance values were below the average variance extracted (Hair et al., 1998). We also compared the CFA measurement model with nested models where the covariances between pairs of constructs were each constrained to 1. All these models were found to have a lower goodness of fit. The test results imply that the discriminant validity of the constructs is supported, indicating that dynamic capabilities cannot just conceptually but also empirically be discriminated into several distinct capabilities (Teece, 2007).

4.3. Assessing common method variance

The factor loadings in the PCA results suggest convergent validity (or unidimensionality) for the items within the constructs, and the presence of five distinct factors suggests discriminant validity. Harman's one-factor test for the possibility of a common method bias showed that restricting the PCA to one factor returns a factor that only explains 40% of the variance, and thus less than 50% of the total variance extracted (Podsakoff et al., 2003). Following Love

Table 6. Standardized factor loadings, composite reliability (CR), percentage of average variance extracted (AVE), maximum shared squared variance (MSV) and average shared squared variance (ASV)

Construct with underlying items	Factor loading	CR	AVE	MSV	ASV
Sensing user needs		0.791	0.561	0.413	0.313
• SensUserA	0.69				
• SensUserB	0.85				
• SensUserC	0.69				
Sensing (technological) options		0.834	0.629	0.549	0.369
• SensingD	0.86				
• SensingE	0.85				
• SensingF	0.65				
Conceptualizing		0.793	0.564	0.549	0.382
• ConcepA	0.76				
• ConcepC	0.85				
• ConcepD	0.63				
Coproducing and orchestrating		0.794	0.659	0.240	0.161
• CoprOrchB	0.78				
• CoprOrchC	0.84				
Scaling and stretching		0.750	0.505	0.336	0.253
• ScaleStretchB	0.56				
• ScaleStretchC	0.77				
• ScaleStretchD	0.77				

Note: Results are based on dataset 2 ($n = 195$).

Table 7. Standardized correlations matrix, with square root of variance extracted (on diagonal)

Dimensions	1	2	3	4	5
Sensing user needs (1)	*0.71*				
Sensing (technological) options (2)	0.643	*0.78*			
Conceptualizing (3)	0.633	0.741	*0.74*		
Coproducing and orchestrating (4)	0.375	0.447	0.490	*0.77*	
Scaling and stretching (5)	0.546	0.559	0.580	0.254	*0.72*

Note: Results are based on dataset 2 ($n = 195$).

et al. (2014), an additional test with a marker variable (Lindell and Whitney, 2001) was performed. When we extended our PCA with items for ambiguity tolerance, a theoretically unrelated concept that was part of our survey as well, the original pattern of capability-related item loadings on different factors remained the same. The finding that our marker variable hardly correlates with the earlier retrieved principal components indicates that common method bias is not likely to be an issue (Love et al., 2014).

To validate the discriminant validity of the measurement scale further, we inspected to what extent correlations between constructs might be caused by common method bias. A common latent factor was included in the CFA model (Podsakoff et al., 2003). This did improve significantly the model fit ($\Delta\chi^2$/df = 0.246 $P < 0.001$), but the improvement was only incremental (Δrho = 0.017), and the factor loadings for the constructs all remained significant and above the threshold levels. These findings suggest that although some common method variance may be present, it did not bias the structure of the measurement model and the respondents could generally differentiate among the concepts.

4.4. Correlations among the constructs

Our analyses showed that although distinctive, the five dynamic capabilities were also correlated. This begs the question whether a firm can develop a DSIC

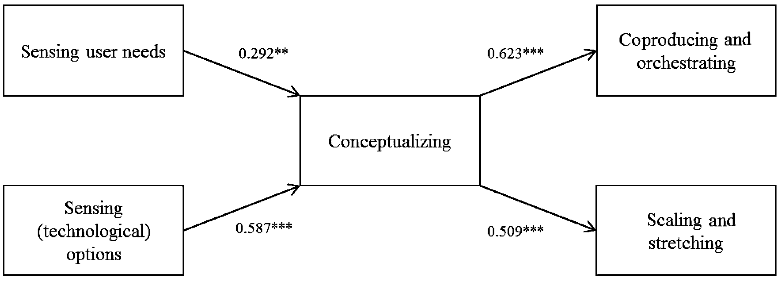

Figure 1. Correlations among the constructs, standardized regression weights. Results based on dataset 2 ($n = 195$). χ^2/df = 1.85; goodness-of-fit index = 0.916; Tucker-Lewis coefficient = 0.932; normed fit index = 0.892; comparative fit index = 0.946; root mean square error of approximation = 0.066. **$P < 0.005$; ***$P < 0.001$.

related to a particular stage of knowledge transformation, without possessing the DSIC that should be enacted in a preceding stage of the innovation process (e.g. searching knowledge). We extended our analysis by building a structural path model among the constructs, using structural equation modeling (SEM) in AMOS 18.

In line with the implicit sequences in the evolutionary processes of novelty creation (Zollo and Winter, 2002; Teece, 2007; Love et al., 2011), our specification followed the order in which capabilities have to be used when acquiring, converting and applying knowledge. Thus, we linked sensing user needs and sensing (technological) options to conceptualizing, which in turn was linked to coproducing and orchestrating, and scaling and stretching. Figure 1 presents the regression coefficients of the structural model. The SEM had a similar goodness of fit with respect to the CFA model, and shows that all of the structural paths are significant.

Analysis of the correlations among the measured constructs confirms that the capabilities should not be seen as completely orthogonal, but that they form a coherent set of complementary constructs. A significant relation between the two sensing capabilities on the one hand, and conceptualizing on the other hand, suggests that translating rough ideas into detailed propositions occurs more in firms that can sense signals in the first place. Similarly, capabilities for the (co)production and upscaling of such a proposition are particularly present in firms that are able to conceptualize. These findings, derived from measuring capabilities, are consistent with the general belief that exploration and conceptualization need to precede exploitation (Roper et al., 2008). It appears to be uncommon for firms in our sample to invest only in one particular type of DSIC: regardless whether it is intentional or not, they rather develop capabilities with relevance through the whole spectrum of knowledge sourcing, transformation and exploitation. To what extent this strategy is preferable for the successful development of service innovations remains to be tested in further research.

4.5. *Nomological validity: the relation with innovativeness and firm performance*

Finally, we assess the nomological validity of our constructs by examining whether their occurrence is empirically associated with correlations we would also expect on a theoretical basis. The interest in dynamic capabilities stems from the assumption that they are of importance for realizing new solutions, and ultimately enhancing a firm's competitive position (Teece et al., 1997). By using other variables present in our survey, we are able to put this to the test.

According to the statistics in Table 8, firms who have stronger DSICs also tend to perform better. First, we see that that presence of several capabilities has a positive correlation with gaining turnover from improved rather than existing products (including both goods and services). This holds for the sensing capabilities as well as the conceptualizing one, but only the latter is also significantly related to the percentage of sales coming from entirely new products.

The findings for comparative firm performance tell a similar story. In general, there is a positive correlation between the total strength of a firm's capabilities and the variables that reflect its competitive position. We also observe, again, that the relation with individual capabilities might point at more nuanced patterns. For instance, coproducing and orchestrating is significantly correlated with having a rapid growth in market share, whereas scaling and stretching is now related to none of the outcome variables.

Together, the encountered correlations also emphasize the discriminant validity of the constructs:

not every capability is related to each performance measure. Empirical evidence of this kind invites us to explore deeper under what exact circumstances the DSICs do relate to innovativeness or firm performance, and whether this is truly a causal relationship.

5. Conclusions

5.1. Discussion

How new services come about is a question asking for concepts and frameworks that differ from the ones used for studying product innovation. While theoretical research on firm-level capabilities for service innovation is providing alternative conceptual frameworks, empirical research so far has only offered scattered and hardly comparable results. This paper contributes to this research gap by providing a basis for empirically gauging the relative strength of DSICs. We have shown how the chosen framework (by Den Hertog et al., 2010) consolidates – and even goes beyond – earlier attempts to conceptualize dynamic capabilities for service innovation. As the framework is unique in its service innovation specificity and wide applicability across sectors, we selected it as the basis for operationalizing the type of measurement scale scholars have urged for.

By providing detailed clues on actual routines (activities and processes), the conceptual framework by Den Hertog facilitated the development of concrete measurement items. In our exploratory and CFAs, we identified that sensing user needs and sensing (technological) options rely on routines that essentially differ. Besides the finding that discriminative validity is generally sufficient for each of the five remaining capabilities, the fact that convergent validity is high reflects that our routine-based items are empirically mostly associated with their respective capabilities.

The broad scope of the selected set of DSICs makes it relevant for the comparative perspective that it is imperative to develop a relative measure for service innovation activities among a wide range of firms. Within a synthesis approach, scholars are being urged to focus on service innovation activity, irrespective of the industry in which it is performed (Rubalcaba et al., 2012). Our main contribution lies in advancing such a synthesis approach to service innovation by operationalizing a capability framework that combines service specificity with the theoretical foundations of the current DCV. Moreover, by building on evolutionary theorizing, we contribute to recent efforts to place service innovation in a Schumpeterian perspective (Drejer, 2004; D'Alvano and Hidalgo, 2011; Leiponen, 2012).

Table 8. Relation between capability strengths and performance measures ($n = 195$)

	Mean	Std. dev.	Sensing User Needs	Sensing (Techn.) options	Conceptualizing	Coproducing and orchestrating	Scaling and stretching	Sum of capability strengths
Percentage of revenues coming from . . . (100% in total)								
. . . unchanged goods and/or services	71.46	22.26	–0.175*	–0.280**	–0.299**	–0.107	–0.182*	*–0.280***
. . . improved goods and/or services	17.89	15.76	0.193**	0.328**	0.275**	0.131	0.120	*0.281***
. . . new goods and/or services	10.70	12.98	0.058	0.073	0.172*	0.021	0.162*	*0.133*
In comparison to our competitors . . . (7-point Likert scale)								
. . . our organization generated a higher return on equity in the past year.	4.16	1.69	0.220**	0.124	0.163*	0.027	0.095	*0.169**
. . . we had more profit growth in the past year.	3.76	1.78	0.221**	0.123	0.201**	0.134	0.121	*0.218***
. . . we had more turnover growth in the past year.	3.92	1.80	0.283**	0.176*	0.204**	0.142	0.137	*0.256***
. . . we had a faster growing market share last year.	3.97	1.66	0.304**	0.202**	0.267**	0.178*	0.127	*0.292***

Note: Pearson's correlations, **significant at the 0.01 level (two-tailed); *significant at the 0.05 level (two-tailed).

Apart from comparisons across firms (individual or clustered by sector, region or any other system), a primary way to determine which capability deserves more attention is by looking at the balance between the various types of capabilities. Besides explicitly involving the idiosyncrasies of services, consistent with the demarcation approach, the framework proposed by Den Hertog et al. (2010) also builds on evolutionary processes of innovation generation that are implicitly present in the assimilative conceptualizations directly based on work by Teece (2007). Therefore, it enables us to identify which specific aspect of novelty exploration and exploitation is strong and which is weak. Rather than simply inferring low capability levels from observing a lack of realized innovations, a form of tautology heavily criticized in the DCV (Williamson, 1999), the operationalized conceptualization allows for a more detailed diagnosis of what type of routines are perceived to be truly (under)developed.

5.2. Research implications

The proposed measurement scale allows for several avenues of future research. First, it provides a comparative measure that can capture the variation in how different organizations or groups of organizations shape their innovative abilities. The scale might be useful for analyzing why differences occur. Apart from firm characteristics such as size, age or geographical location, variation in the perceived strengths of capabilities is likely to depend on the sector where a firm is operating and the strategies it follows (Zahra et al., 2006). Thanks to its high level of communality, the operationalized framework is able to shed light on the question whether manufacturers that successfully engage in servitization have different strengths than innovative 'pure' service providers (Kindström et al., 2012). In this light, future research can investigate whether a capability differential is somehow related to issues like industry maturity or market velocity (Barreto, 2010).

Uncovering the organizational antecedents of service innovation is still one of the main challenges in (service) innovation literature (Ostrom et al., 2010). Therefore, a logical complement to descriptive explorations is the further investigation (and contextualization) of the relation between well- or underdeveloped capabilities and measures of innovation output or performance. Having a common basis for comparing the presence of innovation activities within firms allows scholars to address questions regarding service competitiveness (Bryson et al., 2012) and the 'innovation gap' in services (Gallouj and Djellal, 2010). So far, studies in the DCV tend to find contradicting results (Ray et al., 2004; Zahra et al., 2006), possibly due to different settings. Looking at the domain of services, the availability of our measurement scale provides opportunities to assess under what conditions firms with strong service innovation capabilities actually do realize innovative output.

Routed in evolutionary theories, the proposed measurement scale gives insight in the extent to which firms possess in-house routines that allow them to generate, transform and apply knowledge. Therefore, it can nurture emerging debates on service firms' knowledge processing activities (e.g. Consoli and Elche, 2014). According to some authors, access to the capabilities of partners might be a substitute for developing and maintaining them internally (Van de Vrande et al., 2010). Also in the context of services, the topic of open innovation has been gaining ground in recent years (Chesbrough, 2011). How openness and cocreation should be managed remains unclear (Rubalcaba et al., 2012), but it seems likely that capabilities have distinct roles in the various stages of collaboration (Den Hertog et al., 2010; Love et al., 2011). Following Lichtenthaler and Lichtenthaler's capability-based framework for open innovation (2009), it seems worthwhile to investigate which configuration of service innovation capabilities can be associated with the success of cooperation patterns (Tether and Tajar, 2008).

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Notes

1. In this paper, we follow the general practice of using the term ‘product innovation’ to refer to new technology-based products developed predominantly by manufacturing firms. According to the Oslo Manual for measuring innovation, however, product innovation covers both new goods and new services (OECD, 2005).
2. To emphasize that the term ‘technology’ here is consistent with the common meaning of ‘technological knowledge’, which is broader than only artifact-related knowledge, we place it in brackets.

Matthijs J. Janssen is PhD candidate at the School of Innovation Sciences, Eindhoven University of

Technology, Researcher and Consultant at Dialogic Innovation and Interaction, Utrecht, and Researcher at the Copernicus Institute of Sustainable Development, Utrecht University. He is currently investigating the application of evolutionary theories for creating a better understanding of service innovation processes and output. The resulting insights, in turn, serve to position services better in theories of industrial evolution and economic diversification. Matthijs' (service) innovation research covers both firm-level as well as policy analyses for national and supranational authorities.

Carolina Castaldi is Assistant Professor at the School of Innovation Sciences, Eindhoven University of Technology. Her research spans the economics and management of innovation, and she is particularly interested in service innovation. Herein, her research deals mostly with the conceptualization and measurement of service innovation.

Alexander Alexiev is Assistant Professor in Strategic Management and Innovation at VU University Amsterdam where he teaches courses on services management and behavioral strategy. His main research focus is on the organizational and management aspects of the use of advice in strategic decision making. He studies service innovation in the contexts of professional service firms, cultural organizations and new ventures. He obtained his PhD from the Rotterdam School of Management, Erasmus University.