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SURVEY MEASURES OF FIRST- AND SECOND-ORDER COMPETENCES

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Research summary: *This study tests and validates survey measures of first- and second-order competences in order to foster cumulative empirical research and theoretical refinement in the area of dynamic capabilities. Data from two informants and two time periods for a sample of publicly traded U.S. manufacturing firms are used to examine the convergent, discriminant, and nomological validity, and the reliability of scales to measure various levels and types of competences. Findings suggest that customer competence, technological competence, marketing competence, and R&D competence are related but distinct dimensions, evidencing strong validity and reliability. Qualifying this empirical support, it was found that items regarding manufacturing operations and facilities seemed to measure aspects unrelated to the focal competences, and that marketing competence had no relation to future market-resource accumulation.*

Managerial summary: *This study enhances understanding and measurement of dynamic capabilities, in particular, marketing and R&D second-order competences. Marketing and R&D second-order competences are a firm's ability to build new competences to serve new markets or use new technologies, respectively. The ability of a firm to add new market-related resources (such as brands and distribution channels) and technological resources (such as patents and engineering skills) helps it cope with environmental change and grow in new directions. For firms in stable environments, being able to serve new markets and use new technologies provide opportunities for growth. For firms in turbulent environments, these skills are a matter of survival. Using data collected from publicly traded U.S. manufacturing firms, this study tests and validates questions that can be asked in questionnaires presented to management. It finds that even if a firm has strong skills in serving current customers and great technology, it may not be able to go after new markets or technologies. The survey questions tested here could be used not only by other researchers, but also by practitioners. Managers, management consultants, and industry association advisors could use the scales as diagnostic instruments or to perform benchmarking.*

INTRODUCTION

Dynamic capabilities research is becoming increasingly empirical. A range of methods to study dynamic capabilities has recently been applied, from the historical case by Danneels (2011) on the demise of typewriter manufacturer Smith Corona to Stadler, Helfat, and Verona's (2013) econometric analysis of archival data in oil exploration to the surveys in Drnevich and Kriauciunas (2011) to measure the use of IT to support or develop capabilities.

These empirical studies have helped to clarify the notion of dynamic capabilities, which in its early stage was criticized for being "vague and elusive" (Kraatz and Zajac, 2001: 653). An ambiguous concept is unlikely to lead to solid research findings. This article follows the agenda

Keywords: dynamic capabilities; second-order competences; survey scales measuring strategy concepts; construct validity
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set by Giudici and Reinmoeller (2012: 445) in their review article: "Despite the construct's progress, we need much more empirical research on dynamic capabilities. … We maintain that an increase in carefully crafted empirical work would enhance the chances of challenges to the construct's validity being overcome by both strengthening the recognition of dynamic capabilities in academia and supporting its relevance for external practitioners." To foster this move toward empirical work, I propose and test several measures of second-order competences, a subset of dynamic capabilities, and examine their relations with related constructs.

Research attention in dynamic capabilities "… so far has focused on the definitional issues more than on the technical problems related to the measurement of capabilities" (Grant and Verona, forthcoming). As a relatively young area of strategic management research, the area of dynamic capabilities lacks generally accepted approaches to measure its key constructs. Measuring dynamic capabilities is challenging (Ambrosini and Bowman, 2009; Giudici and Reinmoeller, 2012), and each approach has strengths and weaknesses. One approach is to infer their presence from firm performance outcomes; however, this risks tautological reasoning. It also conflates potential with realization. On the one hand, a competence provides the potential to perform an activity skillfully and purposefully (Helfat *et al.,* 2007), but this option is not necessarily exercised. On the other hand, many extraneous factors could impact actual outcomes.

One approach to avoid the tautology problem is to measure dynamic capability in a way that is distinct from the outcomes of utilizing these capabilities. For instance, Stadler *et al.* (2013) measured the potential for a firm to obtain and develop new resources (the technological sophistication of upstream oil firms' seismic imaging and well drilling technologies) and used these measures to predict the actual amount and success of resource access and development activities (actual oil exploration and development).

Measuring dynamic capabilities using archival data such as in Stadler *et al.* (2013); see King and Tucci, 2002 for another example) avoids perceptual biases associated with first-hand reports. Archival data may also be more readily available. However, the archival measures were not originally collected to measure the constructs researchers have in mind, and may thus lack construct validity (Ketchen, Ireland, and Baker, 2013).

In contrast, survey measures can provide the most direct measures of dynamic capabilities (e.g., Capron and Mitchell, 2009; Danneels, 2008; Drnevich and Kriauciunas, 2011; Sirmon *et al.,* 2010), but they rely on accurate reporting by managers on their firm, most often relative to competitors. These measures may be subject to reporting biases (c.f. Denrell, Arvidsson, and Zander, 2004). For self-report measures to be valid, managers need accurate "resource cognition" (Danneels, 2011) on their firm's resources and competences.

A comprehensive review of the ways dynamic capabilities have been measured is outside of the scope of this article (see Grant and Verona, 2015 for a critical overview). Rather, it is my intention to focus on the survey measurement approach. This study contributes to strategic management research by providing researchers with valid and reliable scales of first- and second-order competences. These survey measures may, in turn, be used, modified, and extended by future empirical researchers, and thus foster cumulative findings that help build a coherent body of knowledge. The next section defines the key concepts and puts them in the context of the dynamic capabilities literature.

KEY CONCEPTS

As Grant and Verona (forthcoming) noted: "Some of the empirical difficulties of identifying and measuring competences have their root in conceptual imprecision." Therefore, I first carefully lay out the key concepts before I test their measures. A *competence* (here, used interchangeably with *capability*) is defined as the ability to perform an activity using a set of resources (Amit and Schoemaker, 1993; Grant, 1991; Helfat and Peteraf, 2003). It refers to "a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end" (Amit and Schoemaker, 1993: 35). The firm is "able" in the sense that it can carry out the specific activity purposefully, repeatedly, reliably, and in an at least minimally satisfactory manner (Helfat and Winter, 2011; Helfat *et al.,* 2007). A *capability* implies a capacity to potentially perform an activity (Winter, 2003); it may lay dormant for much of the time, only deployed on occasion (Helfat and Peteraf, 2009).

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I build on the distinction made between lower- and higher-order competences in the organizational learning and dynamic capabilities literatures. Levinthal and March (1993: 103, italics added) made the following distinction: "Knowledge that has clear, immediate uses is *specialized to current technologies and markets.* It is easily specified and has relatively early and local returns. Broader or deeper knowledge is less likely to have immediate pay-off but results in a greater *ability to adapt to changes.*" Winter (2003: 991, italics added) described an organizational capability as conferring "a set of decision options for producing significant outputs of *a particular type*"—while a dynamic capability "would *change* the product, the production process, the scale, or the customers (markets) served" (Winter, 2003: 992). "Ordinary" capabilities (also sometimes called "operational") are those that enable an organization to perform the ordinary or regular business activities (Helfat and Winter, 2011; Winter, 2003), whereas dynamic capabilities enable "a firm to alter how it currently makes its living" (Helfat and Winter, 2011: 1244). Making a similar distinction of level, King and Tucci (2002) contrasted "operating routines"—which result from "static experience"—with "change routines"—which result from "transformational experience." Operating routines refer to how to serve a particular market niche, whereas change routines refer to conducting organizational change by entering new markets. Gruber, MacMillan, and Thompson (2013) noted that technology start-ups with greater marketing experience on the founding team identified fewer market opportunities. They explained this counterintuitive finding by arguing that founders with marketing backgrounds "tend to have local market knowledge, not second-order competence to identify alternative markets" (2013: 293).

Eisenhardt and Martin (2000) defined *dynamic capability* as the ability of a firm to alter its resource base, in one of three ways: adding new resources/competences, recombining/reconfiguring these resources/competences, and dropping existing resources/competences. Similarly, Helfat and her co-authors (2007: 4) defined *dynamic capabilities* as "… the capacity of an organization to purposefully create, extend, or modify its resource base." The "creating" or "adding" aspect of dynamic capability has been referred to as a *second-order competence* and defined as the competence to build new first-order competences (Danneels, 2002, 2008, 2012).[1]

By adding new resources and competences, second-order competences create "flow" in the "stock" of resources and competences of a firm (c.f. Ambrosini and Bowman, 2009; Dierickx and Cool, 1989). According to dynamic capability theory, firms are heterogeneous not just in their stock of resources, but also in their ability to produce flow of resources (Danneels, 2012). Adding new competences to the firm's repertoire is important for its continued prosperity in a changing environment (Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Teece, Pisano, and Shuen, 1997). Environmental changes make previously acquired competences obsolete, and call for new competences to be built (Cooper and Smith, 1992; Schumpeter, 1942).

In particular, this article focuses on two key second-order competences: marketing and R&D second-order competences as popularized by Danneels (2002, 2007, 2008, 2011, 2012).[2] Marketing and R&D second-order competences are defined as building new competences to serve new markets or use new technologies. Simply put, marketing second-order competence reflects how good a firm is at accessing new markets and R&D second-order competence reflects how good the firm is at mastering new technologies. Second-order marketing and R&D competences reflect the firm's ability to add new customer and technological competences, respectively (Danneels, 2002).

In contrast, technological and customer competences are first-order competences. First-order competences are "local"—specific to a particular technology or a customer base (c.f. Gruber *et al.,* 2013). They enable a firm to currently "make a living" by serving its current customers using its current technology (c.f. Winter, 2003). A technological competence allows a firm to make products, and a customer competence enables the firm to exchange

[1] This distinction parallels Winter's distinction between zero- and first-order capabilities. However, Winter's notion of first-order capabilities is broader as witnessed in his definitions (page 991): "Defining ordinary or 'zero-level' capabilities as those that permit a firm to 'make a living' in the short term, one can define dynamic capabilities as those that operate to extend, modify or create ordinary capabilities." The notion of *second-order* as used here refers only to the creation of capabilities, and is hence narrower. Because it is my intention to build on the empirical work by Danneels (2002, 2007, 2008, 2011, 2012) I follow the latter usage.

[2] The following terms and definitions closely follow Danneels (2002, 2007, 2008, 2011, 2012).

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these products for money with its customers (Danneels, 2002; Mitchell, 1992; Vorhies and Morgan, 2005). I define *customer competence* as the ability of a firm to serve a particular group of customers, and technological competence as the ability of a firm to produce physical products with particular features. *Competence* refers to an ability to accomplish something by using a set of tangible (e.g., equipment, machinery, mail list) and intangible resources (e.g., manufacturing know-how, understanding of customer needs). A competence thus has material as well as cognitive components. Customer competence consists of such resources as knowledge of customer needs, customer purchasing procedures, and competitors, distribution and sales access to customers, customer goodwill or franchise reflected in the reputation of the firm and its brands, and communication channels for exchange of information between the firm and customers. Technological competence consists of such resources as engineering know-how, manufacturing facilities and know-how, and technical design expertise.

Second-order marketing and R&D competences can then be thought of as the ability to add new customer and/or technological competences to the firm's repertoire, respectively. The notion of a second-order marketing competence emphasizes the firm's ability to identify and build relationships with customers it does not yet have, which involves building new resources in order to serve those new customers. Similarly, a second-order R&D competence reflects the ability of the firm to build new technological competences, constituted by the assembly of a set of new technical resources (c.f. the definition of competence). A second-order marketing competence involves skills in such areas as: assessing the potential of new markets, building relationships in new markets, setting up new distribution and sales channels, leveraging brand/company reputation to new markets, researching new competitors and new customers, developing new advertising or promotion strategies, and developing new pricing strategies. A second-order R&D competence involves skills in such areas as: setting up new types of manufacturing facilities and operations, identifying promising new technologies, assessing the feasibility of new technologies, and recruiting engineers in new technical areas.

Previous research has identified organizational characteristics that have a causal relation with these second-order competences (slack, environmental scanning, constructive conflict, and willingness to cannibalize; Danneels, 2008). Recent research has also found that these competences, in turn, affect the firm's financial performance, contingent on competitive turbulence (Danneels, 2012).

This article examines the convergent, discriminant, and nomological validity of a set of survey items developed to measure first and second-order competences. Data from two informants and two time periods for a sample of publicly traded U.S. manufacturing firms suggest that customer competence, technological competence, marketing competence, and R&D competence are related but distinct dimensions.

SAMPLE AND DATA COLLECTION

Sampling frame

Survey and archival data were collected on public manufacturing firms headquartered in the United States. The sampling frame was drawn from the Compustat database. Single business dominant manufacturing firms (2000–3999 SIC codes) were selected for the study to minimize intrafirm heterogeneity regarding organizational and environmental characteristics. Even though these firms are relatively undiversified, they may be involved in various markets and technologies. The comparability among firms in the sample was further enhanced by eliminating the following from the sampling frame: service firms or distributors, firms that outsource all manufacturing, contract manufacturers, and firms without commercial products. This screening led to a sampling frame of 302 firms that were sent questionnaires in the year 2007. The respondents to this survey were again approached in 2009.

Survey data collection procedures

I collected data in 2007 and in 2009. I therefore have data collected at two points in time separated by two years. In each of these two years, one or two respondents per firm filled out an identical questionnaire. In what follows, the measurement analyses are based on first respondents in 2007 and 2009. On the other hand, the regression analyses use both first and second informant responses in 2007 and 2009 (averaged across the two respondents, if available). Respondents were identified from the list of company officers in the firm's annual report or

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proxy filings or company websites. The titles and biographies of officers were examined to identify the most appropriate and knowledgeable potential respondents. Three waves of questionnaires were mailed to each respondent, followed after one week with an email reminder. Personalized cover letters explaining the purpose of the study and assuring confidentiality were sent. Respondents received preaddressed stamped envelopes to return the completed questionnaires. Additionally, each respondent was telephoned twice with the request to return the survey. Respondents could also fill out the questionnaire on the Web. Study summaries, charity donations, and gift certificates were used as incentives to increase the response rate. Questionnaires were received from 154 respondents from the population of 302, yielding a response rate of about 51 percent. At those companies that responded, a second informant was pursued. Consequently, 76 questionnaires were received from a second informant, for about 49 percent. The responding firms were compared against nonrespondents on key firm characteristics: annual sales, total assets, return on assets, and number of employees. No significant differences in the means were found, which suggests that nonresponse bias is not a serious concern.

The same procedures were used in 2009. Of the 154 firms observed in 2007, 21 had ceased to exist by 2009 because they were acquired or dissolved. The remaining 133 firms were researched to examine changes in contact information. To the extent possible, the same informant that provided data in 2007 was approached in 2009. In 72 percent of the firms observed in 2009, responses were obtained from at least one of the same informants as in 2007. In other cases, a replacement was identified. The 2009 data collection effort resulted in 108 responding firms (81% of the firms still in existence), of which 60 provided a second informant (about 56% of 2009 responding firms).

Sample descriptive information

On average, the 154 responding firms in 2007 had 4,305 employees (median = 1,397, σ = 8,375) and $1,023 million annual sales (median = $327 million, σ = $1.858 billion). Their mean age was 34.8 years since incorporation (median = 24, σ = 26.2 years). Of the firms in the sample, 67.5 percent were traded on NASDAQ and 32.5 percent on the NYSE. The 108 firms that responded again in 2009 had 4,200 employees (median = 1,000, σ = 8,712) and $951 million annual sales (median = $327 million, σ = $1.892 billion). Their mean age was 39.3 years since incorporation (median = 28.5, σ = 26.2 years). Of these firms, 63.9 percent were traded on NASDAQ and 36.1 percent on the NYSE.

All respondents were top managers in their corporation (vice president or above). First respondents in 2007 had, on average, 11.4 years of experience with their firm and 19.7 years of experience in their firm's industry (second respondents: 10.9 and 19.8), and scored 6.0 and 6.3 on seven-point questionnaire items measuring confidence in the survey responses and level of involvement with strategic decisions (second respondents: 6.1 and 6.1). Thus, respondents were competent key informants. Of the respondents, 47 percent were general managers such as CEO, COO, or president (second respondents: 21%), 19 percent had a commercial function such as vice president of marketing, sales, or new business development (second respondents: 28%), and 32 percent had a technical function such as vice president of engineering, R&D, or manufacturing/operations (second respondents: 49%). The 2009 respondents were very similar.

MEASURES

I used archival sources of data for the size, age, and industry measures and survey data on the competences and resource accumulation constructs. The survey measures are partly based on published scales (Danneels, 2008) and partly on newly developed items (the measures of first-order competences; see below). All items are measured on seven-point scales, anchored by "not at all—to a great extent." Scale scores are calculated by simple summation of item scores (see Tables A1 and A2 for scale items and Table 1 for descriptive properties and bivariate correlations). To reduce the potential for social desirability bias, respondents were given explicit instructions to reflect the actual situation in their firm (see Notes to Table A1).

Second-order marketing competence, second-order R&D competence, first-order customer competence, and first-order technological competence. The competence scales asked respondents to rate how well or poorly they perceive their organization performs specific activities relative to competitors. Self-report measures that ask respondents to rate their firm's competences relative to competitors

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Table 1. Simple correlations and descriptive statistics[a]

	1.	2.	3.	4.
1. Marketing competence	4.3 (0.90)			
2. R&D competence	0.438**	4.7 (1.00)		
3. Technological competence	0.234**	0.565**	5.3 (0.90)	
4. Customer competence	0.685**	0.232**	0.356**	4.9 (0.99)

[a] Means and standard deviations are listed on the diagonal. Means and standard deviations of perceptual scales are expressed on seven-point scale metric. Calculations based on concurrent validity regression sample (n = 152).
**Significant at $p < 0.01$ (two-tailed).

have become well accepted in the literature (e.g., Capron and Mitchell, 2009; Conant, Mokwa, and Varadarajan, 1990; Denrell *et al.,* 2004; DeSarbo *et al.,* 2005; Sirmon *et al.,* 2010; Song *et al.,* 2005). These relative measures are consistent with recommendations in the literature to view resources and competences in comparison to other organizations performing similar activities (Sirmon *et al.,* 2010).

The second-order competences measures assess the firm's ability to create "flow" in its "stock" of resources and competences (c.f. Ambrosini and Bowman, 2009; Dierickx and Cool, 1989). This competence at adding resources/competences to current stock can be thought of as a *potential* flow, as it is not necessarily exercised. The second-order marketing competence scale consists of eight items that assess the ability of the firm to identify and access new markets. The second-order R&D competence scale consists of six items that assess the ability of the firm to identify and incorporate new technologies. These scales have previously been used in published research (Danneels, 2008, 2012).

In contrast, the first-order competence measures assess the "stock" of the firm's resources and competences (c.f. Dierickx and Cool, 1989). In particular, these scales assess the strength of the firm's current market-related resources and the strength of its current technological resources for the measure of customer competence and technological competence, respectively. The first-order measures of customer and technological competences consist of four items each, intended to measure the firm's ability to serve its current customers and use its current technology, respectively.

Market- and technological-resource accumulation. In contrast to the above measures of potential flow and stock, the measures of resource accumulation assess *realized* flow; the actual addition of new resources/competences (c.f. Dierickx and Cool, 1989). The measures used here, in particular, refer to whether the firm's new products introduced in the last year led to the accumulation of new resources (Danneels, 2002). Items asked the respondent to assess whether their new products led them to build new market-related and technology-related resources, respectively ($\alpha = 0.76$ and 0.79, respectively). Market-related resources include customer knowledge, company and brand reputation, and distribution and sales channels. The technology-related resources include production operations or facilities, technological expertise, and engineering expertise. This measure was newly developed for this study, based on prior qualitative research (Danneels, 2002). See Table A2 for the exact wording of the instructions to respondents and the items.

Control variables. I control for firm size, age, and industry. Firm size is measured in terms of the log of the number of employees. The number of employees was recorded from Compustat. Age is measured as the number of years since the firm was incorporated. Year of incorporation was recorded from Hoovers or the company website. I also include five industry dummies. Based on the business descriptions in Compustat and Hoovers, I inductively derived six industry categories: industrial supplies and components (27.8% of sample), electronic equipment (14.8% of sample), consumer nondurables (4.6% of sample), capital and process equipment (22.2% of sample), consumer durables (8.3% of sample), and biomedical devices (23.3% of sample). Hence, five dummy variables were included as control for the industry of the firm.

FINDINGS

To assess the convergent, discriminant, and nomological validity of the four competence constructs, I followed a procedure similar to Gatignon *et al.* (2002) and Govindarajan and Kopalle (2006).

To test the hypothesized factor structure, the measures were subjected to confirmatory factor analysis using Lisrel 8.8. Each item was allowed to load only on the factor for which it was the intended indicator. However, because certain marketing (Vorhies

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and Morgan, 2005) and technological activities may have idiosyncratic characteristics, I allowed for correlated errors among selected items.

Conducting a CFA without correlated errors makes an assumption of "local independence"—that manifest indicators are unrelated to each other when controlling for the common factor. However, in some cases items may tap additional sources of variation. Such secondary factors often create correlated residuals in a CFA and generate overall model misfit when not explicitly included in the analysis (Hopwood and Donnellan, 2010). Some particular types of resources might share some additional correlation above and beyond their association with a common competence factor. The existence of these residual correlations would contribute to model misfit if they were fixed to zero (Hopwood and Donnellan, 2010). Therefore, specific error terms were allowed to correlate because they may share variance not related to the general underlying competence, but specific to the activity tapped by two corresponding items. Some items were used to measure a reflective construct, but were expected to also each have unique characteristics. For instance, errors of items related to distribution and sales were allowed to correlate across the two levels of commercial competence (marketing and customer competence). I allowed for correlations among errors of the following sets of items relating to distinct resources (for full items, see Table A1): channels/sales force (MComp3 and MComp4, MComp3 and CComp3), reputation/image (MComp5 and CComp2), advertising/promotion skills (MComp7 and CComp4), and production/manufacturing (RDComp1 and RDComp6, RDComp1 and TComp1, RDComp6 and TComp1). Each of these pairs was associated with a large modification index in a CFA with error correlations constrained to zero, supporting their selection. These error correlations were allowed in each of the CFAs reported below.

Convergent validity refers to the degree to which multiple measures of the same construct are in agreement (Bagozzi, Yi, and Phillips, 1991). To assess convergent validity, I assess whether items related to particular resources and skills are associated with the competence they are assigned to (i.e., high loadings), and are not associated with the other competences (i.e., low cross-loadings). I assessed convergent validity by conducting CFAs on 2007 and 2009 data.

First, a four-factor model was assessed using the first informant from the 2007 survey (n = 154). The NNFI, CFI, and the RSMEA fit indices were: 0.943, 0.952, and 0.080, respectively ($\chi^2 = 401.838$, df = 196). These fit indices indicate a good fit of the confirmatory measurement model.[3]

Table 2 shows the item loadings derived from this CFA. Most loadings were quite large, evidencing convergent validity. However, the first items on R&D and technological competence had relatively low loadings (<0.5). Both items refer to manufacturing operations and facilities.

The modification indices associated with the cross-loadings were small, indicating that items were assigned to the appropriate constructs. The highest MI is 19.828, for TComp1 cross loading on customer competence. The second highest is 12.023 for MComp6 cross-loading on R&D Competence. All other modifications indices are smaller than 10.

For robustness, the same measurement model was also assessed using the first informant from the 2009 survey (n = 106; two firms were omitted because of lack of informant qualifications or missing data). For the loadings, see the second column of Table 2. The NNFI, CFI, and the RSMEA fit indices were: 0.954, 0.961, and 0.062, respectively ($\chi^2 = 297.415$, df = 196). Interestingly, the pattern of item loadings was very similar to the 2007 data, with again the items regarding manufacturing operations and facilities being problematic. In these data, the last item of R&D competence falls below the 0.5 threshold at 0.48, and the loadings on the first items of R&D and technological competence are now really low (0.23 and 0.30, respectively). The modification indices also parallel the 2007 data, with a MI of 21.07 of TComp1 cross-loading on customer competence (all other MI < 10).

Taken together, these results support convergent validity for the four measures of the different types of organizational competence. However, the items relating to operations/manufacturing seem to measure distinct aspects.

[3] Without allowing for the above-mentioned error correlations, this model shows poor fit (NNFI, CFI, and the RSMEA fit indices of 0.877, 0.892, and 0.198, respectively, [$\chi^2 = 661.966$, df = 203]). Therefore, allowing the error correlations is essential to obtaining good fit. The need to allow for certain correlated errors shows that particular marketing and technological resources and activities have unique dimensions that are not accounted for by the overall competences. In other words, items measuring these resources and activities serve to not only measure the competences, but also have unique aspects.

Table 2. Item statistics[a]

Item label	Loading[b]	Loading[c]	Unexplained variance[b]	Average deviation index[b]
MComp1	0.64	0.80	0.59	0.65
MComp2	0.76	0.73	0.42	0.72
MComp3	0.62	0.66	0.61	0.69
MComp4	0.67	0.68	0.55	0.63
MComp5	0.76	0.63	0.43	0.59
MComp6	0.63	0.75	0.60	0.71
MComp7	0.55	0.63	0.69	0.63
MComp8	0.62	0.51	0.62	0.69
RDComp1	0.42	0.23	0.82	0.71
RDComp2	0.80	0.78	0.36	0.58
RDComp3	0.89	0.84	0.21	0.60
RDComp4	0.73	0.69	0.46	0.63
RDComp5	0.77	0.79	0.41	0.71
RDComp6	0.55	0.48	0.70	0.63
TComp1	0.41	0.30	0.83	0.57
TComp2	0.91	0.83	0.18	0.53
TComp3	0.96	0.96	0.09	0.49
TComp4	0.83	0.88	0.31	0.55
CComp1	0.68	0.71	0.54	0.47
CComp2	0.66	0.68	0.57	0.49
CComp3	0.70	0.68	0.52	0.54
CComp4	0.63	0.73	0.61	0.53

[a] For item content, see Table A1.
[b] Based on first informant 2007 sample (n = 154).
[c] Based on first informant 2009 sample (n = 106).

Discriminant validity relates to the degree to which measures of different constructs are distinct (Bagozzi *et al.,* 1991). Since the correlations among some constructs are high, I verified that the four constructs are distinct. As a first test of discriminant validity, I examined pairs of competence scales in a series of two-factor confirmatory factor models (Bagozzi *et al.,* 1991). I ran the CFA for each pair twice, once freeing the correlation between the constructs (φ), and once setting the parameter to 1. The results indicated that the difference in chi-square between the two models for each pair was significant ($p < 0.01$). Even for the pair of the most strongly correlated scales, customer competence and marketing competence, the fit of the constrained measurement model was substantially worse. ($\chi^2 = 232.732$, df = 50 when φ is set to 1 compared to $\chi^2 = 132.501$, df = 49 when φ is freely estimated). In sum, these pair-wise CFA tests support the discriminant validity of the constructs.

I also examined discriminant validity of the four constructs by comparing empirical fit between models that separate the latent constructs into distinct factors versus models that constrain multiple items to compose a single factor. Therefore, I ran three alternative models. First, I tested a model in which all items load on one general competence. This model showed a poor fit (NNFI, CFI, and the RSMEA fit indices were: 0.788, 0.815, and 0.190, respectively; $\chi^2 = 988.026$, df = 202). Second, I ran a model in which technical items load on one factor and market-related items load on another factor, in order to examine whether the distinction regarding level of competence was necessary. The model that combined technical versus commercial competences (first-order customer combined with second-order marketing as one factor, and first-order technological combined with second-order R&D competence as another factor) also showed a relatively poor fit (NNFI, CFI, and the RSMEA fit indices were: 0.869, 0.886, and 0.137, respectively; $\chi^2 = 686.541$, df = 202). Third, I tested whether it was sufficient to distinguish levels of competence (first-order versus second-order).

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The model in which first-order items load on one factor and second-order items load on another factor also showed poor fit (NNFI, CFI, and the RSMEA fit indices were: 0.829, 0.850, and 0.180, respectively; $\chi^2 = 837.863$, $df = 202$). Therefore, the distinction between types of competence (commercial versus technical) also seems necessary. The four-factor solution provided a clearly better fit relative to either a single-factor solution or the two two-factor solutions that combined levels or types of competence. In sum, the results suggest customer competence, technological competence, marketing competence, and R&D competences are related but distinct.

Next, I performed reliability analyses of each scale, focusing on univariate properties of the items, item-to-total correlations, and the coefficient α. Cronbach's alphas for the four competence measures range between 0.77 and 0.87, suggesting good reliability. The reliability of customer competence, marketing competence, and R&D competence would not be improved by dropping any items. However, the reliability of the technological competence scale would increase from 0.85 to 0.92 if the problematic manufacturing-related item (TComp1) would be dropped. This item also has a relatively low item-to-total correlation ($r = 0.44$). The reliability of the R&D competence scale would stay at 0.86 if its manufacturing-related item (RDComp1) were dropped (item-to-total correlation = 0.52). These findings parallel the findings of the structural model, which allows for different item weights. The items' unexplained variance in Table 2 assesses the amount of item variance not captured by the underlying factor. For items RDComp1 and TComp1, unexplained variance is very high (82% and 83%, respectively).

To assess interrater reliability, the correspondence between the responses from the first and the second informant in 2007 was examined. First- and second-informant data on the five scales were compared using the Average Deviation Index (Burke and Dunlap, 2002). This index expresses interrater agreement as difference in scale points. For instance, an Average Deviation Index equal to one would mean that for that construct, the responses across the matched pair of raters differs by an average of one scale point. Interrater agreement was found to be acceptable for all scales, ranging from 0.51 for customer competence to 0.66 for marketing competence. The ADI for technological competence is 0.54 and for R&D competence it is 0.64. These estimates are all well below the maximum average deviation of 1.2 for seven-point items proposed by Burke and Dunlap (2002). The ADI for each item is reported in Table 2. For all of the items, the two respondents differed by only about a half point on the seven-point scales. For the purpose of the regression analyses (reported below), I averaged the informant scores for the firms from which I received two responses (about half of the sample).

Nomological validity is the degree to which the focal construct relates to other theoretically connected constructs in the way consistent with a priori expectations (Gatignon *et al.,* 2002; Govindarajan and Kopalle, 2006; Peter, 1981). I assessed nomological validity by conducting OLS regressions on both concurrent and predictive criteria. For the regression analyses I computed scales as the mean of the assigned items. If a firm had two respondents, I took the mean of their responses.

In particular, I tested for the expected relation between the second-order competences and a criterion measured both concurrently and at a later time. As criteria, I used a theoretically expected outcome of second-order competences: resource accumulation (Danneels, 2002). Firms with greater marketing and R&D competences should be better able to introduce products that require new market-related and technological resources, respectively.

Second-order competences refer to the ability of the firm to add new resources. However, these competences denote a *potential* activity, in which the firm may or may not engage given environmental conditions and strategic intent (Helfat and Peteraf, 2009). The actual (rather than potential) creation of new resources should thus be empirically related to the possession of second-order competences. In particular, I expected firms with greater marketing second-order competences to engage in product development that involves the accumulation of new market-related resources (Danneels, 2002). Conversely, firms with greater R&D second-order competences are expected to get involved in new product development that leads to the addition of new technological resources (Danneels, 2002).

I conducted four multiple regressions with the two types of resource accumulation as dependent variables. For concurrent validity I used the 2007 measures and for predictive validity I used the 2009 measures. The four competences were included as independent variables; and size, age, and industry, as control variables. The findings from these regressions are shown in Table 3. Overall, the pattern of

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effects was as expected. In the regressions on the 2007 dependent variables, marketing competence shows a strong and significant effect on the accumulation of new market-related resources through new product development, while R&D competence shows a parallel strong and significant effect on the accumulation of technological resources. In contrast, none of the three other competences has a significant effect on these two outcomes. In sum, these concurrent tests provide very strong evidence of nomological validity. I also examined the predictive validity of the different competences by performing a regression with resource accumulations measured in 2009 as dependent variables. R&D competence does indeed predict technological resource accumulation two years later. However, marketing competence has no predictive relationship with market accumulation measured two years later.

CONCLUSION

The ability of firms to grow and adapt to changing environments is more important than ever. As Teece (2007: 1320) argued, "… dynamic capabilities lie at the core of enterprise success (and failure)." This area has attracted a degree of attention from strategy scholars commensurate with its importance. Until recently, this attention was mainly focused on theoretical development, and empirical research lagged. The lack of valid measures has been a major impediment to progress in research on dynamic capabilities (Grant and Verona, 2015). More than a decade ago, Kraatz and Zajac (2001: 653) stated that "while the concept of dynamic capabilities is appealing, it is a rather vague and elusive one which has thus far proven largely resistant to observation and measurement." Dynamic capabilities research has advanced considerably since, however "empirical enquiry remains underdeveloped" (Grant and Verona, forthcoming). There are as of yet no generally accepted ways to measure any of the various dynamic capabilities. The development of ways to measure capabilities will not only help future empirical studies, but it will also foster theoretical refinement and precision. Theoretical understanding and construct measurement are inextricably linked. Researchers cannot develop a good measure of a concept until it is specified and delineated. In turn, its empirical grounding enhances researchers' understanding of the concept.

This study contributes to dynamic capabilities research by providing and formally testing scales to measure various types of competences. It found that competences measured across two types (commercial and technical) and two levels (first-order and second-order) were both conceptually and empirically distinct. Of course, these competences are only a subsection of the large set of competences that fits under the big umbrella of dynamic capabilities. Other measures could be developed to assess other aspects of dynamic capabilities, such as competences to integrate or orchestrate resources, or to drop/eliminate resources. The approach exemplified in the article (see Gatignon *et al.,* 2002; Govindarajan and Kopalle, 2006 for other exemplars) could provide a template for testing and validating these new measures.

While survey measures have limitations, as the most direct assessments they have a key role to play in empirical dynamic capability research. I measured resource alteration directly, particularly the addition of new market-related and technological resources. Although the findings of this study were largely in line with expectations, the low loadings of production/manufacturing related items were surprising because prior work by Danneels (2002, 2007, 2008) placed these in the technological resources and competences area. It seems that items relating to these activities largely tap other competences than the focal ones. Although care was taken to exclude firms that outsource all manufacturing from the sampling frame, it is likely that the firms in this study varied in the degree to which manufacturing skills and resources are a relevant part of their own competences. Future research might consider leaving out these items, or developing conceptualizations and measures of manufacturing/operations competence in its own right. Another extension is to develop measures of second-order competences appropriate for service firms. For instance, Qaiyum (2014) adapted items in the R&D competence scale such as "Setting up new types of manufacturing facilities and operations" to "Setting up new types of facilities and operations that enable the company to provide its products and/or services" to suit the software firms in his sample.

Interestingly, I found that R&D competence predicts later technological accumulations, while marketing competence does not predict market-related resource accumulation. Perhaps the economic recession of 2008 and 2009 affected the deployment of second-order marketing competence

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Table 3. Regression results

Variables in the equation	Market-related resource accumulation		Technological resource accumulation	
	2007 Beta	2009 Beta	2007 Beta	2009 Beta
Independent variables				
Marketing competence	0.303**	0.029	−0.007	−0.158
R&D competence	0.144†	0.030	0.582**	0.248*
Technological competence	0.011	0.054	−0.117	0.048
Customer competence	0.084	0.119	−0.078	0.037
Control variables				
Size	−0.157	−0.083	−0.152†	0.046
Age	0.037	0.018	−0.040	−0.188
Industry dummies[a]				
Industrial supplies and components	−0.150	−0.241†	−0.003	0.106
Electronic equipment	−0.094	0.040	0.071	0.098
Consumer nondurables	−0.025	−0.025	−0.045	0.021
Capital and process equipment	−0.190*	−0.030	−0.018	0.012
Consumer durables	0.002	−0.121	0.083	−0.059
N (df)[b]	152 (140)	105 (93)	152 (140)	107 (95)
Adjusted R^2 (%)	21.1	3.1	29.8	2.8
F-statistic	4.668**	1.298	6.817**	1.275

[a] Reference category is biomedical devices.
[b] A few firms were omitted because of lack of informant qualifications or missing data.
†Significant at $p < 0.10$; *significant at $p < 0.05$; **significant at $p < 0.01$.
Significance tests are one-tailed for independent variables and two-tailed for controls.

subsequent to the survey conducted in 2007. Marketing investments are particularly subject to cutbacks (Srinivasan, Lilien, and Sridhar, 2011). While this interpretation is speculative, it does suggest an area of future research. I concur with Helfat and Peteraf (2009: 94), who emphasized that dynamic capabilities provide a potential that is not necessarily used, as they stated: "… the word 'capacity' in our definition does not imply use." Dynamic capabilities can be viewed as options that allow firms to alter their resource base when the opportunity or need arises. The distinction between the possession of dynamic capabilities and their actual deployment raises great prospects for research into the conditions under which their potential is tapped.

Whether or not firms with dynamic capabilities will actually exhibit resource alteration may be contingent on prior sensing and seizing activities (c.f. Teece, 2007). The current article has focused on one aspect of the Teece (2007) tripartite of sensing, seizing, and reconfiguring. In a way, sensing and seizing could be considered precursors or antecedents to resource reconfiguration. For example, the sensing of opportunities and threats involves environmental scanning, which Danneels (2008) found is an antecedent to second order competences. The mainstream and emerging customer orientations measured by Govindarajan, Kopalle, and Danneels (2011) contain elements of both sensing (market research) and seizing (commitment and investment), and could be studied as antecedents of resource configuration. Danneels (2008) also found that willingness to cannibalize affects second-order competences. Willingness to cannibalize reflects a lack of constraint by current resources in investment decisions, and hence, facilitates seizing. Future research could examine many more aspects of sensing and seizing, and possibly, draw on existing theories and measures.

My measures of firm resources and competences required respondents to rate their firm's competences relative to competitors, on better to worse scales. Such perceptual measures have been used extensively in prior studies (e.g., Capron and Mitchell, 2009; Conant *et al.,* 1990; Danneels, 2008; Denrell *et al.,* 2004; DeSarbo *et al.,* 2005; Drnevich and Kriauciunas, 2011; Sirmon *et al.,* 2010; Song *et al.,* 2005). Nevertheless, self-reports do assume that informants have a fairly accurate understanding of their firm's competences as well as those of their competitors (Grant and Verona, 2015). Survey measures can provide the most direct

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measures of dynamic capabilities, but they rely on accurate reporting by managers on their firm, most often relative to competitors. I tried to mitigate the problems with self-assessment by asking questions about specific resources and activities, so that the referents were clear and precise. These resources and activities were identified in prior qualitative research (Danneels, 2002). I also made sure that the informants were qualified by examining their position in the firm, their tenure in the firm and in the industry, and by asking them for their knowledge of the survey matter and their confidence in their responses. It would be very fruitful for future studies to examine which kinds of informants have more or less accurate perceptions, and if the perceptions are more accurate about some kinds of resources and competences compared to others. In line with the growing interest in the micro-foundations of strategy there is also a lot to be gained from studying how this "resource cognition" (Danneels, 2011) is shaped by organizational and industry experiences, and how these understandings, in turn, influence strategic decision-making.

In parallel to cognition about capabilities, very recently scholars have developed the domain of "managerial cognitive capability" (Helfat and Peteraf, 2015). This incipient research stream focuses on the mental activities of managers and how their varying skills at performing these activities affect the firm's ability to sense, seize, and reconfigure. Mental activities such as attention, social cognition, and reasoning provide underpinnings for dynamic capabilities at the organizational level (Helfat and Peteraf, 2015). In other words, individual level heterogeneity and path dependence in these cognitive capabilities contribute to the heterogeneity in dynamic capabilities at the firm level. A related stream of research focuses on dynamic managerial capabilities, "… the capabilities with which managers build, integrate, and reconfigure organizational resources and competences" (Adner and Helfat, 2003: 1012). Helfat and Martin (2015) proposed three underpinnings of dynamic managerial capabilities: managerial cognition, managerial social capital, and managerial human capital. They provided an extensive review of variables used to measure these concepts. Scholars wishing to research these underpinnings of dynamic managerial capabilities can draw on well-developed measures and scales.

Finally, another way to push empirical research is through the study of operative mechanisms by which dynamic capability can be exercised. Product innovation, alliances, acquisitions, divestitures are some of the operative mechanisms by which the firm's resource portfolio is altered (Eisenhardt and Martin, 2000). As firms engage in these organizational activities, they may create, integrate, recombine, and shed resources. For example, Schilke (2014) studied alliance management capability and new product development capability as means for reconfiguring the organizational resource base. As in the case of the incipient study of managerial dynamic capabilities, this research stream can draw on extensive prior research, and interpret and extend it with a dynamic capabilities lens. Care should be taken however not to take these operative mechanisms as dynamic capabilities. For instance, new product development may lead to renewal of firm resources, but in many cases it is entirely exploitative and does not involve any change in the resource base (Danneels, 2002). Hence, it would be a mistake to say that new product development *is* a dynamic capability.

Empirical research is essential to progress of research on dynamic capabilities. I hope that this article has contributed to the goal of clarifying and empirically grounding this very important concept.

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APPENDIX

Table A1. Measurement of competence variables

Construct	Item label	Items
Marketing competence[a]	MComp1	Assessing the potential of new markets.
	MComp2	Building relationships in new markets.
	MComp3	Setting up new distribution channels.
	MComp4	Setting up a new sales force.
	MComp5	Leveraging its brand reputation or company image to new markets.
	MComp6	Researching new competitors and new customers.
	MComp7	Developing new advertising or promotion strategies.
	MComp8	Developing new pricing strategies.
R&D competence[a]	RDComp1	Setting up new types of manufacturing facilities and operations.
	RDComp2	Learning about technology it has not used before.
	RDComp3	Assessing the feasibility of new technologies.
	RDComp4	Recruiting engineers in technical areas it is not familiar with.
	RDComp5	Identifying promising new technologies.
	RDComp6	Implementing new types of production processes.
Technological competence[b]	TComp1	Production operations or facilities.
	TComp2	Technological expertise.
	TComp3	Technical skills and resources.
	TComp4	Engineering skills and resources.
Customer competence[b]	CComp1	Knowledge about its customers and competitors.
	CComp2	Brand reputation or company image.
	CComp3	Distribution channels or sales force.
	CComp4	Advertising/promotion resources or skills.

[a] These items were preceded by the statement: "Different companies are good at different things. The following questions ask you to assess your company's skills in various areas, relative to your competitors. Relative to our competitors, my company is good at . . . ."
[b] These items were preceded by the statement: "The following questions ask you to assess your company's resources and competences to support its current activities. Please rate your firm's current resources and competences relative to its competitors (much worse—much better)."
All items were measured on seven-point scales, where 7 = strongly agree and 1 = strongly disagree. Respondents were asked to indicate for each statement the extent to which it described his or her firm.

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Table A2. Measurement of resource accumulation

Construct	Items
Accumulation of technological resources[a]	New kinds of production operations or facilities.
	Technological expertise in new areas.
	Skills and resources in new technical areas.
	Engineering skills and resources in new technical areas.
Accumulation of market-related resources[a]	Knowledge about new customers and competitors.
	Brand reputation or company image in new markets.
	New distribution channels or sales force.
	New advertising/promotion resources or skills.

[a] These items were preceded by the statement: "New products may lead a firm to develop or build new expertise, skills, or resources. In the process of developing and launching our new products we have gained."
All items were measured on seven-point scales, where 7 = to a great extent and 1 = not at all. Respondents were asked to indicate for each statement the extent to which it described his/her firm.

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