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Creation of dynamic capacities and their evolution through engineering projects

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Abstract

Purpose – Based on case studies in engineering services companies contracted by Petrobras, which strongly demands the building of dynamic capabilities in its supplier base, we sought to understand how these capabilities are constructed over time. Consequently, we propose new indicators of dynamic capabilities (DCs) and tested their relevance empirically.

Design/methodology/approach – Initially, we analysed the relationship of fourteen engineering services companies with Petrobras. Next, we selected two cases to carry out a deeper investigation, evaluating three projects with Petrobras in each case and identifying the creation of dynamic capacities during the projects.

Findings – By performing a comprehensive analysis of the case studies, we conclude that through their contracts with Petrobras the engineering services companies develop capabilities that increase the quality and the complexity of the services provided. The four indicators proposed were validated in the field.

Originality/value – Empirical studies contribute to understanding the various theoretical interpretations of DCs. In the cases studied, the creation of DCs is linked to new projects with the client. The accumulation of knowledge and learning, when transformed into learning routines and practices, allow companies to develop or reformulate existing skills.

Keywords – Dynamic Capability; Indicators; Engineering Services; Petrobras

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1 Introduction

The concept of dynamic capabilities (DCs) arose to identify the sources of enterprise-level competitive advantage over time (Teece, Pisano & Shuen, 1997) and appeared as a valuable theoretical approach to promote a better understanding of the reconfiguration of knowledge through routines (Di Stefano, Peteraf, & Verona, 2010). Most of the contributions are theoretical and study the concept, nature, and role of DCs, the mechanisms for their creation, and their results (Baretto, 2010; Di Stefano et al., 2010; Takahashi, Bulgacov & Giacomini, 2017; Wilden, Devinney & Dowling, 2016). Despite these efforts, the concept is still in need of theoretical and empirical development. Empirical studies represent the main challenge in this field, since they can contribute to understanding the various theoretical interpretations (Easterby-Smith, Lyles & Peteraf, 2009; Eriksson, 2014).

The objective of this study is to discuss how the construction of dynamic capabilities occurs, articulating codified and tacit knowledge, and how the progress of these capacities can be evaluated through indicators. For this purpose, we carry out case studies in engineering services companies that provide services to Petrobras (a Brazilian oil company). Engineering services companies have been scarcely explored in the literature, despite their critical importance to the economy as a whole. In particular, engineering services companies with contracts with Petrobras tend to be more concerned about increasing their DCs, since the characteristics of the Petrobras bidding process, based on a demanding supplier qualification system, imply a constant search for improvements in processes and services by engineering contractors. Projects between Petrobras and contractors are complex, particularly those for offshore drilling, manufacturing facilities (refineries and similar projects) and the definition of engineering methods. These characteristics lead its suppliers — prospective or existing — to seek capabilities before and during contracts. So, we objectively asked: how do engineering services companies create dynamic capabilities and how do these capabilities evolve?

The main findings of this study allow us to affirm that most learning takes place through projects, which require greater managerial and technological skills to compete in more complex contracts. Using expertise, information technology tools (more precisely, software) and alliances (such as mergers, acquisitions or partnerships with other companies), engineering services companies develop new capabilities that increase the quality and the complexity of the services provided.

2 Theoretical Framework

The literature regarding DCs has generally been linked with the concept of routine, which would be the most important method of storing the specific knowledge of an organization. Through the absorption and accumulation of knowledge, existing routines are modified and improved, thus characterizing a dynamic way to reproduce knowledge that can shape itself in accordance with the complexity of the environment (Zollo & Winter, 2002) or based on past experiences (Schilke, 2014).

The question about "what are DCs" seems to be well defined in the literature as a set of specific and identifiable processes, such as product development, strategic decisions and alliances (Eisenhardt & Martin, 2000; Eriksson, 2014), which operate jointly toward integrating, extending or modifying resources (Cepeda & Vera, 2007; Easterby-Smith & Prieto, 2008; Winter, 2003). Such processes are able to respond quickly to changes (Kor & Mesko, 2013; Teece et al., 1997; Teece & Pisano, 1994) through the generation and modification of their operating routines (Zollo & Winter, 2002), which generates new strategies for adding value to the company (Santos & Eisenhardt, 2005).

For analytical purposes, DCs can be disaggregated into the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and reconfiguring the business enterprise's intangible and tangible assets (Teece, 2007). For instance, Eisenhardt and Martin (2000) identify knowledge transfer routines and performance measurement systems as essential elements of dynamic capabilities.

Several authors suggest that to improve research on DCs, researchers needed to go beyond focusing on the definition to focusing on how DCs can be measured (Di Stefano et al., 2010; Wilden et al., 2016). Empirical research is needed to test the concepts already instituted (Eriksson, 2014). The question about "how to create DCs" has not achieved consensus in the literature. For instance, Kerzner (2000) defends the idea that the best practices for composing DCs are defined internally in the company, considering what has worked well and is likely to work well in the future if repeated. This idea differs from that of Athreye, Dinar and Shyama (2009), for whom the creation or alteration of a capability occurs in response to new opportunities to capture the competitive advantages in the company's external environment. Any consensus may still be far from being achieved.

Zollo and Winter (2002) investigate the mechanisms through which organizations develop DCs. The model proposed by the authors – and which will be used in this study – addresses the role of (1) experience accumulation, (2) knowledge articulation and (3) knowledge codification. The authors argue that the coevolution of these learning mechanisms shapes DCs.

2.1 Experience accumulation

Experience accumulation through knowledge and ways of learning has become essential in the context of companies' capabilities. Experience accumulation describes the ability of an organization to understand the value of knowledge and translate it into practice (Zahra, Sapienza & Davidsson, 2006). It is also considered one of the primary contributors to organizational performance (Cohen & Levinthal, 1990; Schilke, 2014). This knowledge can be both acquired from the external environment, through mergers, acquisitions and other inter-organizational relationships (Easterby-Smith et al., 2008; Gonzalez & Martins, 2015), and from the internal environment, through past experiences (Eriksson, 2014).

The ability to absorb knowledge forms part of the fields of DCs, organizational learning and knowledge management (Easterby-Smith, Graça, Antonacopoulou & Ferdinand, 2008). When an organization hires experts in each area, encourages the generation of new ideas and develops easily accessible communication systems, the organization reaches a higher level of accumulated experience (Zollo & Winter, 2002). In a context where technological, regulatory, and competitive conditions are subject to rapid change, systematic change efforts are needed to accompany the environmental changes (Takahashi et al., 2017; Zollo & Winter, 2002).

The consensus in the literature is that organizational learning is based on the learning process of individuals in organizations (Easterby-Smith, Crossan & Nicolini, 2000; Kor & Mesko, 2013; Zollo & Winter, 2002). Past experiences, attempts, mistakes and improvisations generate a tacit knowledge stock that does not require a great deal of cognitive and economic effort (Zahra, Sapienza & Davidsson, 2006).

2.2 Knowledge articulation

Many studies on organizational learning have not explicitly mentioned knowledge, which instead has been implicitly assumed as a result of the learning process (Crossan, Lane, White & Djurfeldt, 1995). The transfer of knowledge in organizations – a process by which one unit (individual, group, department, division) is affected by the experience of another – can be the key for increasing organizational competencies (Argote, Ingram, Levine & Moreland, 2000; Kor & Mesko, 2013). Zollo and Winter (2002) called attention to the development of collective competence, through which implicit knowledge is articulated via collective discussions, information sessions and performance evaluation processes. According to the authors, by sharing their individual experiences and comparing their views with those of their colleagues, the members of an organization can achieve a better level of understanding of the learning mechanisms, between the actions necessary to perform a particular task and the performance results produced. Based on this view, knowledge can be regarded as an object, something that can be stored and manipulated as a condition to access information (Eriksson, 2014; McQueen, 1998).

From the perspective of information, Alavi and Leidner (2001) described the systems of knowledge management as being 'a class of information systems applied to managing organizational knowledge,› a view also shared by Prieto and Easterby-Smith (2006) and Gonzalez and Martins (2015). Examples include knowledge registered using online directories and retrieved by searching databases, sharing knowledge and working together in virtual teams, accessing information on previous projects and data and transaction studies aiming to understand the behaviour and needs of the customer, among others (Alavi & Leidner, 2001). When reviewing the literature discussing IT applications for knowledge management, Alavi and Leidner (2001) identified three applications commonly found in organizations: (i) The coding and the sharing of best practices through *benchmarking*; (ii) The creation of corporate knowledge directories, which are able to map the internal competencies of the organization; and (iii) The creation of knowledge networks as platforms that gather experts from different fields, the objective of which is to promote the exchange of knowledge among their members. By adjusting to the needs of each organization, knowledge management systems inspire managers to use IT tools to support the knowledge management processes.

2.3 Knowledge codification

Knowledge coding has been defined by Zollo and Winter (2002) as the degree to which members of an organization express their knowledge through written tools, reports, memories, or work programmes. The building of organizational memory refers to the process of storing a company's experiences through the conversion of individual knowledge into a resource available to other people (Nonaka, 1994). Winter (2003) considered this conversion of knowledge into an available resource as being achieved through 'routine,' which he defined as a highly standardized behaviour that is learned, repetitive (or almost repetitive) and based partly on tacit knowledge and partly on the specificity of goals. Routines are also considered to be managerial processes or management systems that guide the accumulation and strategic use of company resources (Tidd, Bessant & Pavitt, 2008). Whether as an incidental outcome of attitudes or as deliberate acts of communication, the individual execution of routines by members of organizations generates a flow of messages to others (Schilke, 2014).

According to Zollo and Winter (2002), the loss of an employee with relevant idiosyncratic knowledge, for example, represents a fundamental threat to the continuity of a routine: indeed, if this departure is unexpected, consistency will necessarily be broken, and there will be a change in the routine of the organization. When considering the influence of learning mechanisms on the generation of DCs, Molina, Bustinza and Gutierrez (2012) highlighted a significant effect of knowledge coding, as opposed to other learning mechanisms.

2.4 Gaps in the concept of DCs leading to the research question and propositions

DCs were initially seen as a primary capability affecting organizational performance such as new product development, alliancing, and strategic decision-making (Eisenhardt &

Martin, 2000; Schilke, 2014). Although Teece et al. (1997) link the existence of DCs to uncertain and turbulent markets, subsequent research points out that DCs have gone from being merely a response to market dynamics to playing a role in creating new markets (Helfat et al., 2007; Kor & Mesko, 2013; Pitelis & Teece, 2010; Wilden et al., 2016; Zollo & Winter, 2002). Consequently, organizations differ in their need to create DCs.

This text discusses the creation of DCs in companies with specific contexts. It is reasonable to assume that routines or processes are the codification of prior knowledge. However, having a bunch of routines or processes does not mean that a company can gain more competitiveness (Teece, 2012). Easterby-Smith et al. (2008) consider that absorptive capacity lies, in theory, among the fields of DCs, organizational learning, and knowledge management, thereby making it essential to the issues discussed in this article. However, what do we know about DCs based on existing empirical research? An analysis of the literature shows a significant conceptual debate. However, the construct of DCs remains open and subject to a variety of concepts and interpretations (Di Stefano et al., 2010).

This discussion leads to the following research question: how does the building of DCs occur, by articulating coded and tacit knowledge, and how can the progress of those capabilities be assessed utilizing indicators? Based on insights both from the literature and from prior initial research into 14 engineering services companies with contracts with Petrobras, and comparing different projects, we will propose operating indicators for the discussion of the accumulation of capabilities in companies.

In addition, to improve how this study is conducted, we consider the following propositions:

1. Organizational routines are the basis for constructing dynamic capabilities;
2. Dynamic capabilities are constructed through the accumulation of experience and articulation and codification of knowledge absorbed in projects;
3. Dynamic capacities evolve as new project require more specialized skills.

Researching the projects of several companies for the same client has the advantage of context simplification. As the contractual requirements are similar and the projects are complex, the contracted engineering companies must already possess the proper technological and management standards. The discussion on capability building occurs, therefore, in a complex and dynamic environment. We compared different projects using four indicators to assess the evolution of the companies' capabilities:

1. Number of engineers hired by an engineering services company (indicator of tacit knowledge). According to Zollo and Winter (2002), new employees can provide new knowledge. Part of this new knowledge can be coded into software, routines and such, but part of it remains tacit, as the ability to use the software. Hence, the indicator is essential for both the potential to make official new routines to build capability in general and non-coded knowledge, which is crucial in complex activities such as engineering. This indicator is also derived from Jones (2006) and Easterby-Smith et al. (2008).
2. Number of software programs developed and used in the studied projects (indicator of routine). In particular, the internal development of software involves the use of tacit and explicit knowledge, which are individual skills acquired in learning processes. This parameter can be considered a reliable indicator of DCs.
3. Routines created by the engineering services companies (indicators of the formalization of knowledge). This is the traditional indicator suggested by Nelson and Winter (1982) and Zollo and Winter (2002).
4. Number of alliances/partnerships with other companies (indicator of expansion of the venture and the source of knowledge).

This parameter can be considered a proxy for the appropriation of external knowledge in the context of absorptive capabilities, as defined by Easterby-Smith et al. (2008).

The indicators above are not mutually exclusive. For example, the knowledge obtained via alliances can be internalized through routines, software in general, or even in tacit-tacit (master-apprentice style) transmission. However, as the research question and the approach of the article are not quantitative/statistical, there are no significant problems or distortions created by the non-independence of the variables. On the contrary, it can be considered a good sign that a company makes alliances and consequently increases its routines.

2.5 Reasons for studying Petrobras' engineering contractors and their characteristics

Engineering services for Petrobras have the following characteristics: (i) they involve complex activities, involving a myriad of variables; (ii) the discoveries of oil in ultra-deep sea (the so-called pre-salt) presents challenges for engineering activities; (iii) the Petrobras suppliers qualifying system compels companies to innovate and propose engineering solutions in order to make bids. One of the key points is the ability of the companies to evolve. Salerno, Freitas and Missawa (2010) highlighted that companies anticipate Petrobras' requirements by proposing new software and new methodologies in order for them to be in a better position during bidding processes. Therefore, taking into account the approaches to DCs taken by Eisenhardt and Martin (2000), Teece and Pisano (1994) and Zollo and Winter (2002), as discussed at the beginning of the theoretical framework, we can say that cases of Petrobras' engineering contractors are suitable for discussing the formation of DCs and its indicators. It is important to emphasize that there are two types of engineering services companies. The first one relates to companies that develop detailed projects through technical documentation; the second one relates to EPC (engineering, procurement and construction) companies, in which the scope of the engineering activities includes physical planning, civil construction, procurement and contract management, electromechanical assembly and, in particular, commissioning and final tests, in addition to financial responsibility for projects (Madureira & Carvalho, 2015). According to the authors, the search for more specialized teams and the mitigation of risk gave rise to the EPC modality.

The scope studied here consists of companies that provide engineering services and are registered in the Petrobras suppliers database. The study was conducted in two phases. In the first phase, 14 companies were selected that were awarded the highest value contracts with Petrobras between 1998 and 2007 (data provided by Petrobras). During this phase, the goal was to understand the companies' method of operating and Petrobras' requirements. In the second phase, the decision was made to concentrate efforts on 2 EPC companies. The choice of companies for this phase was based on two criteria: (i) being an EPC engineering company; and (ii) having at least three projects already finalized with Petrobras. Both cases will be described in the following section.

3 Methodology

The methods adopted for this research are interviews (phase one) and case studies (phase two). Case studies are indicated to confirm or not the inferences obtained from the cases (Yin, 1994). The research object is engineering services companies – attractive because they are scarcely explored in the literature, despite being critically important to the economy as a whole (Salerno et al., 2010). However, engineering services companies work 'against projects,' that is, the projects are decisive for the creation of DCs. It is therefore interesting to analyze the creation of dynamic capacities and their evolution through projects. As collection instruments, we used semi-structured interviews employing a previously prepared and tested script, whose objective was to obtain retrospective information (past research) about how the construction of DCs occurs.

The research was divided in two phases, which will be described below.

3.1 Data collection and study – phase 1

The first phase of this research aimed at obtaining details on the relationships between engineering services companies and Petrobras. Fourteen engineering services companies were interviewed. Since this is an exploratory study, we chose to interview only the managers responsible for Petrobras projects in each company. The script used in this preliminary stage included questions about the relationship between the contracted companies and Petrobras. The following information was collected: duration of the relationship; Petrobras' requirements for joining its register of suppliers; qualification and procurement-winning factors; possible structural changes as a result of contracts (or registration); the learning resulting from interactions; and possible personnel changes.

In this phase, we conducted face-to-face interviews and document analysis and made subsequent contacts by telephone or e-mail. We stopped the fieldwork once strong convergence was obtained (Eisenhardt, 1989), with no marginal gains. Table 1 shows more details about the interviews.

Table 1
Interviews conducted between October and November 2009

Company	Main Interviewee	Data Collection (interview)	Time (hours)
CNC	Petroleum and Gas Manager	Presential interview	3h25
EGX	Petroleum and Gas Director	Presential interview	2h20
GPR	Business Manager	Presential interview	2h30
IMC	Chief Executive Officer	Presential interview	1h45
KAT	Process Manager	Presential interview	3h00
PGN	Commercial Manager	Presential interview	2h17
PJC	Instrumentation and Electrical Manager	Presential interview	2h08
PRO	Chief Business Officer	Presential interview	1h30
BYN	Chief Executive Officer	Telephone call and email	-*-
GRT	Chief Executive Officer	Telephone call and email	-*-
IEZ	President	Telephone call and email	-*-
JPT	Chief Executive Officer	Telephone call and email	-*-
ODB	Commercial Manager	Telephone call and email	-*-
SEE	Chief Systems Officer	Telephone call and email	-*-
Presential interviews – total hours			18h55

The results of this phase showed that, in principle, it is possible to become a supplier of Petrobras by providing the required documentation. Nevertheless, whether a company remains in the register is determined by its relationship with Petrobras (according to the score achieved in projects completed). Furthermore, it was possible to identify effective changes in the companies, such as new employees, new departments, new R&D structure, new IT systems, and new routines. Contracts with Petrobras increased the need for new employees in the companies, mainly experts from various areas of engineering, such as piping, mechanical engineering, hydraulics, civil engineering and petroleum and gas, in addition to new IT designers and IT experts. It is worth emphasizing that the IT systems of the companies investigated underwent significant changes based on their contracts with Petrobras, given the particularities of the software dedicated to these projects.

That concludes a brief overview of the situation of the engineering services companies, which faced the challenge of increasing their capabilities through the search for new knowledge and competences. Once we understood how the relationship takes place and what capabilities Petrobras requires, we began the second phase of the study, which was to examine how the companies used learning to create and improve their capabilities.

3.2 Data collection and study – phase 2

For the development of the second phase, two engineering services companies were selected from the fourteen interviewed in phase 1. The choice was made based on two criteria: being an EPC company and having staff available to carry out the data survey on three projects completed with Petrobras. This stage required in-depth, retrospective case studies. In this phase, we decided to analyse the construction of DCs in six real projects, three in each company, considering not only routines and software but also skills and organizational arrangements.

The script used had the following goals: (1) to deepen the information on the relationship between the engineering services companies and Petrobras, with regard to the practices adopted to create routines, the issue of the companies' technical competencies, and, in particular, the preparation of the companies to meet Petrobras' contractual and registration requirements; and (2) to compare the projects to demonstrate the evolution through indicators. At this stage, we conducted several interviews in each company and talked not only with the responsible managers but also with other professionals who participated in the projects. During the interviews, the authors made several notes for further analysis. Later contacts were also made via email and telephone. Table 2 shows more details about the interviews conducted in the second phase of the research.

Table 2
Interviews conducted in phase 2

Company	Interviewed	Data Collection	Time (hours)
GPR	Oil and Gas Director Engineering Manager	19/05/2011	1h30
	Engineering Manager Instrumentation Engineering Corporate Systems Manager Pipe Manager Electrical Manager	01/06/2011	3h12
	Oil and Gas Manager Quality Manager Corporate Systems Manager Electrical Manager	22/06/2011	2h30
	Total hours		7h12
KAT	Oil and Gas Manager	31/05/2011	1h00
	Oil and Gas Manager Process Manager	24/06/2011	1h00
	Oil and Gas Manager Instrumentation and Electrical Manager	20/07/2011	1h07
	Oil and Gas Manager Project Engineer	03/08/2011	1h12
	Total hours		4h19

4 The GPR Case

The creation of DCs by GPR can be considered from two perspectives. The first one concerns Zollo and Winter's (2002) learning mechanisms, as summarized in Table 3. In addition to the restructuring of the company, observed in the expansion of a commercial building from three to eight floors, the IT department was completely remodelled, with the acquisition of new machines, new licenses and software and the employment of specialized personnel. Realizing that Petrobras demanded increasingly detailed and complex projects, GPR created an IT department in R&D to develop new software engineering tools. After presenting the first project using the COMOS software, GPR was invited by Petrobras to share the customized version of the software, which is now standard for Petrobras projects with all engineering companies. Here, there is a clear case of the creation of capabilities to be able to compete for contracts with Petrobras.

Table 3
Learning mechanisms in GPR

LEARNING MECHANISMS – GPR	
Experience gain **LEARNING**	• Hiring of engineers • Partnerships with EPC companies • Integrated management system with own team • New software used – Petrobras-induced • New software developed – anticipation of future needs (COMOS and sIdea) • Creation of the 'Telecommunications Engineering' discipline • Competence for studying electrical and flexibility systems
Knowledge articulation **KNOWLEDGE MANAGEMENT**	• Dissemination of (internal and external) training • New engineering applications and software • Dissemination of knowledge among experienced professionals (technical) and beginner professionals (skills in software) • Creation of an R&D centre dedicated to the IT field • Tool for screening of ideas (sIdea software)
Knowledge codification **ROUTINES**	• Use of new software: INtools, Cable Pooling, PTW Dapper, TecAt, PDMS • Creation of new software programs COMOS, ERA3D (customization of COMOS), and sIdea • Creation of the position of 3D modelling Coordinator • Integrated management system with own team • Procedure for the disciplines of piping, electrical and 3D modelling instrumentation • Creation of the 'Telecommunications Eng.' discipline • Review procedure for 3D modelling

The second aspect concerns the four indicators mentioned. Table 4 shows an increase in the number of engineers allocated to each project, which indicates larger size, greater technical difficulties and more risks involved in the projects. Another fact worth noting is the knowledge that the hired professionals contribute to the company, which increases its mass of expertise through the dissemination and exchange of experiences among professionals. One practice adopted by the company was to establish the exchange of experiences among professionals with more technical knowledge (with significant experience in implementing projects) with entry-level professionals (more familiar with IT tools).

Table 4
Indicators of DCs in GPR

GPR	Project 1 October 2004	Project 2 August 2006	Project 3 July 2010
Number of engineers	18	103	194
Software capabilities	PDMS	PDMS COMOS TRIPLEX	PDMS COMOS TRIPLEX ERA3D Review-3D
Created routines	Procedure for 3D piping modelling	Procedure for 3D electrical and instrumentation modelling Procedure for the addition of object or entity in 3D platform	Procedure for the use of Review-3D software Creation of the position of 3D modelling coordinator Integrated management system with own team
Alliances with other companies	EPC Company	EPC Company	EPC Company

Regarding software capability, there was also concern about anticipating possible requirements from Petrobras, which led the company to develop another dedicated software program, the so-called Era3D, to control the generation of reports, the entities to be included in the database and the documentation of the evolution of the scale model, among other features. The applications of those software programs (COMOS and Era3D) resulted in data both for GPR and Petrobras through the generation of indices, such as the percentage of work performed per project. If we compare those three projects, we will conclude that, during them, GPR was able to develop projects using at least five new complex software tools to aid engineering projects. Another source of learning and capability building was the partnership with EPC companies. This partnership led to the gaining of knowledge and capabilities during projects. Partnerships with EPC companies occur normally for large projects requiring high technical and financial capabilities, as well as experience in projects with Petrobras. Projects and data collected in GPR are shown in Table 5.

Table 5
Data on GPR projects analysed

	Title	**Start (Month/ Year)**	**Nº of Specialized Personnel**	**Contracted Expertise**	**Contracted Consulting Service**	**Software programs**	**Main Routines**	**The Greatest Challenge**	**Higher Learning**	**Alliances**	**New Customers**
Project 1	Gas Plant	October 2004	18 Engineers	SMS	Geometric Study Analysis of electrical systems Flexibility Analysis	INtools PDMS	Procedure for 3D modelling – Pipes	Empowering engineering disciplines to work with 3D modelling	Working with 3D modelling in PDMS software	EPC Engineering Services	Shell Braskem
Project 2	Propene Plant	August 2006	103 Engineers	-*-	Geotechnical Study Analysis of electric and flexibility systems made with own team	PDMS COMOS for electric module TRIPLEX for flexibility	Procedure for 3D modelling – electric and instrumentation Procedure for the entity to take part in the project	To become an expert in 3D modelling in all engineering disciplines	Consolidation of 3D modelling – electric and instrumentation; 3D modelling projects for other companies	EPC Engineering Services	Technip EXXON YPF (Argentina)
Project 3	Gasoline Plant	July 2010	194 Engineers	SMS with own team	Geotechnical Study	PDMS TRIPLEX PTW Dapper COMOS	Procedure for review; Function of creating "3D modelling coordination"	Changing for the FEED project Adjusting to the physical space to do the engineering work Creating and training staff	Developing calculation for pulling and cable ampacity Adjustment of the teams to work in adverse conditions Projects with greater technical precision Field analysis with greater accuracy details	EPC Engineering Services	ENAP (Chile)

5 The KAT Case

DC building by KAT can also be viewed as consisting of two aspects. The first involves the Zollo and Winter (2002) learning mechanisms, as according to Table 6.

Table 6
Learning Mechanisms in KAT

Experience gain **LEARNING**	• Hiring of engineers • Alliances with companies: CAG, CMJ, PJT, ALZ and BEM • Partnership with EPC companies • Creation of the department for each engineering discipline (electrical and piping, among others) • Creation of the IT department • New software used – Petrobras-induced • Integrated management system with own team • Flexibility analysis with own team • Expertise in petroleum and gas industry • Group of experts in Petrobras' software and applications • Consolidation of managerial maturity
Knowledge articulation **KNOWLEDGE MANAGEMENT**	• Dissemination of (internal and external) training • New engineering applications and software • Development of competencies internally (employment of engineering trainees) • Training of outsourced staff to work with Petrobras
Knowledge codification **ROUTINES**	• New software: PDMS, Primavera, GED, Gisa, COMOS, GEM, PGSE • Creation of discussion groups • Creation of PER (project event report) • Adoption of 'stand-up meetings' (meetings held standing up, aimed at streamlining discussions)

In addition to the restructuring of the company – relocation of the physical structure to new headquarters, the opening of a new office in Rio de Janeiro (where the Petrobras headquarters is located), restructuring of the IT department, with the purchase of new machines, new licenses and software and the hiring of specialized personnel – one must consider the progress of the company regarding the management practices adopted to serve Petrobras. A new concept of work was adopted, which was more focused on the expertise of professionals and increases in project quality. KAT attributes its "management maturity" to the experience of implementing projects with Petrobras. The company began hiring engineers specialized in every engineering discipline, opened a department for each subject, adopted the practice of hiring trainee engineers and preparing them to later have new skills required by Petrobras projects. Being a Petrobras supplier opened up new opportunities for partnerships and alliances for KAT. The company also adopted new working practices such as periodic training and meetings on the lessons learned from each project completed with Petrobras. We can view those practices as a way to formalize knowledge, thus increasing DCs. The second aspect, concerning the four indicators that demonstrate the evolution of the company's capabilities through the analysis of the three projects, is summarized in Table 7.

Table 7
Indicators of DCs in KAT

KAT	Project 1 December 2007	Project 2 April 2008	Project 3 January 2011
Number of engineers	45	92	103
Software capabilities	PDMS PRIMAVERA PGSE	PDMS PRIMAVERA PGSE DEE	PDMS PRIMAVERA PGSE DEE COMOS GISA GEM
Created routines	Procedure for engineering management of third parties Procedure for detailed analysis of equipment *data sheet*	Implementation of PER Weekly meetings to follow up on projects	Consolidation of inspection of the suppliers' management *Stand-up meeting* Creation of the team of experts in Petrobras' software Integrated management system with own team
Alliances with other companies	EPC CAG CMJ. PJT.	EPC	EPC ALZ. WELL.

Table 7 shows that there was a steady increase in the number of engineering experts. Again, larger sized, more technically difficult and greater risk projects were observed. As in GPR, there was a gain in knowledge through the recruitment of specialist staff, the adoption of specific engineering software tools and the demands that Petrobras established for the management systems of contractors. Regarding software capability, KAT's concern for developing management tools for minimizing the risks and errors in Petrobras' projects is clear. These tools are used in the whole structure of the company. The routines created by KAT demonstrated greater concern for the management of its projects, which seems to be the main focus of the company. Another source of learning and capability building is shown through the alliances and/or partnerships created as the result of the gains in knowledge and capabilities during projects. The three projects studied for KAT yielded alliances with other companies, as well as contracts with new customers. The projects and data collected in KAT can be seen in Table 8.

Table 8
Data on KAT projects analysed

	Title	Start-up (Month/ Year)	Nº of Specialized Personnel		Contracted Consulting Service	Software programs	Main Routines	The Greatest Challenge	Higher Learning	Alliances	New Customers
Project 1	Gasoline Plant	December 2007	45 Engineers	SMS	Soil Analysis Probe Analysis Flexibility Analysis	PDMS PRIMAVERA (Planning software) PGSE	Procedure to manage engineering services; Procedure for detailed analysis of equipment data sheets	Lead project with another consulting engineering company Bureaucracy and execution as EPC	Managing projects with various companies Creating procedures to help reduce errors	CAG CMJ PJT	Yes, but does not mention name
Project 2	FEED to Diesel Plant	April 2009	92 Engineers	SMS with own team	-*-	PDMS PRIMAVERA GED (electronics document management)	Implementation of ROP Project Occurrence Report Weekly meeting to monitor projects	Work expectations of client and employees – the Project was strategic	Technical and Managerial Experience Creating routines for use in other projects and customers	-*-	Yes, three projects with big EPCs – indicated by Petrobras
Project 3	Sulphur Plant	January 2011	103 Engineers	SMS with own team	Soil Analysis Probe Analysis Flexibility Analysis with own team	PRIMAVERA GED COMOS GISA GEM	Addition of team of experts in Petrobras software programs Consolidation of expediting and suppliers management New form of meeting: shorter and more focused (standing).	Use of COMOS GEM software Electronic materials management	SMS with own team Flexibility Analysis with own team Advances in modelling 3D	ALZ BEM	-*-

6 Discussion

In both cases, it was possible to identify the following features: an increase in the physical infrastructure of the company; an increase in the use of engineering experts; the addition of new competences that had previously been outsourced; an increase in capability building involving 3D modelling software; the building of expert teams for Petrobras projects; an increase in the creation of administrative and operational routines; and the formation of alliances with other companies due to the visibility afforded by participating in Petrobras projects. Such features implied an increase in DCs in the companies analysed. However, there is a need for greater specification for the following reasons: a routine related to one particular type of activity might not be appropriate for another; and large clients with significant market power (oligopsony or monopsony), such as Petrobras, might require specific routines that are valid only for their suppliers (in this case, engineering services companies). Below we discuss the four indicators proposed in implementing this empirical research:

6.1 Number of engineers hired by an engineering services company (indicator of tacit knowledge)

According to Easterby-Smith et al. (2000), the individual is considered the unit of analysis of organizational learning. Thus, it is possible that engineering services companies increased their learning capabilities thanks to increases in the number of employees, mainly professional experts (which also increases tacit knowledge). It could also be demonstrated that the companies studied use the 'expertise' mechanism to facilitate learning, as Levinthal and March (1993) noted. Expertise can be perceived in all of the projects studied, in view of the high concentration of individual competencies created in each company, which, in both cases, were previously obtained through outsourcing. Based on Scarbrough et al. (2004), it can be stated that most learning takes place through the projects created for Petrobras. It was possible to identify connections between intraproject learning and the transfer of knowledge to the organization, thus promoting the integration of knowledge. The cases validated the first indicator proposed: the increase in the number of engineers occurred simultaneously with the increase in capabilities, which were measured as the awarding of more complex and more valuable contracts, demanding greater managerial and technological skills.

6.2 Number of software programs developed and/or used in projects (indicator of routine)

Regarding knowledge management, the companies applied tools such as intranets, databases, knowledge repositories and expertise directories, in addition to other information systems. The adoption of organizational structures backed by specific software systems is essential for capturing, focusing and leveraging knowledge and intellectual skills and for accumulating experience (Alavi & Leidner, 2001). According Gonzalez & Martins (2015), information systems are closely related to the processes of storage and distribution of explicit knowledge. They also strengthen the bond of professionals with the organization, providing them with databases, analytical models and a greater capacity to exchange information, which enables them to enhance their performances far beyond their personal limits. The cases validated the second indicator used: commercial software capability has also proved to be a good proxy. Such software is complex, requiring significant competence to be operated. This capability regarding the use of software was a qualifier of the companies in the bids in which they competed.

6.3 Routines created by the engineering services companies (indicators of the formalization of knowledge)

Many routines were found in the companies as a way of storing specific knowledge. According to Nelson and Winter (1982), DCs can be viewed through the process of transformation of the company's resources and its knowledge of such routines. It was found out, through the interviewees, that Petrobras values both formal aspects (software and routines) and tacit knowledge (the development and performance of projects). In the case of engineering services companies, the product of which is a 'solution' sought by a client, the professional intellect creates a good part of the company's value, which takes the figure of the individual to a strategic level (Quinn et al., 1996). Another form of management and transfer of knowledge perceived was the training program, found in the two cases studied, which ensures learning and the transfer of information as a means of increasing the knowledge base of workers (Gephart, et al., 1996; Gonzalez & Martins, 2015). The cases support the third indicator proposed: routines were confirmed as indicators of DCs. Specifically, routines that ended in engineering software, developed internally by the company, proved to be fundamental to increasing the capability of the engineering services companies surveyed.

6.4 Number of alliances/partnerships with other companies (indicator of expansion of the venture and of the source of knowledge)

The environment of EPC-type engineering firms is conducive to developing alliances for learning and sharing resources between companies, which usually results in better project outcomes (Madureira & Carvalho, 2015). In cases of mergers, acquisitions or partnerships between companies, it can be stated that learning through projects with Petrobras encourages collaborative learning, as proposed by Winkelen (2010). Moreover, it increases the companies' competence, through the transition from individual efficiency to collective efficiency (Fleury & Fleury, 2000; Gonzalez & Martins, 2015). The cases also supported the fourth indicator: alliances contribute to the creation of DCs if the company has a policy to take advantage of those alliances.

7 Conclusion

From performing a comprehensive analysis of the case studies, it can be said that, through contracts with Petrobras, the engineering services companies develop capabilities that increase the quality and the complexity of the services provided. This statement can be attributed to two factors. The first one is related to the concern about continuously seeking to improve services, either through an increase in the company's physical structure or through an improvement in its technical, managerial and professional competencies. The second factor relates to the client (in this case, Petrobras) being viewed in the market as a company of reference regarding the standards it requires from its suppliers. Here, the search for capability building in advance is a competitive strategy used to bid on more advantageous terms and get ahead of competitors.

Now, let us concentrate on the research question: how do engineering services companies create dynamic capabilities and how do these capabilities evolve? Based on the study of the projects conducted by each company and considering that there was a chronological order in the selection of these projects, it can be stated that the companies learn with each new project. Experiences are gained, and knowledge is absorbed. Part of that knowledge is recorded in codes and disseminated throughout the organization. This observation can be confirmed by the increase in the number of created or improved routines. How can routines and the employment and development of software be connected with DC building that leverages the company's competitiveness? In the cases studied, the improvement of conditions is linked to being awarded: (a) new contracts with a large client with a strong market position and strong technological and managerial requirements: (b) further contracts with similar purposes but with greater technical and organizational complexity; and (c) further contracts with different purposes, opening a new field of business.

To conclude, our propositions were confirmed. Regarding proposition 1: "Organizational routines are the basis for constructing dynamic capabilities." Dynamic capabilities are more than routines. However, routines, although operational, can be an important means for constructing dynamic capacities, as is the case of the increase in the number of specialists engineers contracted with each new project. Regarding proposition 2: "Dynamic capabilities are constructed through the accumulation of experience and articulation and codification of knowledge absorbed in projects." Dynamic capacities are shaped by the coevolution of the learning mechanisms of Zollo and Winter (2002) , for example, knowledge gained from alliances with other companies. Finally, regarding proposition 3: "Dynamic capacities evolve as new projects require more specialized skills." It was possible to identify, through the indicators, that for each project the companies created new capacities, sometimes to meet the requirements of the project, or sometimes to anticipate possible capacities expected for other projects.

Therefore, we believe we have shown more theoretical constructions related to the building of dynamic capacities through learning in projects.

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Appendix A

Script phase 1

1. How long has the company been contracted to supply and render services to Petrobras?
2. What are the main requirements of Petrobras, so that the engineering company is able to participate in the bids?
3. What is the gain from the contracts, besides the technical competence and price?
4. Were there any structural changes in the company due to the contracts with Petrobras? Have you created any specific activity or tool to serve the client?
5. Is there specific hiring for Petrobras projects?
6. What did the company learn from Petrobras, and how was it learned?
7. Are development and experience with Petrobras qualifying factors and / or order winners with other clients / markets?
8. What has the company done, or does it intend to do, to maintain relations with Petrobras?
9. If Petrobras was to withdraw this company from the suppliers register today, what would be the impact?
10. What are the company's expectations for the future?

Appendix 2

Script phase 2

	Title	Start (Month/ Year)	Nº of	Contracted Expertise	Contracted Consulting Service	Software programs	Main Routines	The Greatest Challenge	Higher Learning	Alliances	New Customers
Project 1											
Project 2											
Project 3											

1. To implement the registration, was there a need for any changes in the company (structure, personnel, machines / equipment, software, certifications)?
2. Does the company seek to anticipate the requirements of Petrobras? How?
3. What path does the company follow to carry out an activity that is beyond its capacity?
4. How does the company generate and modify its operational routines?
5. Is there a system for retrieving information / procedures / routines?
6. Does Petrobras analyse engineering companies for formal aspects (software, routines) or tacit knowledge (development and performance in executed projects)?

Notes:

[1] Article derived from the Msc Dissertation: "Características das empresas de serviços de engenharia e a criação de capacitações dinâmicas: o papel indutor da Petrobras" FREITAS, S. L. T. U. Universidade de São Paulo, Escola Politécnica – POLI/USP, São Paulo, SP, Brasil, 2012.

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1. Definition of research problem	√	√
2. Development of hypotheses or research questions (empirical studies)	√	√
3. Development of theoretical propositions (theoretical work)	√	√
4. Theoretical foundation/ Literature review	√	√
5. Definition of methodological procedures	√	√
6. Data collection	√	
7. Statistical analysis	n.a.	n.a.
8. Analysis and interpretation of data	√	√
9. Critical revision of the manuscript		√
10. Manuscript writing	√	