THE LEARNING DYNAMICS OF EXTERNAL-INTERNAL KNOWLEDGE AND EXPLOITATION-EXPLORATION: THE CASE OF SMES' LEARNING-CAPACITY BUILDING

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ABSTRACT

The research aims to explain the degree of complementarity, interdependency and co-evolution within the process of knowledge integration and learning and over the firm's technological trajectory. In doing so, it searches for the process of capacity building, emphasizing the interaction between knowledge reconfiguration and its orientation.

Three bodies of literature frame the analysis. First, from the literature on knowledge management the main problems of coordination regarding knowledge transfer are discussed. Second, publications on both organizational learning and dynamic capability are considered together to enable the firm's learning dynamics to be understood by distinguishing the mechanisms, the processes and methods used by firms to develop common ground in their interpretative system. Lastly, the absorptive capacity construct is examined in terms of the different levels at which the firm approaches external knowledge and develops its learning experience.

Accordingly, taking a process and micro view of learning, the analytical approach emphasizes the learning schemes, defined as the vehicles through which the action of mobilizing component knowledge into capabilities and routines occurs. Based on their differences and similarities regarding knowledge source and orientation, these learning schemes define six categories of learning capacity: formative, adaptive, transformative, inventive, created and renewed. The way these learning capacities are developed over time defines the firm's learning trajectory, presenting a functional relationship with its technological trajectory.

The research deployed a historical in-depth two-case-study method. The first case is a nursery seedling firm (NSF) within the fruit industry and the second case supplies ingredients for the food industry (ISF). The data was taken from annual review reports and project documents combined with semi-structured interviews with key individuals of the firms.

The cases provide evidence of the firms' learning-capacity building and co-evolution of their knowledge-integration and learning system (KILS). The evidence show that what really matters is how firms develop, at a certain point, a simultaneous and complementary interaction among these learning capacities. This process creates what are defined as a 'sense of opportunity' and 'technological flexibility'.

Moreover, the evidence reveals that the oscillation between 'path-dependent' and 'path-breaking' changes is not linear along the trajectory. Thus, a rather complementary and iterative dynamic

between the six learning capacities throughout the learning trajectory and technological trajectory is exhibited.

The contributions of this research are relevant to firms categorized as established engineering-based SMEs within market contexts identified as 'moderately dynamic' with disperse and erratic 'technological opportunities'.

Keywords: Knowledge integration, knowledge sources, exploitation-exploration, technological learning

INTRODUCTION

This paper examines the processes of knowledge integration and learning that occur in the on-going development of technological trajectories in established engineering based SMEs in an emerging economy. It shows how knowledge integration occurs as an iterative process shaped by the learning dynamics of the firm and mobilization of capabilities. Previous literature provides some insights into these phenomena but has lacked an integrated and complete view with regards to the coordination problems related to the transfer and appropriability of knowledge in the building up of learning capacity over the firms' life cycle.

While previous research tends to be located at the macro-level, this paper seeks to offer a stylized explanation of the underlying characteristics of the micro-components of learning based on a routines and bottom-up practice perspective that takes into account the interaction between tacit and explicit knowledge, individual and collective learning as well as cognitive and behavioural changes.

Drawing upon the literature on organizational learning (Argryris, 1976; Fiol and Lyles, 1985; Levitt and March, 1988), knowledge management (Nonaka, 1994; Pisano, 1994; Grant, 1996a), absorptive capacity (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998) and dynamic capability (Teece and Pisano, 1994; Teece et al, 1997) and building from an evolutionary perspective (Nelson and Winter, 1982; Dosi, 1988), we develop a framework to trace the relationship between the learning and the technological trajectories.

The framework incorporates four concepts: knowledge orientation, knowledge reconfiguration, learning schemes, and learning capacities. These four concepts are combined in firm-specific knowledge-integration and learning systems (KILS) which enable to shape the interpretive system of the firm as it responds to the competitive challenges of new technology and local market demands.

The framework was used to analyse KILS in two established engineering-based SMEs in Colombia in a market context considered moderately dynamic, as they moved from a mature, single technology to an emerging, complex technology. The first case was a specialized supplier of nursery seedlings in the fruit industry selling certified plants of perennial fruit trees to commercial farmers. The second case was a specialist supplier of ingredients – e.g. improvers of flavour, colour and textures, additives and preservatives – to the food processing industry.

Through detailed examination of the learning events (chronologically organized and categorized according to learning schemes and the corresponding learning capacities), the cases provide a complete picture of the depth of the firms' KILS and throw new light on how dynamic capabilities work in this context and how absorptive capacity is gained throughout a firm's lifecycle.

The rest of the paper is organized as follows. First, the paper presents a summary of the main contributions about the nature of the link between knowledge integration, learning and capabilities primarily from the knowledge management and organizational learning literature, together with research on absorptive capacity, exploration and exploitation, and dynamics capabilities which it uses to develop an integrated conceptual and analytical framework. Next, the paper provides a fuller description of each of the main concepts in the framework and how they relate to each other. The case study methodology adopted for the study is further elaborated in the next section, before the main findings and some conclusions are summarized.

DISCUSSIONS ON KNOWLEDGE INTEGRATION AND LEARNING.

There has been a large amount of research on Knowledge Management, Organizational Learning, Absorptive Capacity and Dynamic capabilities so in this paper we limit the discussion to those parts of the literature which relate most directly to the four concepts in our framework: knowledge orientation, knowledge reconfiguration, learning schemes, and learning capacities.

Knowledge orientation: Exploitation and exploration

The orientation of knowledge has been traditionally defined as exploitation and exploration, the first meaning it is used to refer as to those events which develop to improve the efficiency of the current production system and the second meaning denote those events that are meant to create technological and markets breakthroughs.

Those who have researched exploitation–exploration propose that organizational survival in the long run requires a balance between the two orientations in the adaptation process (Easterby-Smith and Prieto, 2008). There are difficulties in carrying out both orientations simultaneously; however, according to Holmqvist (2004) and Gilsing and Nooteboom (2006), organizations unable to do so might drop into what is called a 'competence trap' or the accumulation of undeveloped ideas (Levitt and March, 1988). Levinthal and March's (1993) seminal work stated that organizations should "engage in enough exploitation to ensure the organization's current viability and engage in enough exploration to ensure its future viability" (p. 105).

However, as well as aiming to achieve a balance, the argument should also be concerned with the identification of how and under which conditions these two orientations are iterative and interdependent – in other words, how exploitation-related events serve as a spark for the exploration process and how a learning sequence is developed to integrate knowledge from exploration to exploitation (Easterby-Smith and Prieto, 2008).

Whatever the motivations for an organization to undertake exploratory or exploitative processes, features such as the stage of the industry's life cycle or the technological trajectory and the growth phase of the organization engaged or product life cycle are also important considerations (Laursen and Salter, 2006; Ozman, 2009).

Knowledge reconfiguration: the interplay between internal and external knowledge

The argument that sourcing knowledge externally to develop capabilities for adaptation and innovation is faster and less costly than knowledge sourced internally (e.g. Mansfield, 1985), it has

been increasingly important to address how organizations are able to take technological and commercial opportunities developed elsewhere (Chesbrough, 2003; Laursen and Salter, 2006).

Empirical evidence has shown how organizations have recently moved their learning processes from just internal sources towards the use of external ones (Hagedoorn, 1993; Duysters and de Man, 2003; Nooteboom et al, 2005; Chesbrough et al, 2006). Wernerfelt (1984) for instance described how firms that have been more interconnected with other actors within the technological, industrial and market system are able to reduce the levels of uncertainty that are associated with knowledge integration. The RBV has claimed that firms are not self–sufficient, and efficiency is achieved by having an interactive dynamic with the environment.

Lei et al (1996), drawing upon the work of Reed and deFillippi (1990) and Barney (1991), suggest that arrangements with external partners offer a perspective on a firm's own learning efforts and contribute towards, for example in the case of a competitor, the evaluation of the degree of 'causal ambiguity' related to others firms' competences (Lei et al, 1996).

The general idea is that firms exist because of their internal knowledge but more importantly because they rely on their ability to capture external knowledge. Nonetheless, as Zander and Kogut (1995) have indicated, the ability of the firm to acquire external knowledge is defined by the nature of that knowledge (i.e. whether it is tacit or explicit, its complexity and the learning mechanisms used for its transfer), as well as firm-specific capabilities and previous learning experience (i.e. prior knowledge) (Cohen and Levinthal, 1990).

The concept of knowledge reconfiguration through different sources was initially expressed in terms of the preference that an organization has to create and integrate knowledge from its own experience and capabilities –this being internal knowledge – in contrast to the integration of knowledge that is created externally; the concept is also about the conflict that may arise when a firm has to make a choice between using internal and external knowledge (Dibella et al, 1996). This appreciation defines how organizations favour internal over external knowledge, and vice versa, for the integration of new knowledge.

What we underlined in this section is that the cumulative knowledge internally developed by organizations shapes their attitude and understanding of external knowledge integration. This relates to the path-dependent characteristic of the learning and technological trajectory and the relevance of prior knowledge for seizing new technology (Tsai, 2001). The literature on absorptive capacity (e.g. Cohen and Levinthal, 1990; Lane et al, 2006) shows that researchers have recognized these two characteristics of knowledge reconfiguration.

Learning mechanisms for knowledge integration

One aspect in which knowledge integration is mediated by learning refers to the platforms used by the firm to mobilize either architectural or component knowledge within itself for either exploitation or exploration and from a variety of sources. Shiravata (1983) defined these platforms as 'learning systems', which are described as the means by which organizations learn. Four characteristics define them: first, they work as the interpretative means by which relevant knowledge is used for decision making; second, they go beyond specific areas and functions; third, they are deployed through the current practices of the organization; fourth, all members of the organization broadly know and tend

to reflect regarding the learning system even if it is not documented or explicitly verbalized (Ibid, 1983).

From these perspectives two types of learning platforms can be inferred. The first relates to what can be termed the meta-learning mechanisms (MLMs) (Fiol and Lyles, 1985; Lei et al, 1996) and the second to the functional learning mechanisms (FLMs).

Scholars have mentioned the term MLMs in a different fashion. Kogut and Zander (1992) for instance make reference to the firm's organizing principles based on the presumption that knowledge is socially constructed, and so its mobilization is enabled by the social establishment and conventions, known as politics and culture. Henderson and Clark (1990) distinguished what they referred as to 'architectural innovations' from other types of innovation. These types of innovation as stated by De Boer et al (1999) have more implications for organizational conditions than the component knowledge and the technologies embedded within those components.

A general consensus regarding these types of mechanism is related to the means by which the organization develops common ground through practices of communication between and among groups to enable knowledge integration. De Boer et al (1999) and Kogut and Zander, (1992) found that these mechanisms have implications for the three dimensions of the knowledge-integration process – i.e. on efficiency, scope and flexibility – described by Grant (1996a).

In addition to the MLMs, the learning system is also constituted by the FLMs. These mechanisms can be considered as the means by which component knowledge is acquired with the intention of having a direct and indirect impact on the technology and the production system – i.e. on the state of knowledge. Drawing upon Kogut and Zander (1992), it could be argued that these functional mechanisms are nested within the organizing principles or MLMs and are used to modify the component knowledge. The FLMs resemble the intention through which component knowledge is moved from one site to another.

According to the review by Foss et al (2010) most of the literature focuses either on the MLMs or the FLMs. However, their review challenged a more iterative approach that might occur between the FLMs and the MLs (see also Lipshitz et al, 2002). Based on this discussion this research states that neither FLMs nor MLMs act independently of each other for the knowledge integration and learning system of the firm.

TOWARDS AND INTEGRATIVE AND REFLECTIVE-PRACTICE APPROACH TO KNOWLEDGE INTEGRATION AND LEARNING

We propose with this framework to debate on three main aspects from the previous literature. First, the framework centres the analysis on the micro-components of learning (i.e. component knowledge, operational routines, FLMs and learning process). Second, the framework proposes that the firm's capacity building occurs as a result of a sequence of events in which internal and external knowledge interact with the intentions of the firm to either exploit or explore new knowledge. And third, we propose that knowledge integration and learning are parts of the same systematic process of knowledge creation and application defined as knowledge-integration and learning system (KILS).

The learning schemes: functional learning mechanisms and the learning process

In line with Popper and Lipshitz (2000), learning in organizations occurs through actions in which the interpretative processes of individuals and their social interactions are challenged to meet specific technological targets with regards to the production and market conditions.

On one hand, the micro-components become the actions through which knowledge integration and learning takes form and works, and from which the current component knowledge is exposed to change. On the other hand, the incentives, means of communications, culture – i.e. the meta-learning mechanisms (MLMs) – and the decision-making process create the organizational conditions (macro-components of learning) that enable the selection of certain knowledge directions and learning dynamics. The interaction of these two organizational learning components that should be analytically recognized as one integrated structure (Brown and Duguid, 2001; Ali et al, 2012) represent what is defined here as the knowledge-integration and learning system (KILS).

The literature on organizational learning has paid close attention to higher order learning mechanisms (Kogut and Zander, 1992). Although these mechanisms are important for the strategic learning intent of the organization (Eisenhardt and Martin, 2000; Popper and Lipshitz, 2000; Zollo and Winter, 2002), they represent just one part of the story,. The other part (micro-components) rests on the component knowledge (Boisot, 1998; De Boer, 1999), the operational routines (Gersick and Hackman, 1990; Gilbert, 2005; Loch et al, 2013) and the FLMs, which focus on the cognitive and social practices from which knowledge is integrated.

In this sense knowledge integration is understood as the coordination process (Grant, 1996a) in which firms by mobilizing a variety of component knowledge of different sources and types – i.e. automatic, conscious, collective and objective (Spender, 1996; Lam, 2000) – intend to solve the problems of transferability and appropriability through learning. As a result operational routines as the representation of behaviours are redefined either partially (exploitation) or totally (exploration).

This framework proposes that cognitive and social interactions to modify (or not) the performance of the routines (behaviour) occur mainly as a response of and emerge from the micro dynamics of learning. These dynamics are represented in our framework through the association between the FLM, the process and the methods, and referred to as **learning schemes**. Thus, depending on the type of scheme, learning events can bring together cognitive and behavioural processes as well as individual and collective actions. So, learning schemes individually or combined refer to how an organizational member (or team members) interpret(s) and reflect on the system but more importantly firms through the learning schemes are able to push forward a process to redefine the meaning of the capabilities and routines.

It argues that (1) the learning schemes are the foundations from which an organization's learning capacity can be observed and understood, and (2) it should be possible to depict the organization's learning system by focusing on the micro-components of learning. Some examples of FLMs derived from the literature are set out in Table 1.

Table 1. The learning schemes

Learning schemes (examples)	Intention of the related events	Degree of explicitness	Learning process methods
Technical and engineering experimentation	Anticipating information and know-how for possible technical problems in production	Tacit	Reflection through new rational logics and structured social interactions
Scientifically oriented experimentation	Exploring technological and market divergence in product or production systems	Tacit	Reflection through new rational logics and structured social interactions
Product development	Searching for market renewal and niches	Tacit	Non-structured social interactions with random procedures for assimilation and implementation
Implementation of information management systems	Improving coordination, storage of information and communication	Explicit	Implementation through a combination of formal documented procedures with structured social interactions
Recruiting of new workers	Improving or modifying the knowledge base	Tacit and explicit	Implementation through social practices by the performance of the routines
Technical training	Improving the quality and performance of techniques in production and market system	Explicit	Assimilation through structured social interactions
Management system practices	Certifying the technical conditions of production under regulated frameworks	Explicit and tacit	Assimilation and implementation through a combination of formal documented procedures with structured social interactions
Acquisition of technical devices and equipment	Improving the technological conditions of the production system	Explicit and codified	Implementation through formal documented procedures and one-to-one assistance

Source: the author

The analytical construct of the learning schemes covers three components: FLMs, the learning process and the methods. The FLMs are the first component of the learning schemes; as discussed above they represent the learning intentions, can take different forms and are performed in a variety of ways.

In terms of the forms of the FLMs, the literature on technological learning has paid attention to certain types of mechanism such as product development (e.g. Henderson and Clark, 1990; Newey and Verreynne, 2011), equipment acquisition (e.g. Flowers, 2007), hiring of skilled people (e.g. Song et al, 2003), the contracting of consultants (e.g. Bessant and Rush, 1995), introduction of management systems (e.g. Oliver, 2009) and experimentation or R&D (e.g. Cohen and Levinthal, 1989; Hage et al, 2008; Knott and Posen, 2009). These mechanisms represent the intentions of learning schemes and the forms they can take. They could be described by their degree of explicitness, formality, scope, and sophistication (Shrivastava, 1983).

The learning process, which is the second component of the learning schemes, deals with asymmetries in individual and collective interpretations. Indeed, approaches to dealing with the problem of the learning process have come to capture the transition from cognitive interpretation to routines (behaviours). Crossan and Berdrow (1999) developed a framework in which they defined this transition in a four-stage sequence – intuiting, interpreting, integrating and institutionalizing. In this thesis, the sequence has been reduced to a three-stage process – i.e. stages of reflection, assimilation and implementation[1].

This third component of the learning schemes links the process with the methods of diffusion and internalization. Following the framework of Karsnlüoglu and Easterby-Smith (2011), FLMs could be performed as part of either participative learning systems or expert learning systems. Either way, learning schemes must take place under certain conditions to ensure that knowledge is mobilized from individuals' cognition to routines.

However, a single event related to a single mechanism and method might not be enough to pass through the interpretation of that knowledge to the creation of shared conventions and routines. As previously discussed, depending on the complexity of the knowledge and the routine involved, several mechanisms and methods should be used in order to generate behavioural changes. While some related events should be pursued through a systematic pattern along the learning process, others might be discretionary. This perspective defines the learning process as a sequence of stages through which new knowledge enters the organization.

All in all, the learning schemes are defined through the FLMs which explain the intention and form that a single learning event takes, the scope in the transition from cognitive to behavioural indicating an association with the learning process and methods through which knowledge integration happens. Understanding knowledge integration and learning from this perspective serves to illustrate somehow the singularities that each learning mechanism might offer in terms of experience. However, as is discussed in the empirical analysis, the framework proposes an analysis of the complementary, rather than individual, effects of the FLMs throughout the organization's technological development.

The following section focuses on how the organization's learning capacity is understood through the lens of the learning schemes, but more importantly, it also considers the way in which knowledge reconfiguration is related to knowledge orientation.

A taxonomy of learning capacity: knowledge reconfiguration and knowledge orientation

This section highlights the importance of the reconfiguration and orientation of knowledge. It is expected that the problems of transferability might have different implications depending on whether knowledge is integrated within the same or different interpretative systems.

1 Reflection refers to the intentions to understand new technological approaches from a variety of alternatives, based on an understanding of technological status quo. Other events are related to assimilation. This stage combines what Crossan and Berdrow (ibid.) defined as 'interpreting and integrating'. It is expected that events related to assimilation processes, if they are not systematic, rely on individuals' intuition in terms of how they interpret the production system – i.e. the events rely on their state of knowledge. The third, implementation, stage involves the methods through which a firm internalizes new knowledge in combination with the established routines to redefine the course of action of the firm's trajectory. The implementation processes imply therefore the incorporation of information and know-how into the routines that constitute the newly accepted operational principles through which the production system will run.

We define **knowledge reconfiguration** as the attitude that organizations have towards the use of external knowledge to align their own experience with other organizations' experiences with the intention of adding value to the routines.

In line with work by Czarniawaska (2001), we proposed that knowledge externally sourced for the purpose of creating an appropriate interpretative system must interact along the learning process with internal knowledge through staff members and/or by connecting with learning events. What matters the most for knowledge reconfiguration is how the evolving operational routines fit with the strategic intentions behind the integrated knowledge. So, in contrast to the internal–external traditional view, Grant (1996b) and later Lane and Lubatkin (1998) have both suggested three different approaches to how knowledge is distinctively integrated, these being from internal staff members, through markets, or via collaboration. Building upon these two approaches, a broader description is used. Hence, three attitudes to source knowledge – termed passive, active and interactive – will be used instead.

Besides the reconfiguration of knowledge, the literature highlights the relevance of knowledge orientation for the knowledge-integration and learning system. **Knowledge Orientation** is considered in two ways: it can be either exploitative or explorative (March, 1991). These two types of orientation of knowledge explain whether the knowledge is used to improve current capabilities for existing market conditions or foreseen new technological trajectories to pursue future productive and commercial opportunities.

The suggested argument (e.g Easterby-Smith and Prieto, 2008) refers to how organizations enable an iterative balance between the two of them. However, in order to create a balance, firms should move towards a systematic approach across the learning trajectory and not just use a discretionary approach, because exploitative-related events might also serve as a bridge that integrates the outcomes of explorative types of event.

Once the learning schemes are categorized with regards to the knowledge reconfiguration and orientation, they form the firm's learning capacities. **Learning capacities** are defined as the abilities and expertise that a firm gains by reconfiguring its attitude towards external knowledge through the use of a variety of mechanisms; in turn these mechanisms trigger capabilities for either improving the efficiency of the production system or creating the opportunity to use divergent and more advanced technologies. So, the learning capacities are the building blocks of the learning schemes.

The framework depicts learning capacity based on a taxonomy that takes account of the knowledge reconfiguration – i.e. passive, active, and interactive – and the orientation –i.e. exploitation, exploration. The matrix defines six types or groups of capacity; the first group corresponds to exploitative learning capacities, these being formative, adaptive and transformative. The second group comprises the explorative learning capacities identified as inventive, creative and renewed. This taxonomy of learning capacities could be seen as a decomposition of the absorptive capacity of the firm. (see Table 2).

Table 2. The firm's learning capacities

Knowledge Orientation	Knowledge reconfiguration		
	Passive	**Active**	**Interactive**
Exploitation	Formative	Adaptive	Transformative
Exploration	Inventive	Created	Renewed

Source: The author

METHODOLOGY

A case-study method was used as a research strategy. More precisely, the adopted approach we used for this research is called a historical–comparative, in-depth, two-case-study method. The research was completed in eight phases. The research process started with the definition of the research question (phase 1); the question was defined in response to selected theoretical problems regarding the relationship between learning, knowledge integration and capabilities. It acted as a guide throughout all the phases, and enabled the research inquiry to be positioned within a body of literature (phase 2). Subsequently, the concepts and linkages were defined to frame the research (phase 3). These initial phases covered the first approach to the theory.

The next three phases (4–6) involved all the activities related to the fieldwork. One important aspect of this group of sequences was the definition of the empirical evidence, including the identification of the most accurate source for identifying the population of firms and characteristics of the cases according to the related aspects of the analytical framework (phase 4). The outcome of this part of the process was the selection of cases. The fieldwork then continued with data gathering (phase 5) and finished with the organization and evaluation of data (phase 6). The analysis concluded with the writing up of the individual cases (phase 7) and the subsequent cross case analysis (phase 8)

Two main characteristics describe the data needed for the study. First, because historical events were indispensable, one feature was the tacit character of the data embedded in the memory of the firms' staff. Second, the data was related to facts rather than perceptions or qualifications of events; therefore the data collected corresponded to descriptions of historical realities.

Key individuals (the main manager and those responsible for each area) were assigned to help with the data gathering process from each of the firms. The data gathering included a review of all the documents (annual reports, projects, notes) and two rounds of interviews conducted with key individuals of both firms.

SMES AND THE EVOLUTION OF THE KILS

The settings: Stablished engineer SMEs

These two SMEs were intentionally selected because of their potential to allow the observation of the long-term learning and technological trajectories of stablished firms that happened to be pioneers in their respective industries (within the Colombian context). By having undertaken collaborative R&D projects with a research centre, these firms also showed evidence of some level of absorptive capacity. The fact that the two firms had undertaken projects to develop biotechnological techniques, despite being part of mature industries – i.e. food processing and plant production – by using a single knowledge base – i.e. a chemical engineer and an agricultural engineer, respectively – was itself a sign of their path-breaking intentions.

The two selected cases showed some similarities, which made their analysis comparable. Apart from the size and length of time in their respective industries, the two firms shared characteristics such as their positions in the value chain, definitions of their business models, overall organizational forms and strategic responses to the market. Additionally, both firms pursued engineering-based knowledge (their core knowledge being focused on either chemical or agricultural engineering). The characteristics of the cases are described in table 3.

Table 3. Main characteristics of the cases

Characteristics	Nursery seedling firm (NSF)	Ingredient supplier firm (ISF)
Size (by number of employees)	Medium-sized firm (2010): 77 employees	Medium-sized firm (2008): 250 employees
Years established	27 years in the market	23 years in the market
Position in the value chain	Specialized supplier; at the bottom of the value chain	Specialized supplier; at the bottom of the value chain
Business model	Provide technological solutions for commercial farmers of perennials fruits	Provide technological solutions for food processing firms
Overall organizational form	In between operating adhocracy and machine bureaucracy (Spender, 1996); division form (De Boer et al, 1999)	In between operating adhocracy and machine bureaucracy (Spender, 1996); division form (De Boer et al, 1999)
Strategic response to market	Diversification (10 commercial lines)	Diversification (10 commercial lines); double segmentation
Engineering-based knowledge	Agricultural engineering (core); chemical engineering (complementary)	Chemical and food engineering (core); microbiology (complementary)

Source: the author.

SMES's patterns in their KILS

As indicated by the evidence knowledge integration, as the framework proposes, has a distinctive characteristic for the interpretative system if the source of the learning event is passive, active or interactive knowledge and if it is oriented towards exploitation or exploration. From the communalities exhibited by the learning events, based on these two characteristics the six categories of learning capacity (numbered 1 to 6 below) were identified in the two cases.

The evidence indicates that interaction between knowledge reconfiguration and knowledge orientation varies across the firm's life cycle. **Knowledge reconfiguration** refers to how firms create the conditions to synchronize their operational routines with knowledge and technology produced elsewhere. According to the evidence firms mostly rely on their internal knowledge, mainly because it gives them the foundation for their interpretative system to gain a greater understanding of their operational routines. The evidence suggests that the more firms adjust and experiment with new methods of production and the solution of new problems the more they are able to understand the direction of their routines and the technologies at their disposal in their external environment.

Firms search for knowledge and technology that is externally produced according to how they understand, and have learnt about, their operational system. The evidence suggests that firms expose themselves to external knowledge when their cognitive system for the understanding of the technological and market directions is limited to producing behavioural changes. It is expected that firms fit their operational system with more advanced technologies when they relate to external knowledge-and-technological producers. One important aspect indicates how firms decide the direction in which the technological trajectory will be taken.

The evidence suggested many differences in the learning dynamics between passive, active and interactive attitudes to sourcing knowledge. Dissimilarities are related to the coordination process of transferring knowledge of different kinds to assure appropriability, to the mechanisms used to mobilize knowledge, and to the outcomes of each of these attitudes towards the external knowledge produced. As a result each attitude leads to a different way of learning, therefore to a specific learning capacity.

In contrast to knowledge reconfiguration, **knowledge orientation** refers to whether the learning dynamics are developed to challenge the established interpretative system or create a new one through market and technological breakthroughs. As acknowledged above, the way firms decide to start shifting their learning efforts from exploitation to exploration can be motivated by completely different reasons than just wanting to go ahead in their technological development. In the case of the firms studied for this thesis these motivations ranged from maintaining reputation and substituting ingredients from suppliers (integration of downstream activities) to assuring assertiveness.

In the case studies, the way the firms faced the knowledge integration process from exploitative and explorative learning events was also quite different from each other. One of the main differences is defined by the implications of both types of event. The former were closely related to the needs and expectations that the firm's members had regarding improvements in the operational routines whereas the latter were normally considered as peripheral of the production's activities of the firm with no clear understanding of their effects. While exploitative learning events are visible within the

firm's figures within a reasonable assessment period, explorative events cannot easily be evaluated under the same criteria.

In both firms the KILS evolved according to how they faced the interaction between knowledge reconfiguration and knowledge orientation, and therefore the building up of the learning capacities along their life cycles. However, the shape of the learning trajectories in which these two characteristics of knowledge interacted differed slightly in each of the two firms as is shown in table 4. Two of the main difference relate to the intensity with which learning events were developed and the focus given to specific learning capacity in each stage of the cycle along the KILS.

Table 4 The learning trajectory through the firms' life cycles

Firms' life cycles	NSF						ISF					
	F	A	T	I	C	R	F	A	T	I	C	R
Initial conditions	*	*					*	*				
Formation	*						**	***	*			
Establishment	***	**		***	*		***	***	*	*	*	
Expansion	***	**	*	**	*	*	***	***	*	*	*	*

F=formative; A=adaptive; T=transformative; I=inventive; C=created; R=renewed

//*** Represent the level of intensity of the events associated with the specific learning capacity in the related period: less than 20 events (*); more than 20 and less than 40 (**); more than 40 events (***).*

The brown colour corresponds to the exploitative learning capacities and the blue colour to the explorative learning capacities.

Source: the author

The patterns in which the learning capacities evolved can be analysed in two ways: first, by comparing the significance of each learning capacity for these firms as part of the KILS; second, by analysing the extent of their interaction at each stage of the life cycle. Each learning capacity emerged and evolved through the use of a particular group of learning events and played a singular role in the effectiveness of the technological transformation throughout the transitions periods. In this sense what the evidence suggests is that, according to the nature of the technology and the market, firms give emphasis to one specific capacity over another. And so, the interaction patterns between capacities might diverge from one organizational and industrial context to another.

In both firms the emergence and further development of the **formative learning capacity** (1) allowed them to create the conditions under which the process and product technologies were understood with regards to the market conditions.

The development of the **adaptive capacity** (2) was more fundamental for the technological progress of the ISF than for the NSF. The ISF reconfigured most of its knowledge by constantly exposing its interpretive system to explicit and codified knowledge mainly to incorporate new conditions for the production system, which needed to be efficient and flexible enough to respond to productive opportunities. Considerable learning effort was then made to upgrade the hard part of the

technology to diminish possible differences in production (in scale and scope). Other forms of related learning adaptive schemes such as technical assistance and training (these being methods for assimilation) helped to support the implementation of new equipment or the incorporation of new routines for the development of new business lines.

The development of the **transformative learning capacity** (3) in both firms was odd but efficient for provoking technological transformations. These SMEs develop this capacity, as suggested by the evidence, when they are able to align and complement embedded knowledge to transfer know-how into the firm through sharing processes. However, in the two cases studied here, appropriability problems made this capacity difficult to develop. For this type of scheme to be worthwhile the partner organization should have different interests or knowledge that would represent a real advantage and be difficult to get otherwise.

Learning events, reflected as learning-before-doing, contributed to developing the **inventive learning capacity** (4). The firms decided to be more objective in its interpretation of the methods of production by studying them in more detail instead of just making online changes as had been the practice up to then. Consequently, the SMEs started to use more rigorous methods of analysis and to take more time to identify solutions to current and future problems in production; this was done through what has been defined as technical experimentation.

Both **created learning capacity** (5) and **renewed learning capacity** (6) were developed after. So, These SMEs firm also decided to expose itself to external organizations for the purpose of undertaking R&D, mainly so it could take advantage of their knowledge and thus strengthen its own explorative learning capacity. However, misalignments in the interpretative system (or values) alongside the technical characteristics of the technology – as Leonard-Barton (1988) has noted – regarding the way these learning events were understood by each of the parties involved were the cause of the lack of effectiveness in the knowledge integration process. In the case of the ISF problems were more related to differences in the appropriability of the technology.

The previous analysis led to the interpretation that learning schemes are not isolated events. The evidence shows that firms experience different learning dynamics through the use of exploitative and explorative types of learning scheme by sourcing information and know-how passively, actively and interactively. By using any one of these sources, exploitative events tend to be linked to learning-by-reacting, learning-by-anticipating and learning-by-doing, whereas explorative types of events are better associated with learning-before-doing. The KILS in firms, as shown by these two SMEs, is developed in fact as a combination of all these processes, the patterns of which mostly depend on how far the new knowledge is from the current interpretative system. The further the knowledge the keener the firm is to follow a learning-before-doing process.

The interaction pattern between levels of capacity also depends on how experienced the firm is in understanding the technological applications to the market but mainly on how the firm defines its strategic orientation. This gives some prerogatives to time and context for the pursuit of learning and the development of certain capacities. The strategic orientation along with the cognitive distance and the state of knowledge then defines which learning sequence and pattern firms follow. Also, the firm's relative position with regards to how the industry has evolved should be recognized. This illustrates the relative importance that the market and technological context have for the firm's

learning capacity. If the firm is coherent, learning dynamics are determined by the scope of the strategic orientation.

As important as it is for firms to engage in a variety of learning dynamics, jumping into more complex type of learning capacity – e.g. renewed capacity – (which implies a developing learning events with greater cognitive distance and higher recognition of the state of knowledge) does not necessarily mean a better absorptive capacity or a more effective technological transformation without considering the alignment–misalignment with the organizational and industrial context and the process that firms have followed over recent years. These findings suggest that it is perhaps inappropriate to define a general assessment for the firm's absorptive capacity without acknowledging the internal and external context of the firm and the evolving process of the KILS.

GENERAL CONSIDERATIONS

In this section we present the overall discussions of the paper. By taking a deductive-inductive approach the research analysed the process of knowledge integration, learning and capabilities by discussing the knowledge management, organizational learning, absorptive capacity and the dynamic capabilities literature in light of the evidence of two established engineering based SMEs in an emerging economy.

The proposed terms of KILS actually emphasizes that what matters the most for the firm's learning capacity relates to how it is able to get the right information and give meaning to it in order to develop better routines (know-how) in relation to its strategic orientation. In this sense the evidence supports the importance of a bottom up approach for firms to open and exposed them self to learning.

This paper then goes beyond previous conceptions of the absorptive capacity and dynamic capability of the firm by adding and combining further characteristics for the explanation of how the learning capacities are developed and their relation with the firm's technological transformation along different transition periods. The general idea is that although firms learn from their internal dynamics, their interpretative system evolves when firms are also able to build their foundations to learn through passive learning events and in doing so understand how strategically select knowledge from external sources to modify their capabilities and routines.

The concepts of absorptive capacity and dynamic capabilities have been linking in this approach in a variety of ways from the perspective of the KILS. We proposed to expand the mechanisms that firms exercise for the mobilisation of knowledge which in these two literatures have been limited to R&D, product development and advanced training. But rather than just recognising further important mechanisms this research analytically and empirically through the analysis of the SMEs gave an important contribution in to how all these mechanisms are related to each other, in a type firm and context that have traditionally neglected from this perspective. By linking the FLMs with the learning process the research in this thesis defined the learning schemes as a more comprehensive vehicle for knowledge integration offering a broader explanation for the building up of the firm's learning capacity. So, the construct of the learning schemes is constituted as a mechanism that represents the absorptive capacity and the dynamic capability of the firm

This research posited the idea that firms have to use the proper schemes to mobilise knowledge across the organization enable the development of the firm's learning capacity. These schemes

represent then the means through which firms are able to reflect and assimilate knowledge (PACAP -potential absorptive capacity-) and implement knowledge (RACAP-realized absorptive capacity-) (Zahra and George, 2002). Then, the papers provides a more interactive view in which the sequence between PACAP and RACAP is defined, distinguishing three possible patterns, 1) Discretionary, 2) Complementary and 3) Systematic.

Moreover, for the understanding of the process of absorptive capacity and development of dynamic capabilities for the KILS we combined two frameworks in this paper. The first relates to attitude towards kno1wledge sourcing and the second to the knowledge exploration and exploitation framework. Although previous works like the one developed by Rothaermel and Alexandre (2009) have already identified the importance to relate these two frameworks to differentiate their effects on firm performance, do not suggest much about their interaction and do not have a clear understanding about how a process of capacity building is developed through different transitions periods in the firm's life cycle. Previous research has looked at them in a distinctive and more static way.

In relation to exploitation-exploration framework researches within the organization learning literature have claimed the importance for firms to create a balance between these two orientations for the development of the firm's capabilities. The findings in this research evidenced that exploitative related mechanisms purposes are beyond getting efficiency for the known technology but also serve as a pipeline to integrate knowledge from explorative related schemes in to the routines. As a result firms need to poses the learning capacities to assimilate and implement the technological opportunities before they learn how to reflect on new technologies, otherwise exploration became a continuous futile effort for the firm's technological development. More than balancing exploitation and exploration this research suggests that firms should be develop a symbiotic learning interaction between these two distinctive orientations, which is just possible when firms also develop unbounded interactions with their business environment through any of the three attitudes towards external knowledge –i.e. passive, active and interactive. And so, firms might not be able to create an ambidextrous interaction between exploitation and exploration without exposing themselves to external knowledge[2].

Nonetheless, others factors were looked for to explain how the KILS could evolve; these also relate to the alignment between the functional learning mechanisms (FLMs) and the meta-learning mechanisms (MLMs), which create the conditions for learning to happen.

The findings then are explained and generalised under specific extrinsic and intrinsic settings. In terms on the extrinsic conditions by the situations in which the technological opportunities are dispersed and discontinuous and where the industry is considered moderately dynamic. Regarding the organizations, the theoretical contributions of this research focus on SMEs with engineering knowledge bases that are embedded in an organizational form defined as a machinery bureaucracy, and they are moving forward from mature single technologies to emerging complex technologies.

It proposes that future research in this field should challenge integrative frameworks to understand knowledge integration and learning from different angles. Therefore, process and historical case studies should be pursued to gain more inside knowledge of how the micro-components of

[2] In this sense this research also includes Lane and Lubatkin (1998) construct that they termed as 'relative absorptive capacity'.

knowledge integration and learning actually work and inform decisions of how the technological trajectories of firms should be oriented. However, because of the acknowledged limitations, future research could be oriented towards informing policy and managerial recommendations. In this sense, more knowledge is needed to understand differences among other industries and technological and market contexts. It would also be beneficial get more inside information from firms who might have developed these learning capacities without having gone through the four stages of the life cycle. With this additional research, some of the propositions in the research for this thesis could be challenged. Research should also be focused on larger samples of firms in which proxies to assess the evolution of the sense of opportunity and the technological flexibility could be reviewed. Finally, an understanding of the role of knowledge producers such as universities, research centres and technological providers at each level of learning capacity could be useful to improve the understanding of how the external business environment could be oriented to accelerate the building capacity of firms.

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