Interacción del conocimiento interno y externo y el aprendizaje tecnológico. Políticas y estrategias.

Conversatorio COLCIENCIAS
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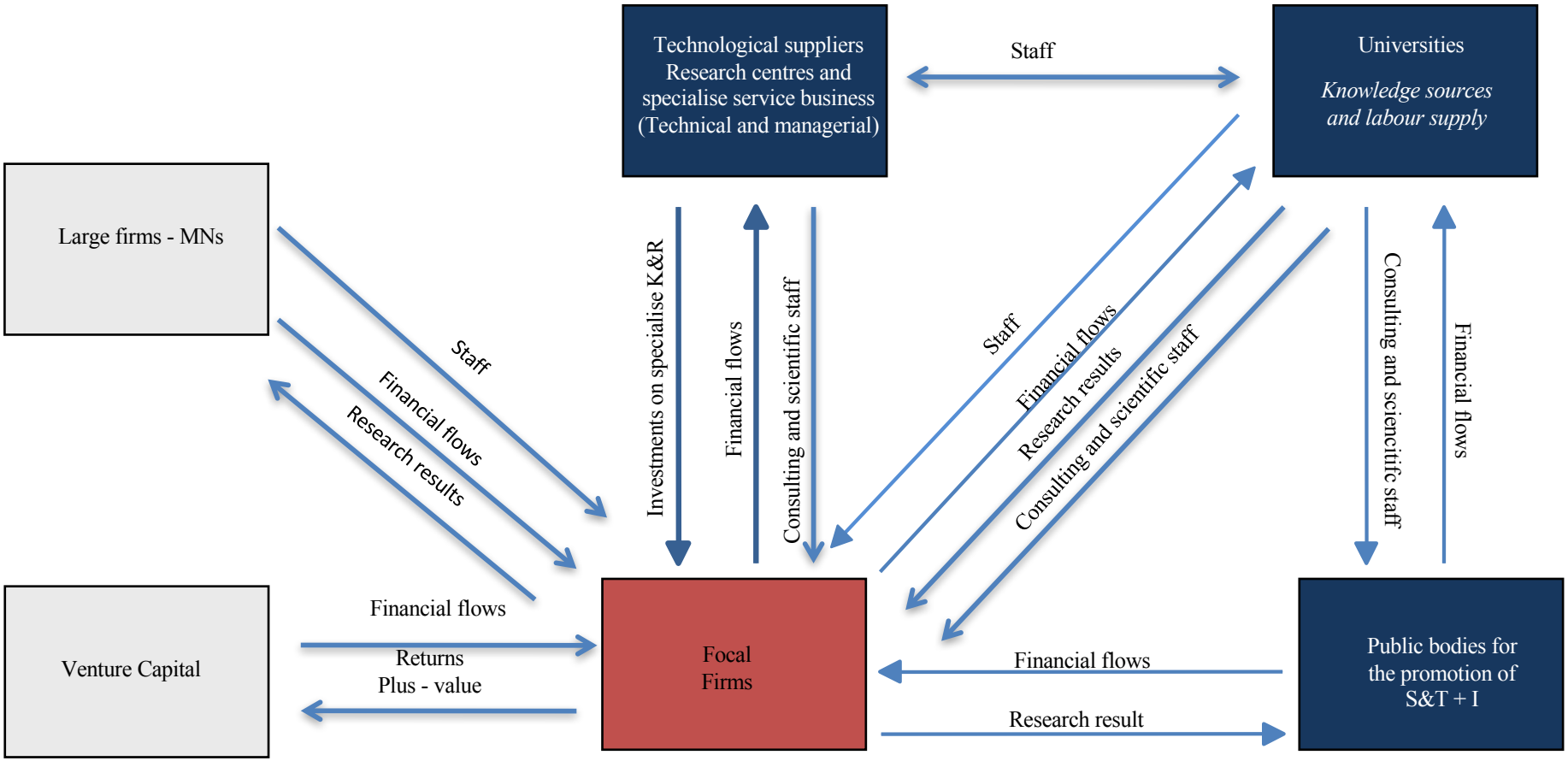
The importance to understand how organizations learn in a given Technological system



Source: Adapted from Orsenigo, 2004

THEORETHICAL FOUNDATIONS

The research studies the link between:

- Knowledge integration
  - **The transfer problem and knowledge conversion**: embrained (explicit-individual), encoded (explicit-collective), embodied (tacit-individual) and embedded (tacit-collective) (Polany, 1966; Anderson, 1983; Nonaka, 1994; Lam, 2000)
  - **Knowledge hierarchies:** architectural knowledge (De Boer et al, 1999) and component knowledge (Leonard-Barton,1988)
  - **Knowledge reconfiguration:** external and internal knowledge (Grant, 1996; Lane and Lubatkin, 1998))
  - **Knowledge orientation:** exploitation and exploration (Levitt and March, 1988; March, 1991; Levinthal and March,1993)
  - **Effectiveness of Knowledge integration:** Scope and outcome (Grant, 1996)

- (Technological) Learning system
  - **Organizational learning mechanisms and dynamic capabilities** (Levitt and March, 1988; Spender, 1996; Teece, 1997; De Boer et al, 1999)
  - **Learning process:** cognitive and behavioral changes (Fiol and Lyles, 1985; Senge, 1990; Dodgson, 1993; Akbar, 2003)
  - **Searching for absorptive capacity (AC):** The state of knowledge and experience (Cohen and Levinthal, 1989; Lam, 2000; Dodgson, 1993; Schilling et al's, 2003)
  - **Decision-making process and the learning system (**Shrivastava, 1983)

- Capabilities and routines (Levitt and March, 1988; Kieser at al, 2001; Holmqvist, 2004)

FOCUS OF THE DISCUSSION AND PROPOSITIONS

- The micro-foundations of knowledge and learning nurture technological change: Assessing the interaction between the Individual and collective learning actions
  - The cognitive and behavioral condition of learning
  - The transferability of knowledge from different forms
  - Learning occurs an action-practice based process (systemic and systematic)

- The learning capacity building traced a path-depended and path breaking process over the firm life's cycle.
  - Knowledge reconfiguration: (passive, active and interactive) firms' interpretative systems are built through a variety of sources, where internal and external knowledge are clearly more interactive than tends to be acknowledged.
  - Knowledge orientation: (exploitation and exploration)The interaction between exploitation and exploration could be sequential or iterative based on how a firm's learning trajectory evolves over time and how individuals come to understand the firm´s strategic position in the industry and interpret the direction that its trajectory can take.

- The macro-components of learning are overemphasized aspects
  - The decision making process and the organizational learning mechanisms might change as a respond of the learning required conditions that emerge from the interaction of individuals with the routines in relation to market.

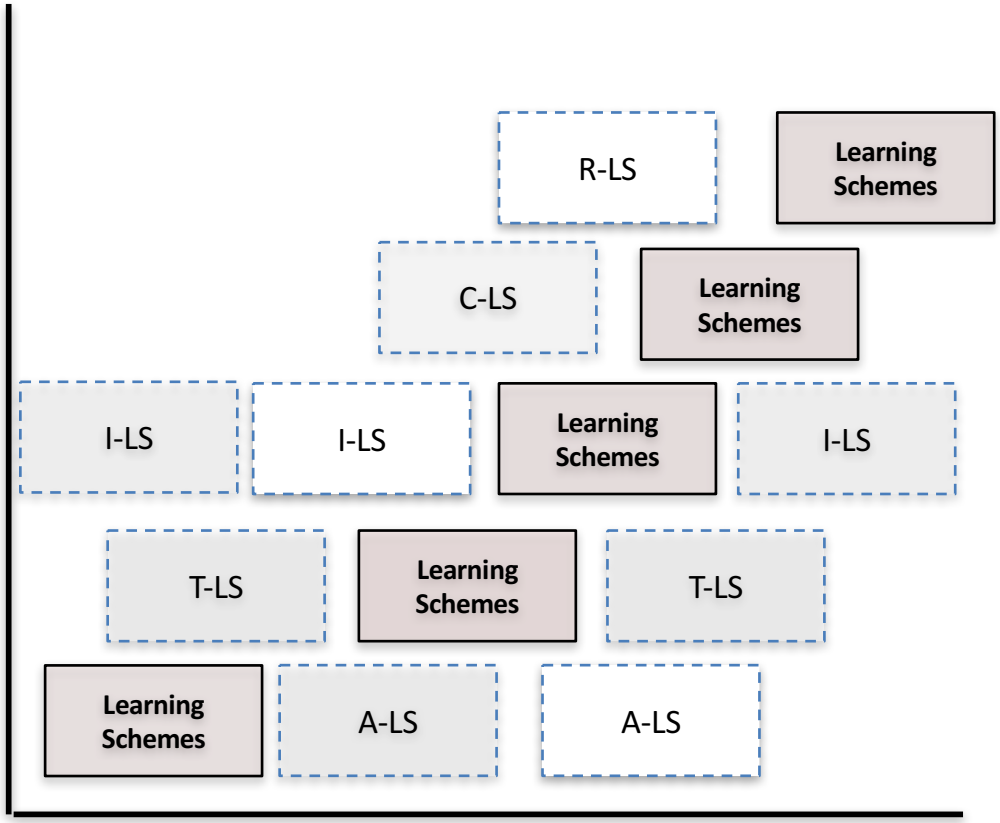
- Technological transformation happen as the result of an efficient, coherent and flexible knowledge-integration and learning process .An integrative view of knowledge integration and learning: **Knowledge integration and learning system (KILS)**

A LEARNING-CAPACITY FRAMEWORK

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

Learning schemes: Functional Learning Mechanisms (FLMs) and learning process

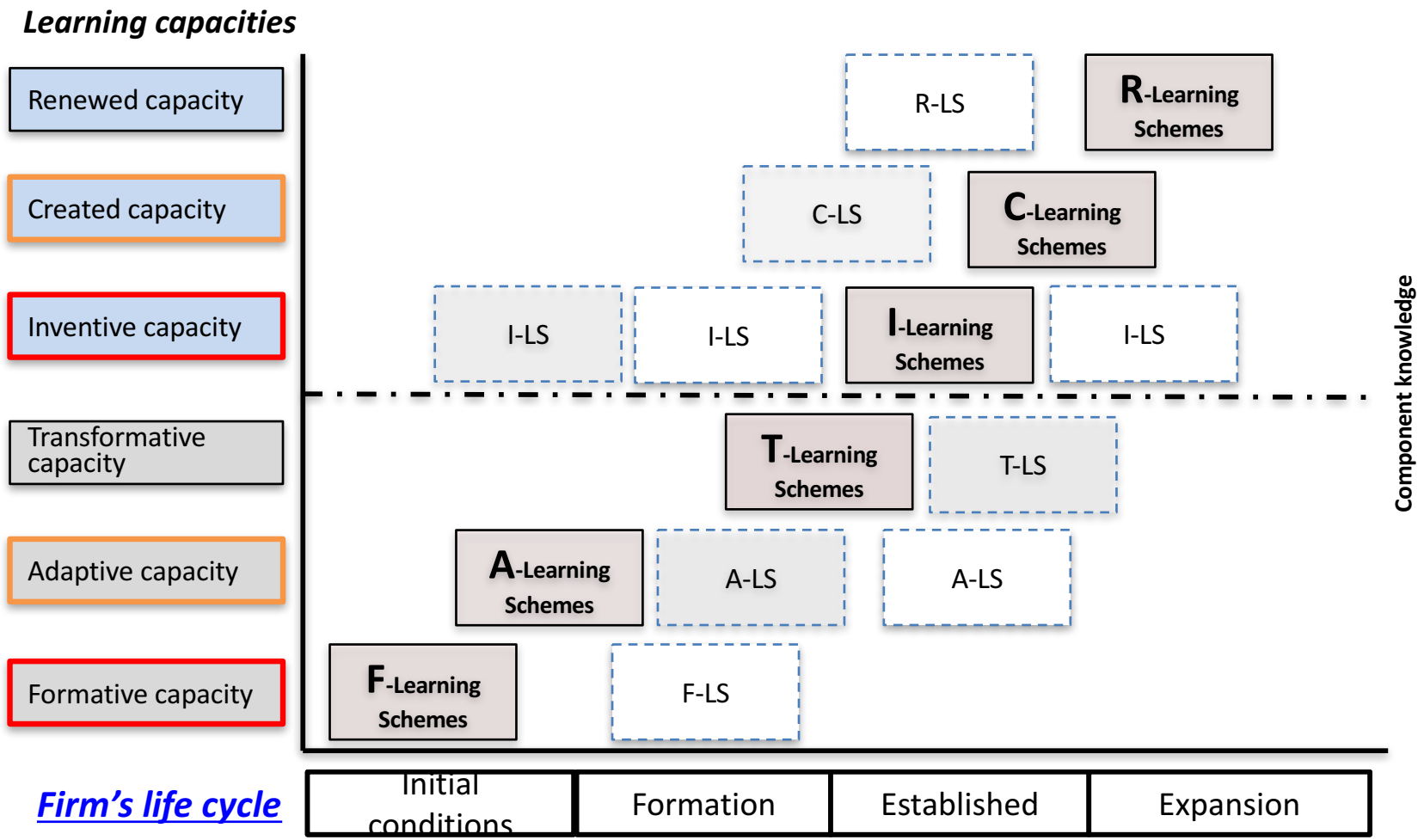
Refer therefore to the efforts that organizations make to acquire and internalize knowledge from elsewhere into their production systems.



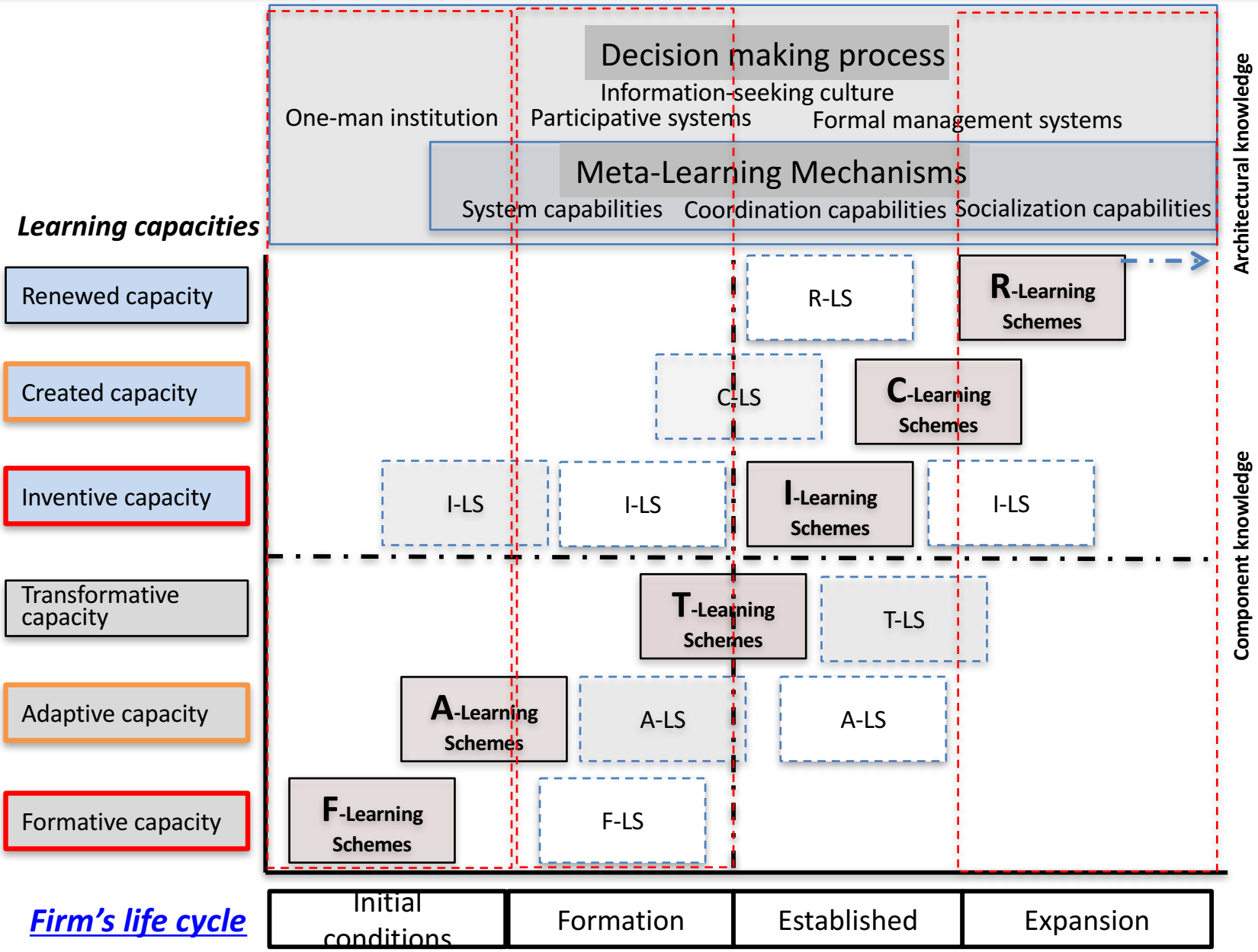
Firm's life cycle

A LEARNING-CAPACITY FRAMEWORK

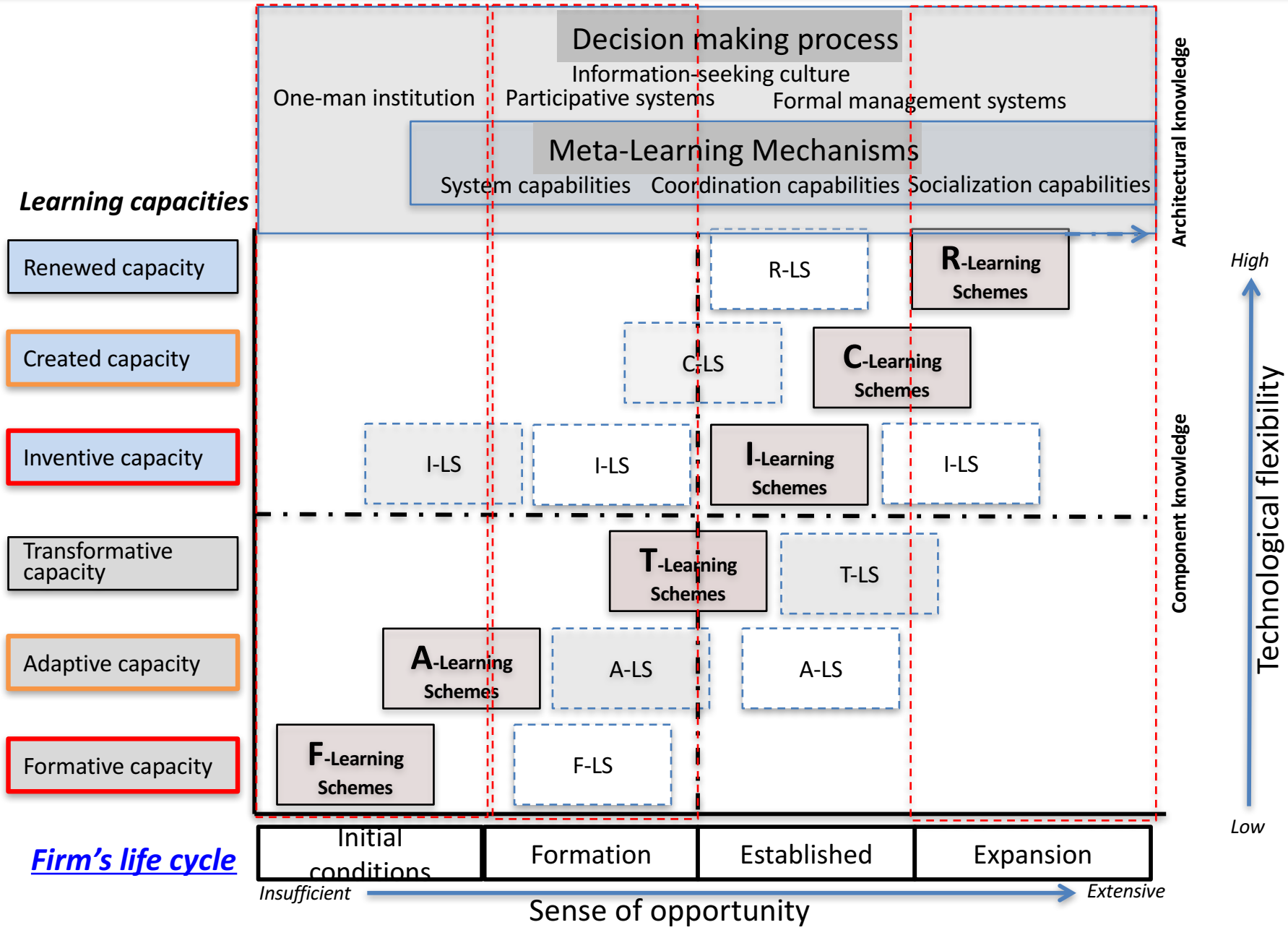
Learning capacity is defined by the ability of the organization to integrate different types of knowledge from a variety of sources with the aim of modifying current technological capabilities and routines to fit into the industry or create productive opportunities.



A LEARNING-CAPACITY FRAMEWORK



A LEARNING-CAPACITY FRAMEWORK: KNOWLEDGE-INTEGRATION AND LEARNING SYSTEM (KILS)



- *Towards effective technological transformation: 1. Efficiency; 2. Coherence; 3. Flexibility*

An historical comparative in-depth 'two-case' study method

Criteria	Foundations connecting to the research question	Foundations connecting data availability	Foundations connecting to theory
Purpose	Constructs, an analytical framework and initial propositions grounded on empirical evidence	Historical progression of events	Build–expand and generate theory
Sequence logic	Deductive (from theory)	Deductive–inductive	Inductive–deductive
Typology	Retrospective (historical)	Comparative cases	Explanatory
Replication logic	Atypical cases/ subgroups' case design*	Theoretical replication	Literal* and theoretical replications (Yin, 1993)
Context setting	Deterministic consideration of context	Geographically bounded in Colombia / industrial applications	Emerging technological opportunities/ moderated market/ SMEs
Unit of analysis	Learning capacities	Learning dynamics: schemes and process	Organization's learning and technological trajectory
Unit of observation	Learning events	Description of learning-related facts recovered retrospectively	Learning schemes
Timescale	Observation interval: more than 20 but less than 30 years. From 1980s to 2010	Existence interval: events collected and grouped by year	Validity interval: from inception through the firm's life cycle

Source: the author

An historical comparative in-depth 'two-case' study method

Phases	Methodological decisions	Activities
(1) Definition of the research question	Research question responding to theoretical gaps	NA
(2) Positioning the inquiry of research within a body of literature	Focus on: • Organizational learning and process research • Knowledge integration • Dynamic capabilities • Absorptive capacity	• Identify initial works according to the primary literature selection • Define some key words • Identify through references a list of articles • Identify through the journals the community where the inquiry of research takes place • Identify common claims related to the inquiry of research
(3) Development of the analytical approach	Propose a new observation framework based on prior assumptions from the literature	• Conceptual and analytical framework • Initial propositions
(4) Definition of the empirical evidence	Strategic and theoretical sampling	• Define the population framework • Select case studies
(5) Data gathering process	• Multiple sources • Triangulation • Collect factual events	• Define the research protocol • Operationalize the analytical framework • Contact the firms • Present the research to the firms to ask for accessibility • Organize the agenda • Collect the information from the selected reports • Collect data from the interviews
(6) Organization and evaluation of the data	• Chronologic tabulation of events in a database • Organize the narratives to support the description of the events	• Transcribe the recorded interviews by using the free software 'F5' • Organize the physical files according to the topics • Organize the interviews in a document by topic, interviewer and year • Elaborate a database to organize the learning events according to the categories previously defined in the framework by using the information from the interviews and files • Apply coding process to the data • Assemble and integrate data • Check the consistency and validity of the data by contrasting different sources • Validate the information with the firms
(7) Analysis and writing up the reports	Write each case based on the analytical framework Single researcher	• Write up the single case reports • Review each case analysis with the firms • Write up the cross-case analysis
(8) Contrasting with theory	Consider alongside similar and contrasting literature	NA

Source: the author

Bounding the context: High growth SMEs in a Emerging economy

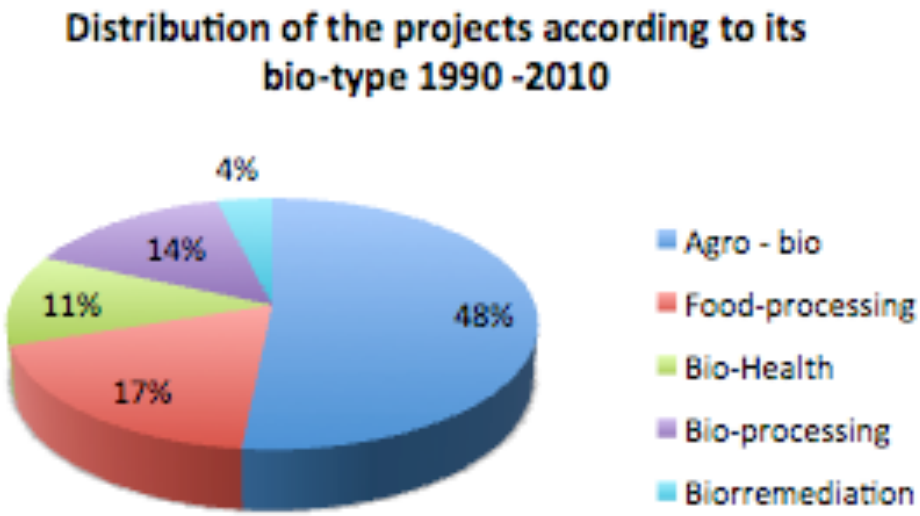
- Technological opportunities: inconsistency, and/or unreliable knowledge generated by engineering and scientific knowledge providers.
- Moderately dynamic market: (1) The regulatory framework, (2) the technical sophistication of the clients and (3) distribution of competitors
- Transition: From mature single technologies to complex emerging technologies
- Type of firms: Established and engineering-oriented SMEs
- Country: Colombia
- Industries: Nursery seedling firm in the agricultural industry and an ingredient supplier firm in the food processing industry

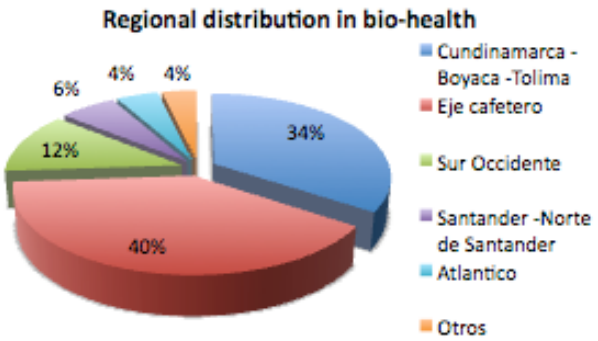
Making sense of the Technological system: Colombian Biotech system 1990 - 2010

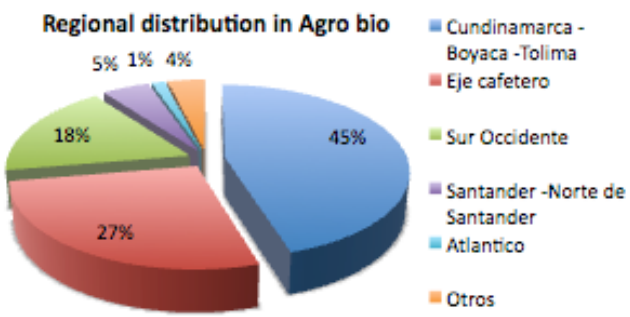
Bio - type	Number of projects	Percentage	Density of organizations			
			Universities	Research Institutes	research institutes	Firms
Agro - bio	539	48%	32	19	1	27
Food-processing	191	17%	27	8	0	52
Bio-Health	123	11%	22	11	0	26
Bio-processing	151	14%	25	13	0	22
Biorremediation	41	4%	8	8	0	1
Bio - informatics	5	0%	2	0	0	0
Unknow	63	6%				
Total	1113		116	59	1	128

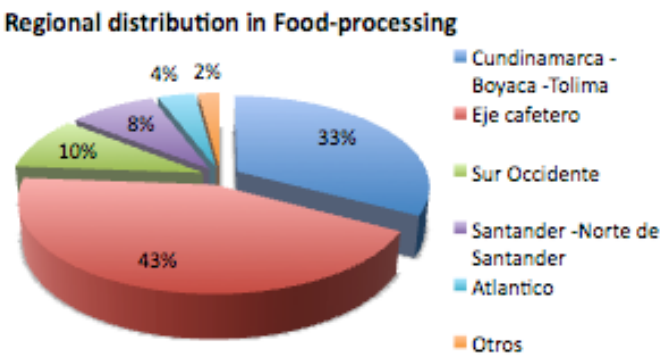
Leader organization	Number of projects	Percentage	Density	Projects per organization in average	Projects per organization per year - in average
Universities	626	56%	53	12	0.6
Research Insititutes	380	34%	33	12	0.6
International researc	14	1%	1	14	0.7
Firms	77	7%	71	1	0.1
Others*	16	1%			
Total	1113				

Making sense of the Technological system: Colombian Biotech system 1990 - 2010

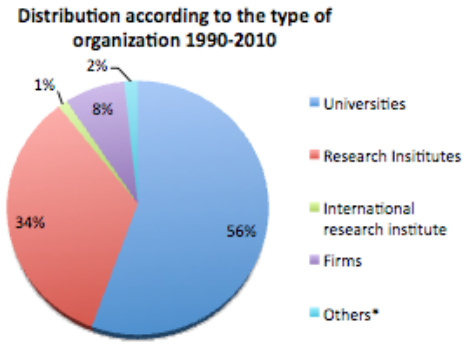


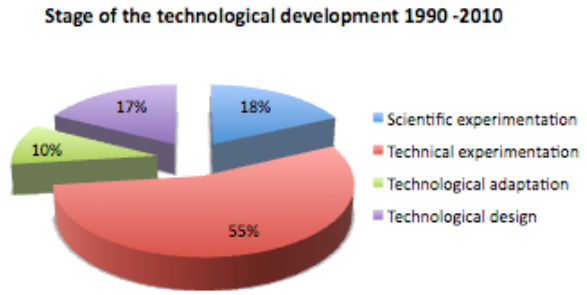


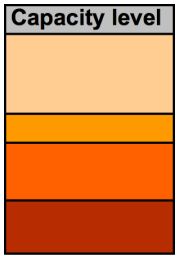




Making sense of the Technological system: Colombian Biotech system 1990 - 2010







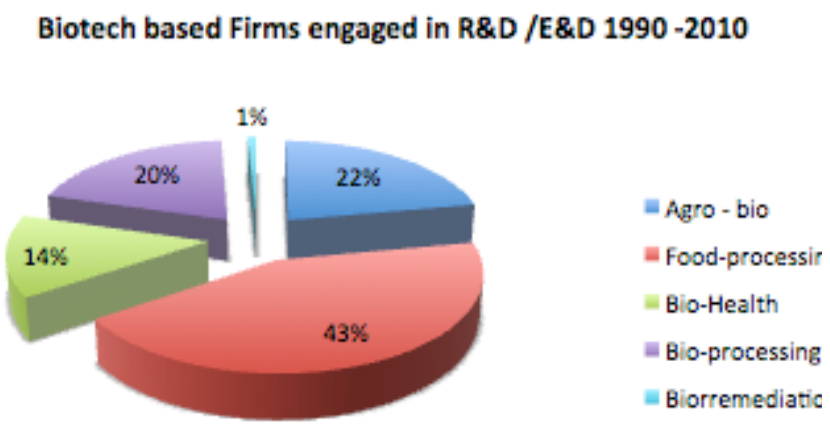
Number of projects 1990 - 2010	Cundinamarca - Boyaca -Tolima		Eje cafetero		Sur Occidente	
1 to 5	9%	8	13%	12	1%	1
5 to 10	5%	2	4%	1	11%	1
10 to 20	15%	2	13%	2	14%	1
20 to 50	15%	1	26%	2	73%	2
more than 50	57%	1	44%	1		0

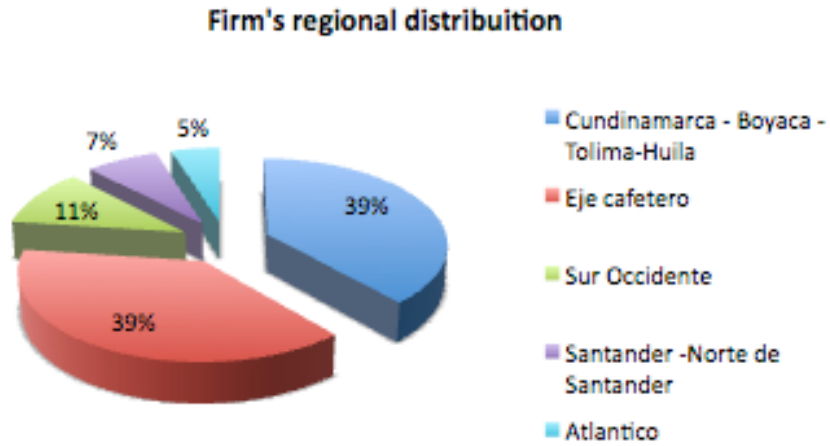
Cundinamarca - Boyaca -Tolima	Eje cafetero	Sur Occidente
		0.5
0.975	0.7	0.65
1.9	1.35	1.65
7.35	4.65	

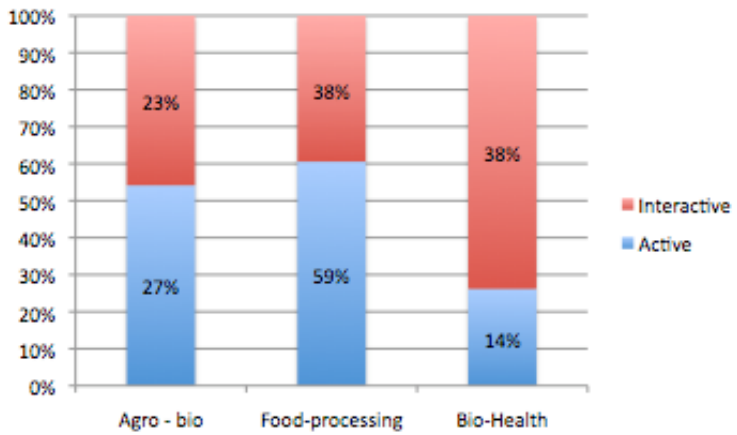
Number of projects 1990 - 2010	Cundinamarca - Boyaca -Tolima		Eje cafetero		Sur Occidente	
1 to 5	12%	6	2%	2	0.36	6
5 to 10	8%	2	7%	1	0.14	1
10 to 20	10%	1	26%	2	0	0
20 to 50	0%	0	17%	1	0.5	1
more than 50	70%	1	48%	1	0%	0

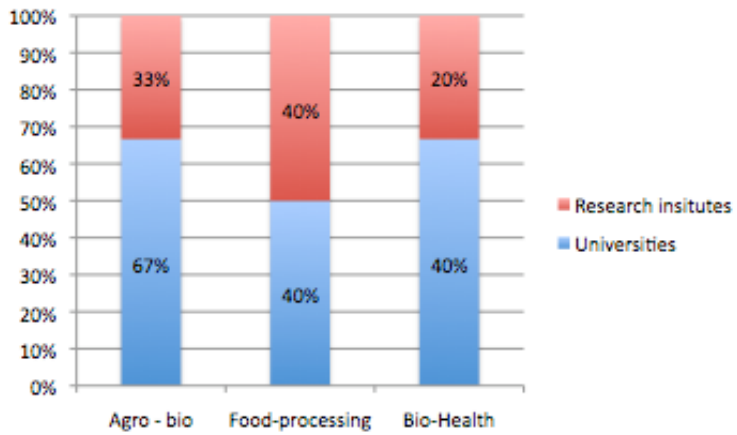
Cundinamarca - Boyaca -Tolima	Eje cafetero	Sur Occidente
0.85	0.875	
	1.15	1.25
6	3.25	

Making sense of the Technological system: Colombian Biotech system 1990 - 2010

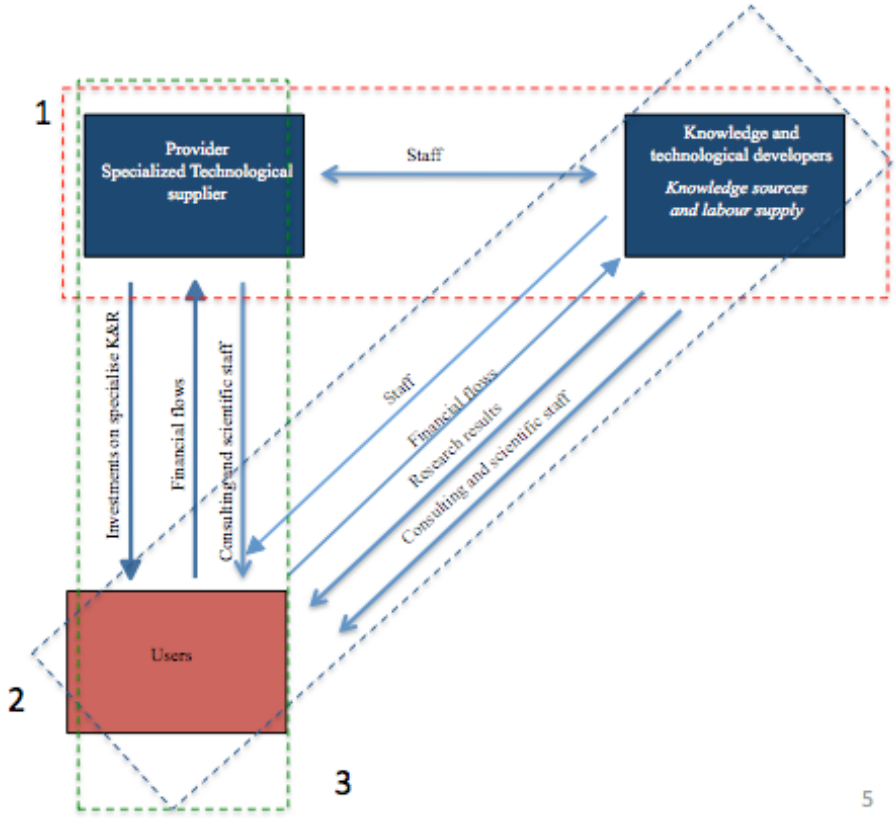


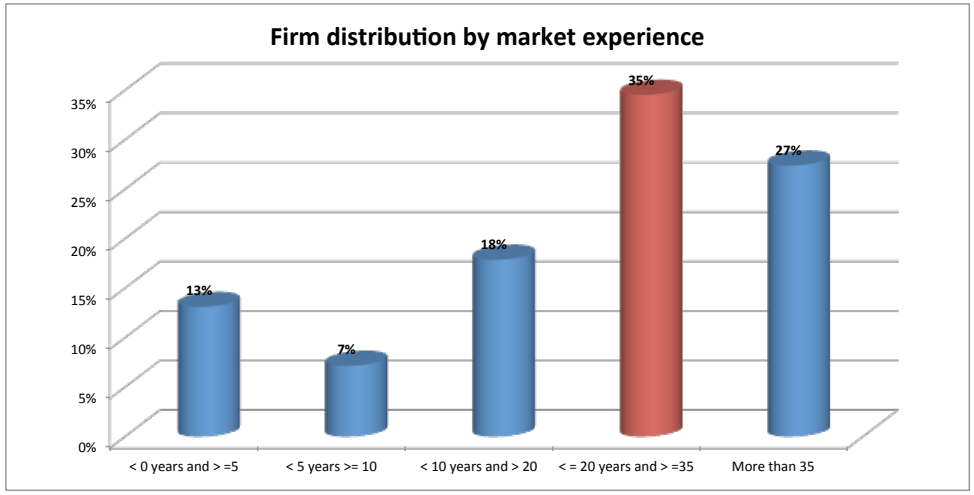






Making sense of the Technological system: Colombian Biotech system 1990 - 2010





1. The firm should has received funds from Colciencias 1990 -2010	43	35%
2. The firm should has started to produce and comercialize its products at least in 2000	29	24%
3. The firm should has developed the interactive E&D/R&D project in between 2004 -2008	12	10%
4. Firms that belong to Agro -bio / food processing/ bio health in the three main regions	6	5%

Two established engineer based SMES: patterns in their learning-capacity building and technological trajectories

Main characteristics of the cases

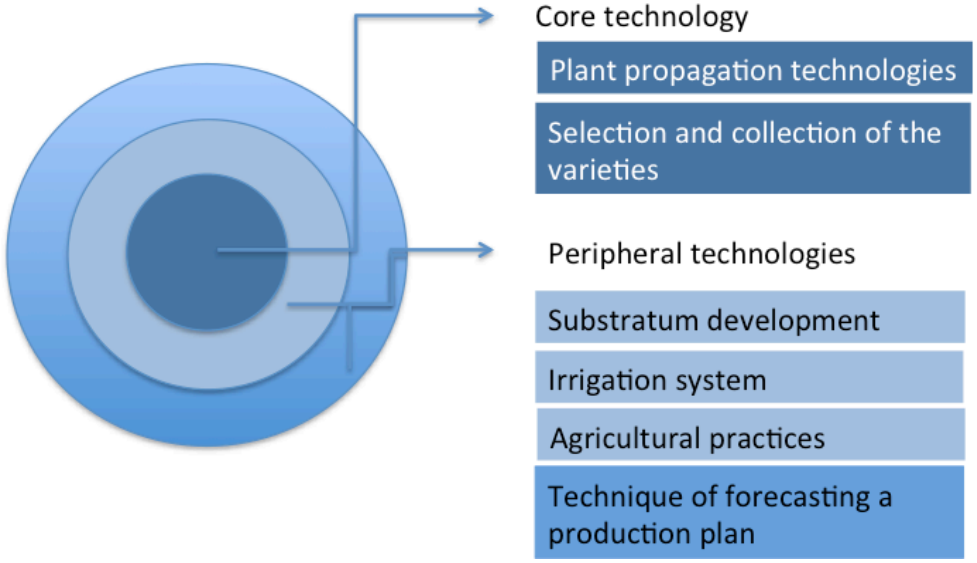
Characteristics	Nursery seedling firm (NSF)	Ingredient supplier firm (ISF)
Size (by number of employees)	Medium-sized firm (2010): 77 employees	Medium-sized firm (2008): 250 employees
Years established	27 years in the market	23 years in the market
Position in the value chain	Specialized supplier; at 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

Two established SMES: patterns in their learning-capacity building and technological trajectories

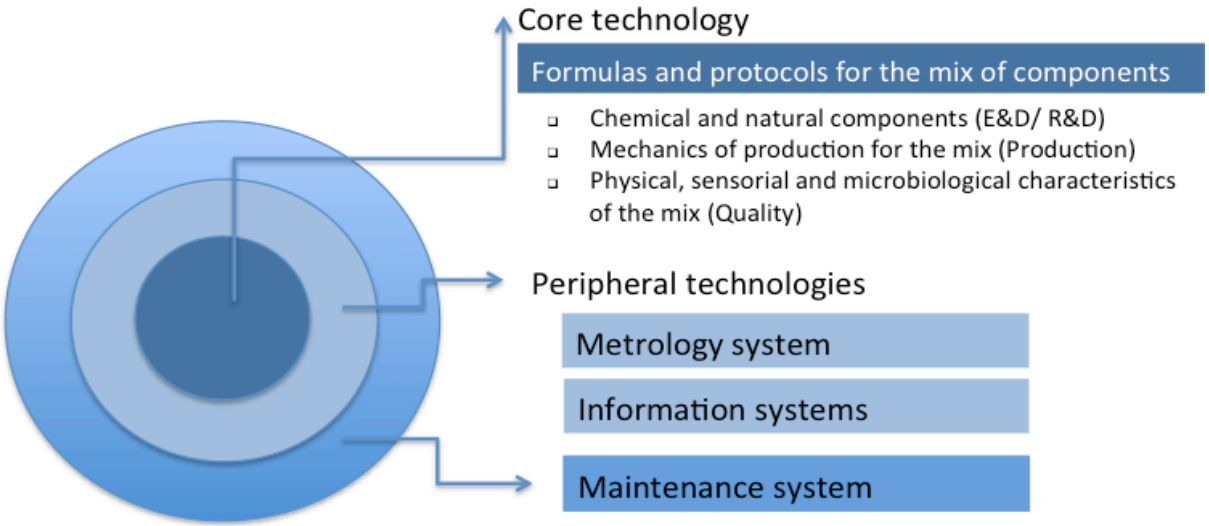
NURSERY SEEDLING FIRM (NSF)

- Production of certified propagated plants of perennial fruits
- Emphasis on the soft part of the technologies
- Technology-push



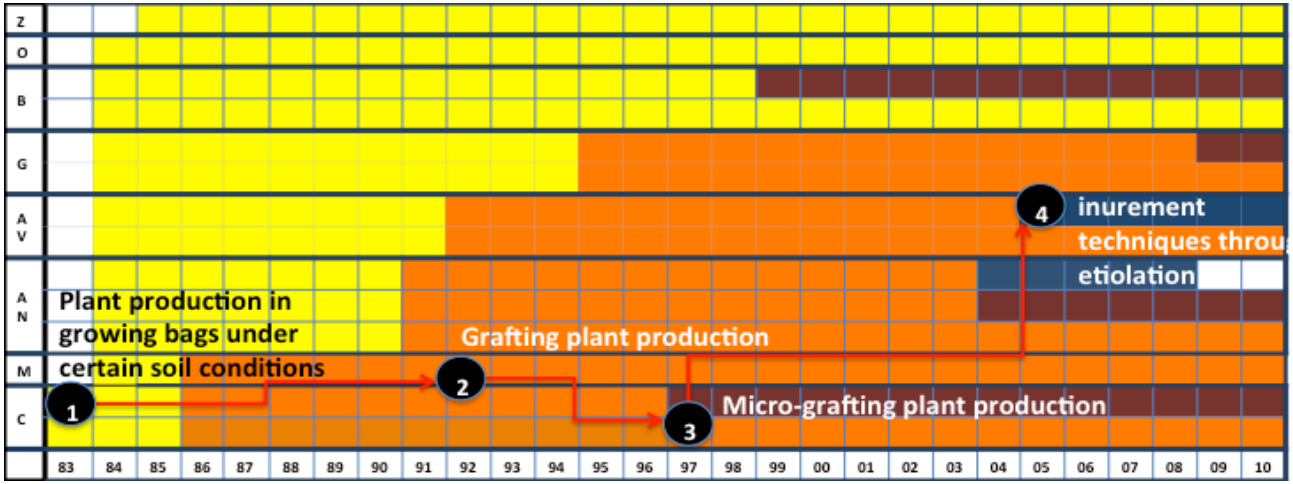
INGRIDIENT SUPPLIER FIRM (ISF)

- Development of formulas and protocols of production for the food processing industry
- Emphasis on the hard part of the technologies
- Demand-pull



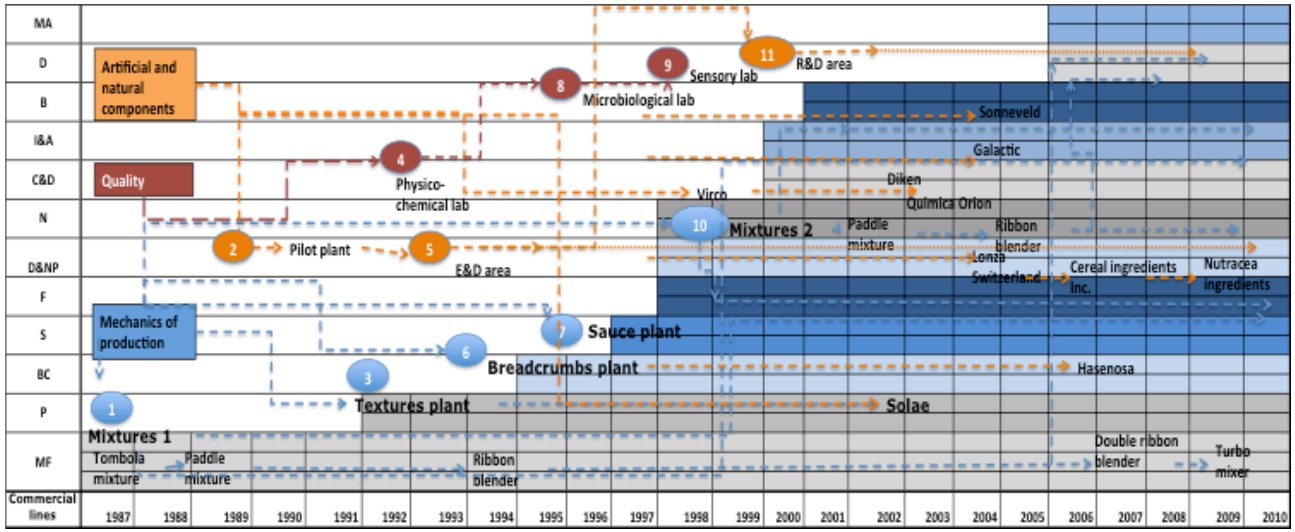
Two established SMES: patterns in their learning-capacity building and technological trajectories

NURSERY SEEDLING FIRM (NSF)



From(1) Agricultural engineering (principal) **to** (2) Advanced biotechnological techniques for propagation

INGRIDIENT SUPPLIER FIRM (ISF)



From (1) Chemical (principal) and Food engineering (principal) **to** (2)Biotechnological techniques for extraction of natural components and micro-encapsulation techniques

Two established SMES: patterns in their learning-capacity building and technological trajectories

The learning trajectory through the firms' life cycles

Learning capacities	Nursery Seedling Firm			
Renewed				*
Created			*	*
Inventive			***	**
Transformative				*
Adaptive	*		**	**
Formative	*	*	***	***
Firms' life cycles	Initial conditions	Formation	Establishment	Expansion

Learning capacities	Ingredient Supplier Firm			
Renewed				*
Created			*	*
Inventive			*	*
Transformative		*	*	*
Adaptive	*	***	***	***
Formative	*	**	***	***
Firms' life cycles	Initial conditions	Formation	Establishment	Expansion

*/**/*** 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 grey colour corresponds to the exploitative learning capacities and the blue colour to the explorative learning capacities.
Source: the author

NSF's KILS figures

- 409 learning events
- 17 learning schemes

ISF's KILS figures

- 850 learning events
- 23 learning schemes

The co-evolution of the KILS and the technological trajectory: gaining absorptive capacity over the firms' life cycles

The KILS at initial conditions of the firms

Features	NSF	ISF
Period	1983–1986: 4 years	1987–1991: 5 years
Learning capacities	Formative and adaptive capacity	
Interaction patterns	Complementary learning events to start developing the capabilities to substitute the initial technological settings	Systemic sequence of learning events for developing the meat and flavouring market
Coherence: strategic orientation	Creating the initial conditions and enhancement of capabilities of production	Achieving sufficient efficiency levels for the establishment of the operational routines to guarantee market entrance
	Favouring exploitation and development of core competences	
Efficiency: core technological routines (behavioural changes)	Establishing the routines to produce growing bags under soil of substratum Developing new capabilities for grafting technology capabilities	Establishing the routines for the mechanics of production to produce the mixes Developing new capabilities for formulation facilities (pilot plant)
Flexibility: diversity–intensity	Low learning experience and limited options available	
Decision-making process	One-man institution	
MLMs	Non-MLMs were installed	Non-MLMs were installed

Source: the author

The co-evolution of the KILS and the technological trajectory: gaining absorptive capacity over the firms' life cycles

The KILS at the formation period of the firms

Features	NSF	ISF
Period	1987–1991: 5 years	1992–1996: 5 years
Learning capacities	Formative capacity	Formative–adaptive–transformative capacities
Interaction patterns	Discretionary learning interactions between learning events	Complementary learning interactions between learning events
Coherence: strategic orientation	Establishing a better propagation technique to enhance efficiency levels in production	Expanding the technological versatility
	Favouring exploitation and development of core competences	Favouring exploitation by balancing the development of core competence and market opportunities
Efficiency: core technological routines	Assimilating grafting technology	Assimilating new techniques for the mechanics of production for new production plants
Flexibility: diversity–intensity	Focusing on learning-by-doing without expanding learning experiences	Retrieval of previous learning experience and expanding the options for new forms of learning
Decision-making process	One-man institution	
MLMs	Non-MLMs were installed	The firm started to develop system capabilities

Source: the author

The co-evolution of the KILS and the technological trajectory: gaining absorptive capacity over the firms' life cycles

The KILS at the establishment period of the firms

Features	NSF	ISF
Period	1992–2001: 9 years	1997–2004: 8 years
Learning capacities	Formative–adaptive–inventive–created	Formative–adaptive– transformative–inventive–created
Interaction patterns	Systematic interactions between exploitative learning events Complementary interactions between explorative and exploitative learning events Systematic interactions between explorative learning events	Complementary interactions between exploitative learning events Discretionary interactions between explorative and exploitative learning events Complementary interactions between explorative learning events
Coherence: strategic orientation	Market diversification	Market and production diversification
Efficiency: core technological routines	Implementing and diffusing the grafting technology throughout the production system Assessing the micro-grafting technology	Implementing the mechanics of production for new plants to support the technological versatility Assessing extraction of natural ingredients
Flexibility: diversity–intensity	Expanding the KILS by using new forms of learning	Retrieval of previous learning experience and expanding the KILS by using new forms of learning
Decision-making process	Participative system Information-seeking culture	Formal management system One-man institution
MLMs	Coordination capabilities by creating technical meetings Socialization capabilities by creating a sense of identity	Socialization capabilities by creating a sense of identity System capabilities by distinguishing the functions and relations between areas

Source: the author

The co-evolution of the KILS and the technological trajectory: gaining absorptive capacity over the firms' life cycles

The KILS at the expansion period of the firms

Features	NSF	ISF
Period	2002–2010: 9 years	2005–2010: 6 years
Learning capacities	Formative–adaptive–transformative–inventive–created–renewed	Formative–adaptive–transformative–inventive–created–renewed
Interaction patterns	Systematic and complementary interactions between exploitative learning events Discretionary interactions between explorative and exploitative learning events Systematic interactions between explorative learning events	Systematic interactions between exploitative learning events Complementary interactions between explorative and exploitative learning events Systematic interactions between explorative learning events
Coherence: strategic orientation	The development and consolidation of the market through better technologies and internationalization	Technological independence, consolidation of new markets and internationalization
Efficiency: core technological routines	Implementation of the micro-grafting technology Implementing the method of protecting the production	Implementing the routines to integrate production, E&D and marketing among the business lines
	Advance biotechnological techniques for propagation	Biotechnological techniques for extraction of natural components Technologies for micro-encapsulation of flavours
Flexibility: diversity–intensity	Retrieval of previous learning experience and expanding the learning system by using new forms of learning	Retrieval of previous learning experience
Decision-making process	Participative system Information-seeking culture	Formal management system Participative system
MLMs	System capabilities by developing more formal and structured means of communication System capabilities by distinguishing the functions and relations between areas	Coordination capabilities through: • Job rotation • Establishment of monthly reporting meetings and advisory committees System capabilities by developing more formal and structured means of communication

Source: the author

General discussion: The knowledge integration and learning system (KILS)

- By focusing on **the learning schemes**, the research for this thesis sought to redefine the (learning) routines in which dynamic capabilities are located. The learning schemes focus on **satisfying** and **gaining perspective** on the firm's potential to learn in relation to its technological options.

- The learning schemes represent a vehicle for knowledge integration offering a broader explanation for the building up of the firm's learning capacity, especially for SMEs.

- The research therefore argues that the way in which firms develop their learning capacities and capabilities is influenced by how individuals and managers are able to make of sense of **the knowledge-integration system** (Tsoukas, 1996) and **the learning system** (Shirivasta, 1983) together in response to **the firms' strategic orientation**.

- Firms achieve their **'absorptive capacity**' when they are able to pursue of knowledge integration by creating an iterative and systemic process throughout all the learning capacities. By looking at the learning trajectory through the lens of the learning-capacity building, an assessment of the firm's learning capacity can be understood by looking at two factors. One refers to the **sense of opportunity** and the second to **technological flexibility**.

General discussion: The knowledge integration and learning system (KILS)

- The two cases studies revealed three interactions patterns between learning capacities throughout their development and evolution process: (1) **Discretionary pattern**; (2) **complementary pattern**; (3) **systematic pattern**

- 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.

- The more open and exposed firms are to learning, the more able they are to avoid **ambiguity** in the direction of their technological development and expand their technological platform.

- The evidence argues for, and favors, the view that firms who develop a **sense of opportunity** through their learning dynamics open up their choices and alternatives. If firms accumulate information and know-how through learning, they increase their **technological flexibility.**

General discussion: The knowledge integration and learning system (KILS)

Learning capacity	Singularities	Challenges	Conditions	Representative learning schemes
Formative	• Tacit knowledge embedded in staff members • Efficiency-driven learning events • Basis for the implementation process • Focused on the development of core competences • Prompted by a participative learning system and socially based methods	• Reducing superticious learning and causal ambiguities	• Creating a sense of autonomy and empowerment among staff members • Development of socialization capabilities. • Developing an Information-seeking culture	• Technical adjustments • Operational practices • Product development
Adaptive	• Explicit and codified knowledge • Efficiency and efficacy-driven learning events • Focused on the development of core competences and market opportunities • Promted by an expert learning system and formal communication methods	• Recognition of the state of knowledge of the production system • Matching selected technologies with commercial opportunities	• Developing system capabilities • Formal management system	• Hiring key technical specialists • Technical advisors • Technical training • Equipment acquisition
Transformative	• Tacit knowledge under different interpretative systems • Risk-sharing of a complementary technology • Focused on market opportunities and strategic focus • Prompted by a participative learning system and socially based methods	• Advoiding unproveness and casual ambiguty • Complementary values between parties to avoid leakage of information	• Developing system capabilities • Formal management system	• Shared specialized equipment • Supplier agreements • Technical mission
Inventive	• Tacit knowledge for development of in-house research expertise • Experimentation to provide divergent technological solutions • Focused on strategic focus • Promted by a participative learning system and formal communication methods	• Advoiding unproveness and casual ambiguty • Formalized and routinized the research activities	• Developing Coordination capabilities • Developing socialization capabilities • Developing an Information-seeking culture • Combining formal management system with a participative system	• Technical experimentation
Created	• Explicit knowledge embedded in specialists • Development of productive opportunities • Prompted by an expert learning system and formal communication methods	• Advoiding unproveness and casual ambiguty	• Developing system capabilities • Formal management system	• Hiring key reaseachers • Technical advisors • Interships
Renewed	• Tacit knowledge under different interpretative systems • Searching for divergent technological and market directions • Promted by a participative learning system and socially based methods	• Advoiding unproveness and casual ambiguty (assimetries in the interpretative system between parties) • Complementary values between parties to avoid appropriability problems	• Developing Coordination capabilities • Developing system capabilities • Developing an Information-seeking culture • Combining formal management system with a participative system	• Experimental research • Engineering research

Source: the author

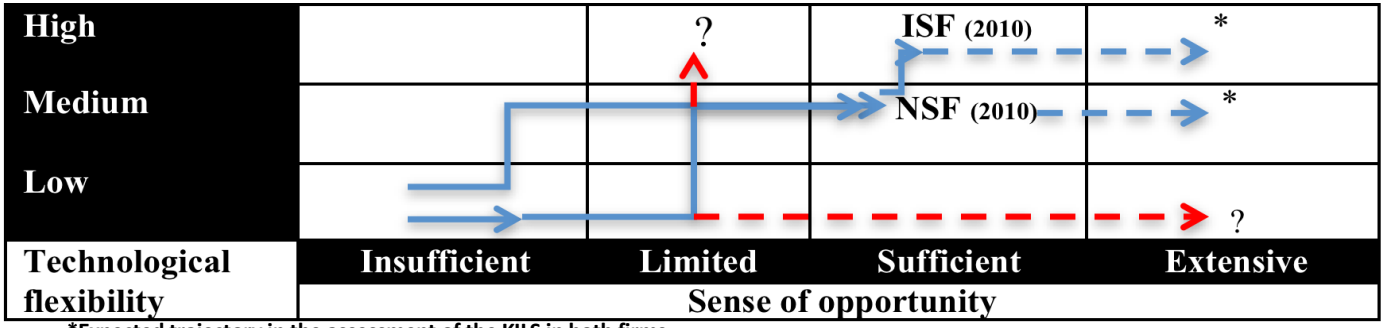
General discussion: The knowledge integration and learning system (KILS)

Assessment of the firms' KILS

Case studies	Life cycle	Initial conditions	Formation	Establishment	Expansion
NSF	Technological flexibility	Low	Low	Medium	Medium
	Sense of opportunity	Insufficient	Insufficient	Limited	Sufficient
ISF	Technological flexibility	Low	Medium	Medium	High
	Sense of opportunity	Insufficient	Limited	Sufficient	Sufficient

Source: the author

Patterns in the evolution of KILS and strategic orientations



*Expected trajectory in the assessment of the KILS in both firms
The blue lines in dashes represent the possible route to follow and the red lines in dashes question if those possible routes could happen over the firms' life cycles.
Source: The author

General discussion: The knowledge integration and learning system (KILS)

- The research proposes that firms must combine a **routine and practice based approach** to learning in which decisions and actions emerge from the individuals in charge of the operational routines with **a strategic based approach** in which conditions for learning are oriented by high ranged managers.

- The evidence from the cases suggests that the characteristics of **the decision-making process** are particularly influential in creating the conditions that spark the learning dynamics. Once firms start to hire knowledgeable staff and they began to develop some expertise through learning-by-doing, the decision-making processes are likely to turn towards more structured, inclusive and participative systems.

- The evidence from the research informs implications for individuals, for managers and industrial policy makers.

Interacción del conocimiento interno y externo y el aprendizaje tecnológico. Políticas

MUCHAS GRACIAS POR SU ATENCIÓN.

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