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EXTENDED ABSTRACT

Title: Break free the dynamics of entrepreneurial ecosystems: the case of the development of the LPWA niche technology and the emerging IoT industry in Toulouse.

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Abstract: *(minimum1500 words)*

Why and what for?[1]

Why is the topic of interest?

While some regions experience the advent of emerging technologies *(Rotolo et al. 2015)* and as a corollary, the emergence of industries *(Gustafsson et al. 2016)*, other regions, despite having a supportive environment, do not observe a similar trajectory.

Therefore, it would be interesting to understand the mechanisms of emerging industries in the context of the development of a technological niche *(Geels, 2001)*. More accurately, we wonder to what extent macro and micro events, also named here as "sub-processes of industry emergence", matter for emerging industries?

[1] Why and what (four): The basis for writing a Good Introduction – Emmanuel P. Papadakis

What is the background on the previous solutions?

A rich scientific theoretical body has embraced the public policy hot topic of industry emergence. In our literature review, we find that most scholars agree that emerging conditions of industries are closely related to spatial dimensions, institutional environment[2] and entrepreneurial activities[3], among other fundamental conditions.

Indeed, a first set of arguments states that geography matters when understanding economic development. Economic studies showed that R&D spillovers *(Audretch et. al 2004)*, patent publication *(Järvenpää et al. 2011)*, scientific and technological development *(Malerba and Orsenigo, 1996)*, spatial agglomeration of industries *(Marshall 1890; Krugman 1991; Markusen 1996)* and clusters *(Porter 1990, 1998; Vicente 2018)* are good indicators and/or catalyzers for economic development *(see Marshall, 1920; Krugman, 1991; Feldman 1994, and others).*[4]

A second set of arguments highlighted by economists and scholars concern the fundamental role of institutions in the development of economies *(North, 1991)*[5] and more accurately local entrepreneurship *(Fuentensaz et al. 2016)*. Indeed, emerging conditions of new industries and technological niches vary according to the maturity of the sectors, and thus of the institutions in place *(Acs et al. 2018)*. In addition, emerging conditions are not the same as those that allow a system to perpetuate because institutions are not necessarily the same at certain stages of maturity because they respond to different needs in terms of the life cycle of the system[6].

Finally, a third set of arguments that would explain the different conditions of emergence of industries lies in the role of the entrepreneur, also known as the individual promoter of development and innovation *(Schumpeter, 1934)*. Since Pervaiz, A. and C. Lechner (2013), entrepreneurs "*act as drivers of change, seizing an opportunity due to changing circumstances and through new industries bringing a change in the economic landscape*. It is the entrepreneurs who, at those different stages for the industry emergence, "*using the resources successfully in a given environment in response to the opportunities they discover, can create a new industry*" *(Aldrich & Fiol, 1994)*. However, entrepreneurs are not isolated from the society nor are they individual heroic actors. In the specific case of emerging industries, according to Aldrich (1994) *"founders of entirely new activities, by definition, lack the familiarity and credibility that constitute the fundamental basis of interaction. Thus, access to capital, markets, and governmental protection are all partially dependent on the level of legitimacy achieved by an emerging industry"*. This illustrates that entrepreneurs are part of a

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[2] *Be formal or informal and which has an inciting or inhibiting role depending on the case*. Institutional Dynamism in Entrepreneurial Ecosystems - Fuentelsaz, Lucio Maícas, Juan P. Mata, Pedro (2017)

[3] The lineages of the entrepreneurial ecosystem approach - Acs, Zoltan J. Stam, Erik Audretsch, David B. O'Connor, Allan (2017)

[4] Even if criticized, an explanation added to the debate is that the world is "spiky" – in contradiction with T. Friedman's "flat world" - that is to say innovation concentrate in specific places and in the "creative class". This argument would explain the difference between regions that are innovative and others that would be less.

[5] « It is the incentive structure embedded in the institutional/organizational structure of economies that has to be key to unraveling the puzzle » - North (1991)

[6] Institutional Dynamism in Entrepreneurial Ecosystems - Fuentelsaz, Lucio Maícas, Juan P. Mata, Pedro (2017)

larger social system, that include the environment of entrepreneurs in the broader sense. As Van de Ven (1993) state *"the social system framework emphasizes that any given entrepreneurial firm is but one actor, able to perform only a limited set of roles, and dependent upon many other actors to accomplish all the functions needed for an industry to emerge and survive"*.

What is the background on potential solutions?

Emerging industries are industries in the early stages of development *(Van de Ven et Garud, 1989)*. In a recent work, Gustafsson et al. (2016), based on previous literature, identified three key phases of industry emergence process*: "an initial stage in which the stage for the industry emergence process is set; a co-evolutionary stage in which the different elements of the emerging industry co-evolve and converge to form a new industry; and a growth stage in which the sales of the newly formed industry take off"*. This key contribution must be nuanced as the conditions influencing the early stages of industries are dependent on the nature of the industry in question *(Bergek and Jacobsson, 2003)* and the type of actors involved in its development. In the specific case of the development of a technological niche *(Geels, 2001)* the competitive advantages and pitfalls from being a first mover in the market are well documented. As Lieberman and Montgomery (1988, 1998) stated, *"while first-movers may be able to achieve technological leadership, pre-empt key resources and opportunities, and shape the emerging industry to their advantage, they suffer from the high levels of technological and market uncertainty and the potential free-riding of their late-moving competitors »*. From another point of view, in his study on the creation of a community and legitimation of US bicycle market, *Burr (2006)* added the seminal idea, that *"early firms may also suffer from the poor performance of early technology and battles over the control of the emerging technology such as patent disputes"*.

In our study, those seminal works are really important because they introduce the necessity of understanding emerging industries on the lens of the entrepreneurial ecosystem (EE) concept *(Isenberg 2011; Feld 2012; Mason and Brown 2014; Spigel, 2015, Spiegel and Harrisson 2018),* for at least four reasons. The first reason is that emerging industry studies bridge commonly accepted and potentially fertile ideas to the EE concept as the idiosyncratic nature of EE lies in the fact that it focuses the analysis on the entrepreneur (the individual promoter of development and innovation in emerging industries) and is distinguished in particular by placing the circulation of resources at the center of the entrepreneurial process. As such, entrepreneurial ecosystems are considered as a driver of economic development in regions, nations and the world *(Acs et al., 2018)*. However, it is important to note that this concept is both different and complementary of other concepts like cluster *(Porter 1990, 1998; Vicente 2018)*, industrial districts *(Marshall 1890; Krugman 1991; Markusen 1996)*, regional innovation systems *(Cooke 1998; Asheim 2005)*, national innovation systems *(Freeman 1987; Lundvall, 1992)* and the technological innovation system *(Hekkert et al. 2017)*[7].

The second reason is that our approach seems suitable to combine emerging industries literature with EE, transition and technological innovation system studies, as they explore in a convergent manner the emergence of new industries (or growth industry). However, there are still some challenges to address at the confluence of those

[7] For a summary, of similarities and distinctions, see Stam (2015)

literatures. First of all, EE literature has not sufficiently explored the institutional and political context of EE interactions *(Alvedalen and Boschma, 2017)*. Even if *"institutions like laws, norms and cultural attitudes enable, or not, interactions across individuals, firms and other organizations"* – that is as crucial ingredients for entrepreneurial networks and thus *"it becomes extremely complex to disentangle what causes what" (Spiegel and Harrisson 2018).*

Thirdly, although several works show the role of ecosystems in the development of the local entrepreneurial process *(Mason and Brown 2014; Sorenson 2017)* and others have studied how geography impacts on entrepreneurship *(Stam 2015; Sorenson 2018)*, the emergence of these ecosystems through time and through scales remains underexplored. In particular, when emerging industries and technological domains are involved. Indeed, as Malecki (2009) mentioned, despite the fact that entrepreneurship is a local event, "distant resources can also be critical". In fact, *"some network links are nonlocal or with transnational firms, which try to embed within key entrepreneurial ecosystems in specific technologies"*[8].

The last reason we should investigate the emerging industry studies on the lens of entrepreneurial activities is because a highly interesting shortcoming spotted by *Gustafsson et al. (2016)* remain unaddressed and fit in our case study : *"when and how disruptions in technological, institutional and regulatory environments, combined with the actions of entrepreneurs and non-market actors, accumulate to the point that leads to the emergence of an industry is unclear in the current literature."*

What was attempted in the present effort?

This paper contributes to filling this gap by monitoring the birth /initial stage of a technological entrepreneurial ecosystem in time, across geographical boundaries (local, regional, global) and institutional scales *(Harrington 2016, Alvedalen and Boschma 2017, Malecki 2017, Mack and Mayer 2015)*. In other words, the proposed effort aims to explore the emergence of a new technological niche through the analysis of its events *(see M. Hekkert, A.H. Van de Ven, A. Bergek, etc.).* Indeed, in this empirical case study, we will try to combine different literature (transition studies, entrepreneurial ecosystems studies, economic geography) in order to understand the advent of a new technology driven by a multi scalar entrepreneurial ecosystem and understand how its structure evolves over time by gathering events.

Because *"all historical technological transition started in technological or market niches" (Geels, 2011)*, and because *"the process (event) approach creates much more insight in the underlying mechanisms that determine technological change through time" (Hekkert et al. 2007),* we think that a sequence analysis of events[9] seems to be a plausible fertile solution for explaining emerging conditions of industries and the building processes of the development of so-called "niche" technologies. However, we do not limit our case study to the local geography as mentioned in the EE literature because in this specific case, Malecki (2018) underlines that even global links matter in local entrepreneurial systems: *"we can conclude that the local scale is the most appropriate for studying entrepreneurial ecosystems"* .

[8] Geographical environments for entrepreneurship (Malecki, 2009)

[9] A. Abbot, Sequence analysis: new methods for old ideas, Annu. Rev. Sociology 21 (1995) 93–113

What will be presented in this paper?

In this work, we will use a sequential events perspective to understand the system building activities of a specific field emerging technology. Since Hekkert et Al. (2007), *"the so-called process approach or sequence analysis is a more fruitful research approach [because] the process approach conceptualizes development and change processes as sequences of events. It explains outcomes as the result of the order of events. It encompasses continuous and discontinuous causation, critical incidents, contextual effects and effects of formative patterns" (Abbot, 1995; Poole et al, 2000)*

Thus, we will use the event definition given by Hekkert et Al. (2007) « events are what the central subjects do or what happens to them » and focus inter-organisational and individual level of analysis *(Van de Ven, 1993).* The idea is to question both, the role of these entrepreneurial ecosystems and the relationship between entrepreneurial activities and the establishment of technological basis. Indeed, the standardization of a domain is important since it allows 1) a facilitation in interoperability standards 2) a role in demand side 3) gain in market acceptance of a domain/ a technology.

Methodology

Objectives (adapted from previous Joan work)

Produce a systematic analysis of the actors and events that are involved in LPWAN construction since 2008 in order to understand the emergence of the development of a technological niche: the LPWAN technology (IoT industry) through the lens of the entrepreneurial ecosystem concept.

LPWAN – *Low Power Wide Area Network* - is an IoT – *Internet of Things* – technology that arise in the early 2010s.

How to reach the objective?

First, we focus on actors (entrepreneurs and firms) that can enhance or hinder the processes of emergence in this specific technological field. We provide a typology of actors based on their characteristics and on their activities in developing the LPWAN technology.

Second, we focus on the events that enhance or hinder the processes of emergence. We provide a typology of events to map the emergence of IoT industry (Gustafsson et al. 2016)

Thus, we will:
1) List the actors (to date, +400)
2) Allocate characteristics
3) List events according to our sourcing method (to date, +1000)
4) Analyze the correlation between actors and events

Actors we are going to study (since Joan previous work)

- Actors identity
    - Actors that are in Toulouse region and are in the IoT-LPWAN technological value chain
    - Actors that are not in Toulouse region and are in the IoT-LPWAN technological value chain

- Actors characteristics
    - 1. Nature of the actor
        - Private Firm and Individuals
        - Public Government agency, university, public research center
        - Others Association / NGO / Network / Regulatory institution

    - 2. Firm position in the IoT-LPWAN technological value chain
        - Material

- Chipset producer
- Module producer
- Device producer
- Network Equipment (base station) producer

- Transmission
  - Techno Network Operator
- Platform
  - Platform Service
  - Information treatment
- Application
  - Vertical use case
- Service
  - Consulting / Service / Accelerators

- 3. Actor relation with IoT-LPWAN paradigm

  - LPWAN Dedicated = fully IoT LPWAN dedicated
    - Actors whose main area of activity is related to LPWAN technology

  - LPWAN Follower = Partially IoT LPWAN dedicated
    - Actors who, through the emergence of the LPWAN technology, evolve their products / services to LPWAN technologies, but without this activity becoming the major element of their commercialization.

  - Happy few = benefits from LPWAN IoT (Technical partners from IoTV at the local level)
    - Actors who do not make LPWAN but make products / services that are needed by IoT LPWAN players, and thus benefit from the emergence of this new domain (ex: electronic component suppliers, antennas, cloud, design ...).

  - Consumer = later adoption of IoT LPWAN (Big groups that partnership with IoTV at the local level)
    - Actors who do not make LPWAN but who adopt LPWAN solutions for the development of their business, to be more efficient in their production or the provision of their services

- 4. Life firm (date pivot: 2009)
  - New firms
    - Companies that were recently created and did not have an activity before 2009
  - Existing firms
    - Companies that already existed in the past and either diversify and start to make LPWAN into their product /

service or rotate and change their business to invest in LPWAN.

- 5. Geographical scale
  - Local (Regional)
  - Non-Local (National – International)

Events we are going to study

We focus on the sub-processes of industry emergence (Gustafsson et al. 2016)

- Establishment of technological basis
  - Development of standards (Rice and Galvin 2006),
  - Engage in technological alliances (Rosenkopf and Tushman 1998),
  - Development of complementary and enabling technologies,
  - Emergence of a dominant design.

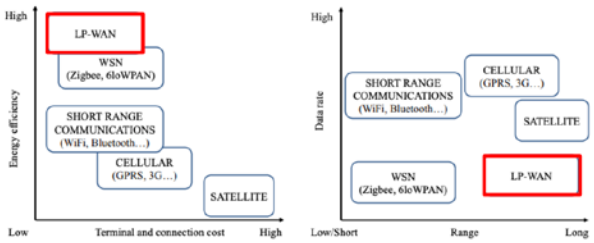
- Emergence of activity networks
  - Collaborative industry university projects (Powell et al. 2005),
  - VC investors to mobilize financial commitments (Spencer et al. 2005),
  - Large incumbent firms to generate marketable products (Vasudeva 2009),
  - Start-ups seeking to generate marketable products,
  - National governmental and political institutions influence,
  - Discursive activities by active organizations and individuals (Lounsbury and Glynn 2001).

- Market emergence
  - Demonstrate the market viability of the new technology (Phaal et al. 2011),
  - Establish and institutionalize new patterns of transactions to facilitate market, generation (Leblebici et al. 1991),
  - Commercialization of emerging technologies (Spencer et al. 2005),

- Formation of industry identity
  - Legitimizing activities - cognitive + socio-political (Aldrich and Fiol 1994),
  - Identification, acquiring and cooperating with firms they perceive as their competitors or peers (Kennedy 2005, 2008; Santos and Eisenhardt 2009),
  - Media coverage (Kennedy 2008),
  - Engagement of industry associations and regulators (McKendrick and Carroll 2001).

What is LPWAN?

No need for a huge pipe to circulate a drop of water. This is the principle behind the LPWA IoT network protocol. Unlike conventional mobile networks, such as 4G or 5G, which can carry large amounts of information, LPWA networks are not tailored to meet the needs of devices that "talk a lot" like smartphones. This barbarian acronym stands for Low Power Wide Area (Network).



Sanchez-Iborra and Cano 2016

Low-Power Wide-Area Networks (LPWAN) or Low-Power Wide-Area (LPWA) Networks are a set of wireless communication technologies designed for low data-rate, power-efficient communication over long distances at a low cost.

LPWAN technologies are aimed at IoT applications that require the transmission of small amounts of data over long distances or to gather information from hard to reach locations (e.g. deep underground or remote areas) from battery-operated devices that can operate for several years without any human intervention, with minimal device and connectivity costs.

This frequency modulation technology can circulate only small packets of data, emitted by temperature or humidity sensors, for example, attached to connected objects. This information can travel longer distances than traditional telecom networks. To send in LPWA, connected objects need little energy. No need for human intervention to change the battery. A device can emit for ten years with a small battery.

It exists many LPWA Technologies fighting to establish a standard as LoRa, NB-IoT, LTE-M, RPMA-Ingenu, OnRamp, Sigfox and others. There is not one better solution than the other a priori, everything is a compromise of power and range, but all of them are fighting to become the LPWA next standard.

IoT LPWA networks thus connect everyday objects (from communicating textiles to cars), machines and people communicate with it via embedded systems. At the electronic and software level, the LPWA has not involved a real revolution, but rather an evolution of systems that implement a set of technologies, existing or new. Connected objects are "classic" embedded systems in the sense that they are autonomous, sometimes real-time and specialized in a specific task. Nevertheless, they are particularly constrained in terms of their resources: industries will to optimize them

to the maximum in terms of consumption, congestion and components to reduce their overall cost. For example, at the Sigfox World IoT Expo in 2017, the CEO of the Toulouse company announced the design of a unidirectional component whose manufacturing cost is 20 cents.

Keywords: *(maximum 6 words)*
JEL codes: