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Shared Leadership and Team Creativity: A Social Network Analysis in Engineering Design Teams

Qiong Wu [*1], *Kathryn Cormican* [1]

Abstract: This research explores the relationship between shared leadership and creativity in engineering design teams. To do this, a social network perspective was adopted using four measures to assess key elements of shared leadership networks. These are (a) network density, (b) centralization, (c) efficiency and (d) strength. Data was collected from a sample of 22 engineering design teams who adopt a shared leadership approach. Our results support previous findings that the density of a shared leadership network is positively related to team creativity. In contrast, we learned that centralization exerts a negative influence on it. Moreover, while we found that there is no evidence to support a positive correlation between efficiency and team creativity, we demonstrate an inverted U-shaped relationship between strength and team creativity in a shared leadership network. These findings are important because they add to the academic debate in the shared leadership area and provide valuable insights for managers.

Keywords: shared leadership; social network analysis; team creativity; engineering design teams

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1. Introduction

High-quality leadership is essential to team effectiveness (Kozlowski & Bell, 2003; Pearce et al., 2004). In fact, some scholars have argued that it is the most decisive enabling factor (Zaccaro et al., 2002). However, the majority of existing research in the area of team leadership has concentrated narrowly on the influence and behavior of individual team leaders who occupy formal leadership positions, therefore largely ignoring leadership roles provided by team members (Kozlowski & Bell, 2003). In recent years, the concept of shared leadership has emerged in the literature. It is defined as *"leadership that emanates from the members of teams and not simply from the appointed team leader"* (Pearce & Sims, 2002). Shared leadership, occurs when all team members are fully engaged in the leadership process instead of being led by a solitary designated leader (Seers et al., 2003). Studies have found that shared leadership has proven to produce greater effectiveness (Muethel & Hoegl, 2013), to be a significant predictor of team outcomes (Shane Wood & Fields, 2007) and team performance (Ensley et al., 2006), and it is related to an increase in the quality of problem solving skills (Pearce, 2004). Thus, we are witnessing an evolutionary shift in leadership responsibilities from a single appointed manager to that of many team members. Hooker and Csikszentmihalyi (2003) assert that shared leadership is now becoming the new dominant organizational form. There are two key reasons for this. Firstly, because in the present complex working environment, it is difficult for a sole leader, despite the level of experience or education background, to have sufficient knowledge and skills to carry out all leadership functions required 0. Secondly, high performance teams rely on knowledge workers who demand a participative approach to decision making (Bergman et al., 2012). As a consequence, attention has begun to concentrate on this shift from solitary leaders to that of shared leadership as a better way of leading high performance teams (Ensley et al., 2006; Mehra et al., 2006).

Table 1 synthesizes recent studies that have been conducted in the area of shared leadership. It illustrates the various contexts that recent research studies have been conducted, the relationships between shared leadership and team outcomes, as well as the methods that researchers have used to measure shared leadership. Specifically, looking at the first column in Table 1, we can see the different contexts in which shared leadership has been studied. This includes change management teams (Pearce & Sims, 2002), independent professional teams (Muethel & Hoegl, 2013), consulting teams (Carson et al., 2007), sports teams (Fransen et al., 2015), virtual teams (Pearce et al., 2004), field-based sales teams (Mehra et al., 2006), top management teams (Ensley et al., 2006), product development teams (Cox et al., 2003), and extreme actions team (Klein et al., 2006). The second column of Table 1 depicts the correlations between shared leadership and team effectiveness (Cox et al., 2003; Muethel & Hoegl, 2013; Pearce & Sims, 2002; Pearce et al., 2004); team performance (Carson et al., 2007; Ensley et al., 2006; Mehra et al., 2006), team leading roles (Fransen et al., 2015) and team dynamic delegation (Klein et al., 2006). Lastly the third column of the table synthesizes the methods used for measuring shared leadership. We found that prior work has mostly focused on aggregating team members' ratings of their perception of the extent to which leadership responsibilities are shared. For example, Pearce et al. (2004) study on virtual teams and Ensley et al. (2006) work on new venture top management teams both used ratings (aggregated to team level) on behavioral scales for four leadership strategies namely directive, empowering, transactional and transformational.

(1) College of Engineering and Informatics, National University of Ireland, Galway
*Corresponding author: Q.Wu1@nuigalway.ie

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Table 1: Previous research of shared leadership related to contexts, correlations, and methods

Contexts	Correlations	Methods	References
Change management teams	Team effectiveness	Aggregating ratings	Pearce and Sims (2002)
Independent professional teams	Team effectiveness	Not defined	Muethel and Hoegl (2013)
Consulting teams	Team performance	Social network analysis	Carson et al. (2007)
Sports teams	Leading roles	Social network analysis	Fransen et al. (2015)
Virtual teams	Team effectiveness	Aggregating ratings	Pearce et al. (2004)
Field-based sales teams	Team performance	Social network analysis	Mehra et al. (2006)
Top management teams	Team performance	Not defined	Ensley et al. (2006)
Product development teams	Team effectiveness	Not defined	Cox et al. (2003)
Extreme actions teams	Dynamic delegation	Aggregating ratings	Klein et al. (2006)

An analysis of the extant literature reveals some gaps in the research that warrant further investigation. Most notably Bergman et al. (2012) have suggested that future studies in the area of shared leadership should pay attention to aspects beyond traditional team performance metrics. Hooker and Csikszentmihalyi (2003) ascertain that shared leadership may offer both timely and useful assistance in promoting the creative potential of engineering design teams. However, we notice a dearth of studies focusing on the correlation between shared leadership and team creativity. Furthermore, there is lack of empirical analysis and practical arguments for the influence of shared leadership on team creativity. It seems that this important issue should be addressed.

Engineering design comprise knowledge workers from many different disciplines and requires complementary skills to execute innovative efforts. Such teams focus on problem solving (Lessard & Lessard, 2007) where creativity plays a vital role (Gehani, 2011). Indeed, the creative capacity of the team is lauded to consolidate the platform of organizational innovation (Pandey & Sharma, 2009) and mold the foundation for positive team outcomes (Kratzer et al., 2010). Additionally, according to Ensley et al. (2006), the creative process is accelerated when workers are encouraged to collaborate with peers and to autonomously self-direct. In light of this, our research aims to expand the current debate on shared leadership to engineering design teams. We found that prior work has failed to capture the relational nature of shared influence among team members. Therefore, using social network theory, (see Carson et al. (2007), Mehra et al. (2006), and Small and Rentsch (2015)), we advance a more complete conceptualization of the relational phenomenon of shared leadership and use social network analysis to better capture patterns of influence. Consequently, the goal of our research is to explore the correlations between shared leadership and team creativity in engineering design teams using social network analysis. To do this, we create a conceptual model of our study and propose four key hypotheses about the correlations between key metrics in shared leadership networks and team creativity. We develop binary matrices and sociograms to plot the interactions between the team members in each of the sample teams. Finally, we conduct inferential statistical tests using correlation analysis and hierarchical regression analysis to examine our proposed hypotheses.

The remainder of the paper is organized as follows: in section 2, a synthesis of the relevant literature is presented which focuses on shared leadership and social network analysis. From this, key hypotheses are generated. Section 3 presents the research methodology employed in this study. This describes the data collection process, sampling method, measuring process as well as the data analysis process. Finally, the research findings are discussed, limitations of the study are identified and the final conclusions are drawn.

2. Literature review and hypotheses generation

2.1. Shared leadership

Traditional models of leadership in organizations emphasize hierarchy where a single appointed leader is responsible for communicating visions and controlling operations (Cox et al., 2003; Shane Wood & Fields, 2007). However, with the pervasive presence of self-managed teams (Latora & Marchiori, 2001), team members tend to share leadership responsibilities, with visions, plans and actions emanating from many members within a team as opposed to a single individual. Shared leadership, thus, is attracting more scholars, and has been defined in many different ways. It is considered in terms of team processes during which team members engage in the leadership role and interact with each other to achieve organizational goals (Ensley et al., 2006). It is also characterized by the serial emergence of official and unofficial leaders (Pearce, 2004). Moreover, it refers to a mutual influence process that is dynamic, simultaneous, on-going, as well as multidirectional (Fletcher and Kaufer 2003). Carson et al. (2007) propose that shared leadership should not be considered in a narrow sense where the focus is on specific leadership traits, characteristics or behaviors. But rather they contend that a wider perspective should be adopted where shared leadership is considered in terms of multiple influencing resources within teams. Building on these ideas, we can say that shared leadership refers to the widespread influence that arises from the distribution of leadership responsibility among team members. Moreover, based on the research of Shane Wood and Fields (2007), we present a comparative analysis of traditional leadership and shared leadership characteristics (see Table 2).

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Table 2. Comparative analysis of traditional leadership and shared leadership

Dimension	Traditional leadership	Shared leadership
Ways of leading	Centralized vision (Pearce & Conger, 2002)	Self-led (Cox et al., 2003)
Communication & information flow	Vertical and top-down (Shane Wood & Fields, 2007)	Lateral and interactive (Hackman & Johnson, 2013)
Decision-making process	Decisions made by the appointed leader (Cox et al., 2003)	Members involve in decision making process (Bergman et al., 2012)
Members' behaviors	Dependent and instructed (Pearce & Sims, 2002); Executing individual tasks appointed by the formal leader (Day et al., 2004)	Autonomous (Mehra et al., 2006); Social integration (Pearce, 2004)
Team's behaviors	Responsive to the leader' s expectations (Seers et al., 2003)	Cooperative and consensus–driven (Bergman et al., 2012)
Organization's vision source	Top down (Pearce & Conger, 2002)	Shared vision stemmed from team (Pearce & Conger, 2002)
Intragroup environment	Tend to hierarchy (Pearce & Conger, 2002)	Less conflict, higher cohesion and intragroup trust (Bergman et al., 2012)

2.2 Social network analysis

Shared leadership has been regarded as a relational phenomenon that involves patterns of reciprocal influence within a team. Therefore many studies have used social network analysis techniques to measure it (e.g., Mehra et al., 2006; Small & Rentsch, 2015). This approach is appropriate for two main reasons. First of all, social network analysis is an intrinsically relational method used to examine relationship patterns; it provides methods to model the interpersonal influences and uses network graphs to identify patterns of leadership. Secondly, social network analysis is lauded to better preserve information about actual distributed leadership patterns within teams (Balkundi & Kilduff, 2006). In this research, we use social network analysis to assess the characteristics of shared leadership networks by employing four measurements: density, centralization, efficiency and strength. Table 3 lists the concepts and application of these four measures based on an analysis of the literature of social network analysis. We note that previous studies of shared leadership has applied density (Carson et al., 2007; Lee et al., 2015), centralization (Mehra et al., 2006; Small & Rentsch, 2015) or a combination of these two to measure the distribution of leadership functions among team members (Pastor & Mayo, 2002). However, we notice a lack of research on strength and efficiency in shared leadership networks. Strength and efficiency, have been widely applied to communication networks (Kratzer et al., 2010; Yuan et al., 2009). Communication is regarded as an essential antecedent and a critical success factor to shared leadership (Hoppe & Reinelt, 2010). The willingness of team members to communicate closely aligns with their willingness to interact with peers which in turn can influence the effectiveness of shared leadership in a team (Hackman & Johnson, 2013). As a consequence, efficiency and strength should also be examined in shared leadership networks in order to help us understand a new perspective and enable a deeper analysis.

Table 3. Concepts and applications of four measurements of social network analysis

Measurements	Concepts	Applications	References
Network density	Measures the compactness or closeness of team member interactions with each other.	Shared leadership Networks	Carson et al. (2007); Lee et al. (2015)
Network centralization	Measures the extent to which team members rely on a small concentrated number of people.	Shared Leadership Networks	Mehra et al. (2006); Small and Rentsch (2015)
Network Efficiency	Measures the amount of contact among team members. This implies how much information flow is in a network.	Communication Networks	Kratzer et al. (2010)
Network Strength	Measures the frequency of contact among team members. This can influence how often information is exchanged.	Communication Networks	Yuan et al. (2009)

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2.3.1 Network density

Density in a leadership network describes the percentage of actual leadership ties relative to all potential leadership ties among team members (Carson et al., 2007). When more group members perform leadership responsibilities more leadership ties emerge which then increases the network density. Lee et al. (2015) used network density to measure shared leadership by studying its effects on knowledge sharing as well as the subsequent influence on team creativity. Their results illustrate that knowledge sharing plays a partially mediating role between shared leadership and team creativity. In other words, the process of knowledge sharing is boosted in shared leadership networks with high levels of density, where more team members perform leadership behaviors. During this process, members can also share their own expertise and integrate these in new ways. Integration is likely to increase the cross-fertilization of viewpoints and promote the probability of team creativity. On the contrary, low levels of density in shared leadership networks with fewer links among team members hinders knowledge sharing and acts as a barrier to creativity. Therefore we propose:

Hypothesis 1: Density in a shared leadership network is positivity related to team creativity.

2.3.2 Network centralization

Centralization represents the extent to which one or several team members are predominant in a shared leadership network (Sparrowe et al., 2001). The theoretical basis for proposing a hypothesis that there is a negative correlation between shared leadership network centralization and team creativity, is extracted from differences among dependence, independence and interdependence presented by Molm (1994). Those arguments imply that lower levels of network centralization can facilitate interdependence among team members that in turn contributes to co-operation. Group members in interdependent network relationships are different from those in dependent relationships where team members have fewer interactions with each other. Individuals in interdependent networks tend to have more communication and cooperation with their peers. As network centralization represents the degree to which exchange relations are focused on a small number of actors, the higher the centralization in a shared leadership network, the less interdependence, and thus the less cooperation that exists. It is the cooperation among team members that fosters exchange of knowledge, and encourages participation of individuals. This in turn increases the chances of interaction among networks and thus raises the possibility of team creativity. On the basis of these studies, the following hypothesis is proposed:

Hypothesis 2: Centralization in a shared leadership network is negatively related to team creativity.

2.3.3 Network efficiency

According to Burt (2009), "*network efficiency is the first design principle of an optimized network*". Thus when measuring shared leadership networks, we should consider this factor. In light of this, we propose that efficiency in a shared leadership network exerts a positive influence on team creativity. The main argument behind it is that leadership interactions among team members can be confined by the available energy and time, yet a highly efficient network generates less waste of energy and time, and, consequently, more would be used to transform information into new ideas. Moreover, high network efficiency means that teams have more access to various non-overlapping information flows and mutually unconnected partners (Kratzer et al., 2010), which boosts the diversity of knowledge and then increases the possibility of creativity. As a consequence, we present:

Hypothesis 3: Efficiency in a shared leadership network is positivity related to team creativity.

2.3.4 Network strength

Network strength, refers to the frequency of contacts among team members which can affect how often information is exchanged within the team (Kratzer et al., 2010). High frequency means that individuals can communicate and exchange their expertise more regularly, which would thus raise the level of creativity in the team. Additionally, frequent contact can promote internal trust among team members. Trust was found to contribute to knowledge sharing and collaboration (Mcevily et al., 2003). Flap and Völker (2001) contend that team performance benefits from teams with a high level of trust and collaboration. In this situation, team members are likely to be more creative. However, it should be noted that some researchers have argued that too much interaction can impede innovation (Baer, 2010). In this view when there is much interaction within a team, opinions and perspectives can become very similar and even redundant, which could exert a negative influence on the creative process. Recently, Kratzer et al. (2010) suggested that there may be a curvilinear relationship between strength and creativity. This means that with the increase in network strength, team creativity shows a downward trend after rising to an optimum level (i.e. an inverted U-shaped relationship), which implies that a certain amount of contact among team members in shared leadership network can promote team creativity, whereas too much communication would exert a hindering effect on it. Consequently in this study we used network strength to help assess frequency of contact in shared leadership networks and also tested this curvilinear relationship:

Hypothesis 4: There is an inverted U-shaped relationship between strength and team creativity in shared leadership networks.

3. Methodology

3.1 Study setting

We collected data from two types of engineering design teams - chemical engineering design teams and mechanical engineering design teams who adopt a shared leadership approach. 173 respondents from 24 teams initially participated in our study, which accounts for a response rate of 89%. The data collection process lasted almost three months, during which questionnaires were distributed via email to teams in order to measure the level of shared leadership and the level of creativity within the teams. As results of network analysis are more sensitive to data omission than others a within-team response rate of 90% is required (Maloney et al., 2010). In light of this, all data from teams with a response rate below 90% was excluded. Finally, our data analysis relied on 22 teams which accounted for a total of 158 participants. The characteristics of the sample are shown in Table 4.

Table 4. Attributes of the sample

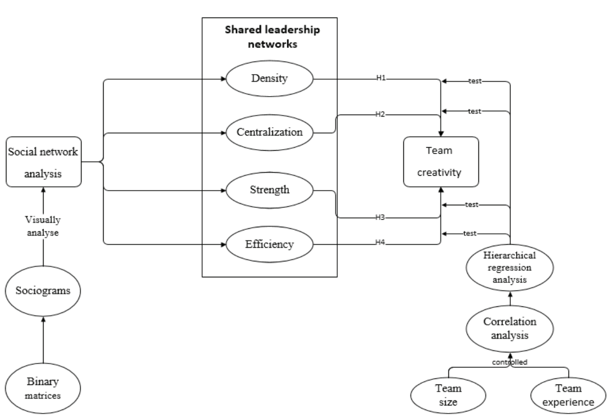
	Total amount (respondents)	Average age (years)	Average tenure (years)	Team number	Team size (persons)
Sample	158	32.8	3.7	22	7.2

	Gender (%)		Education degree (%)				Nationality (%)			
	Male	Female	<Bachelor	Bachelor	Master	PhD	China	England	German	Others
Sample	66.7	33.3	3.4	51.6	35.9	9.1	69.9	10.2	11.8	9.1

3.2 Measures

The measurement process can be divided into three parts. It is illustrated in Figure 1. The first is to examine shared leadership networks in terms of their structure and properties. During this process, we developed binary matrices to identify the level of shared leadership in each of the teams, we employed sociograms to visually analyze what shared leadership networks look like for each participating team, and then we calculated the coefficients of network density, centralization, efficiency and strength in order to reveal each of the shared leadership networks' properties. Secondly, we measured team creativity from four angles, novelty, originality, usefulness and flexibility. The third part introduced two control variables (e.g. team size and team experience) in order to eliminate their influence during the data analysis. Specific details of the measurement process are presented below.

Figure 1: The measurement process



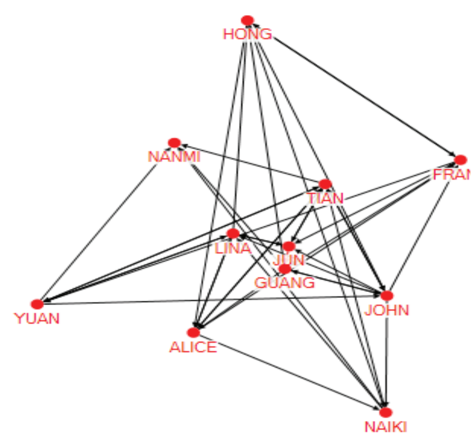
3.2.1 Shared leadership networks

In order to assess the distribution of leadership responsibilities from each of the 22 engineering design teams, a roster method was used to collect data following the procedures of the classic sociometric work of Stogdill (1948) on leadership in teams. Each team was provided with a list of names (in alphabetical order) representing all members of the team and a list of leadership responsibilities based on the research of Pastor and Mayo (2002). Respondents were required to select the names of individuals that they perceived to perform leadership responsibilities. The data collected from participants were analyzed using the following procedures.

Binary Matrices: Binary matrices are useful because they can represent the presence or absence of relationships between pairs of elements in a system. In our study they are used to measure the level of leadership responsibilities for each participant in the study relative to another. To do this, we arranged data from 22 teams in separate g*g matrices (g is the total number of actors in one network) and used this to identify and describe shared leadership. To be specific, in each matrix, cell would be given the value of 1 if *i* perceived *j* perform 3 or more than 3 leadership responsibilities (range from 0 to 6); otherwise, can be deemed as 0.

Sociograms. A sociogram is a graphical representation of the social links that each team member has. It is used in this study to visually depict the structure of each network from the codes in the binary matrices for each team. This visual analysis can also be used to clarify the overall network topology and reliably recognize central nodes (see Freeman, 2004). Figure 2 below provides an example of a sociogram developed by NodeXL. It represents a mechanical engineering design team comprising 11 members. As shown in this figure, almost no members are central in this network and they are all nearly equally distributed.

Figure 2: One example of shared leadership sociogram in this study



The last procedure is to quantify shared leadership networks by calculating the coefficients of network density, centralization, efficiency and strength for each sociogram. The value of all coefficients vary between 0 and 1.

Network Density. The coefficient of network density was calculated by the sum of all direct links (L), and then dividing by the number of all potential direct links that could have emerged (Wasserman & Faust, 1994). In this research the coefficient was computed by Ucient Software (Borgatti et al., 2002).

$$ND = \frac{L}{g(g-1)} \text{Eq. (1)}$$

(g is the total amount of team members; L is the sum of all links)

Network Centralization. Based on a mathematical definition of centralization proposed by Freeman (1979), centralization can be measured using Eq. (2). We used Ucinet software to compute this parameter (Borgatti et al., 2002).

$$NC_A = \frac{\sum_{i=1}^{g}[C_A(n^*) - C_A(n_i)]}{\mathrm{Max}\sum_{i=1}^{g}[C_A(n^*) - C_A(n_i)]} \text{Eq. (2)}$$

($C_A(n_i)$ is a centrality index of one member; C_A (n^*) is the greatest index among it; g is the total amount of members.)

Network Efficiency. Our study used the measurement of Burt (2009) to calculate network efficiency as shown in Eq. (3).

$$NE\,(n_i) = \frac{\sum_j[1 - \sum_q P_{iq} M_{jp}]}{N} \text{Eq. (3)}$$

(N is the total amount of members; P_{iq} is interaction with q divided by the sum of i's relations; M_{jp} interaction with q divided by the strongest of j's relationships with anyone, q≠i, j)

Network Strength. Followed on the research of Kratzer et al. (2010), we used Eq. (4) to illustrate how to calculate the coefficient of network strength. A scale of 0 to 6 is used in this research.

$$NS\,(n_i) = \frac{(\sum_{\forall i \neq i} L \cdot S)}{\sum_{\forall i \neq i} l \cdot S_{max}} \text{Eq. (4)}$$

(S_{max} is the maximum strength 6; L is the value of direct links (0 or 1); S is the contacting strength (0 to 6))

3.2.2 Team creativity

Team creativity was measured via a 7-point Likert scale based on items developed by Kratzer et al. (2008) which comprised items such as novelty, originality, usefulness and flexibility. The results show a Cronbach's Alpha coefficient of 0.81, which proves a high level of scale reliability. Next, we calculated the value of team creativity from the collected data. To do this we counted individuals' creativity scores by averaging the scores of these 4 items. Then we calculated the scores of each teams' creativity, by summing the values of individuals' creativity and dividing by the total number of team members.

3.2.3 Controls

We controlled two variables namely team size and team experience to eliminate their influence on the results. Specifically, we controlled team size because literature on teams has shown that size has a significant influence on team creativity. For example, Leenders et al. (2003) found that team size has negative effect on creativity. Team experience is included as a control variable, as pervious scholars have found there is a curvilinear relationship between that organizational tenure and team engagement in the creative processes (Gilson & Shalley, 2004). In this research, team experience was measured by calculating the average tenure of leaders and members in teams.

3.3 Analysis and results

In this research, there are four independent variables (density, centralization, efficiency and strength), one dependent variable (team creativity) and two control variable (team size and experience). In order to explore the correlations among these variables we conduct a correlation analysis using a one-tailed test as it can help us predict whether a relationship exists and if so it can determine the direction of that relationship (Kutner et al., 2004). We also used hierarchical regression analysis to test hypotheses as this study conducts multilevel analysis (Tabachnick & Fidell, 2007). The descriptive statistics for the dataset are reported in Table 5: the mean value of team creativity is 5.62 (on a scale from 1 to 7), and the mean network density, centralization, efficiency and strength are 0.43, 0.21, 0.51 and 0.58 correspondingly (on a scale from 0 to 1).

The matrix in Table 5 also shows the results of correlation analysis on team-level data and reveals the relationship among these variables. We can see that network density is significantly correlated with network strength (r = .37; $p < .05$), and network centralization related to network efficiency (r = .43; $p < .05$), which would affect the results of a regression analysis due to multicollinearity problems. However, this research also found that the values of Variable Inflation Factor (VIF) (which is an indicator to quantify the severity of the multicollinearity) among all variables are below 1.5. This suggests that the strength of the relationship is not enough to be overly concerned when estimating the regression coefficients (Kutner et al., 2004).

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Table 5. Descriptive statistics and Correlations *p<.05 **p<.01

Variables	Mean	SD	ND	NC	NE	NS	TS	TE
Dependent variable								
Team Creativity (TC)	5.62	0.68	.72**	-.54**	-.16	.48*	-.47*	.02
Independent variables								
Network Density (ND)	0.44	0.06	-	-.31	-.20	.37*	-.30	-.01
Network Centralization (NC)	0.20	0.05		-	.42*	-.14	.05	-.07
Network Efficiency (NE)	0.51	0.08			-	-.24	-.13	.22
Network Strength (NS)	0.57	0.11				-	-.23	.13
Control variables								
Team Size (TS)	7.18	1.56					-	-.23
Team Experience (TE)	3.71	0.81						-

Table 6 illustrates the results of the regression analysis with team creativity as the dependent variable. Model 1 in this table shows the basic model with only control variables (= .15), which explains 15% of the variation in team creativity.

Table 6. Hierarchical regression analysis with dependent variable team creativity *p<.05, **p<.01, ***p<.001

Independent Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Controls							
Team size	-.49*	-.29	-.32*	-.31*	-.30	-.18	-.18**
Team experience	-.10	-.05	-.08	-.10	-.10	-.06	
Predictors							
Network density		.63**	051**	.52**	.44*	.37**	.36**
Network centralization			-.38*	-.41*	-.38*	-.35**	-3.14**
Network efficiency				.10	.02	.06	
Network strength					.21	6.27**	4.40***
Strength squared						-6.03**	-4.26**
	.23	.60	.72	.72	.75	.89	.88
Adjusted	.15	.52	.65	.63	.65	.83	.84
F	2.81	8.58**	10.64***	8.28**	7.64**	15.43***	23.50***

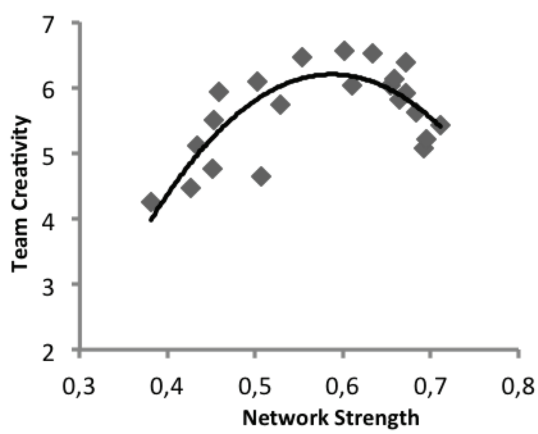
Model 2 refers to network density, a predictor variable, which is used to test Hypothesis 1 (*density in a shared leadership network is positivity related to team creativity*). The result shows that there is a positive statistically significant correlation between network density and team creativity (β=.63; *p*<.01), implying that higher levels of team creativity would exist in shared leadership networks with more links among team members. Thus, our Hypothesis 1 is fully supported by this result. The control variables and network density explains 52% of the variance.

The independent variable network centralization was added to the equation and is listed in Model 3 of Table 6. The result supports Hypothesis 2 (*centralization in a shared leadership network is negatively related to team creativity*) due to a negative statistically significant correlation between network centralization and team creativity (β= -.38; *p*<.05), suggesting that a more centralized network with higher variance has unequal distributions about leadership within teams tents to hinder creativity. The of this model accounted for 65% of the variance in team creativity.

Unexpectedly, when we entered network efficiency (shown in Model 4 in Table 6), it did not achieve statistical significance. In other words, we cannot find a significant relationship between network efficiency and team creativity (β= .10; *p*>.05). Therefore, Hypothesis 3 (*efficiency* *in a shared leadership network is positivity related to team creativity*) is not supported. Moreover, when we added the network efficiency variable, the value of (.63) in Model 4 reduced by .02, compared to the value of (.65) in Model 3. This implies that network efficiency plays a negative role in explaining the variance in team creativity.

Next we tested Hypothesis 4: *there is an inverted U-shaped relationship between strength in shared leadership network and team creativity*. To do this, network strength was entered (see Model 5 in Table 6). This was found not to be correlated to team creativity (β= .21; p>.05). This model accounts for 65% of the variance in team creativity. Next the quadratic term of network strength (i.e., network strength squared) was added (see Model 6). Then, we found it has a significant and positive quadratic effect on team creativity (β= 6.03; p<.01), during which the value of adjusted increased from .65 in Model 5 to .83 in Model 6. It means an additional 18% of the variance increases the linear effect. This negative quadratic term associated with a positive linear term (β= 6.27; p<0.01) implies that there is a predominantly positive, concave downward curve (Aiken et al., 1991). We plotted this interaction in Figure 4: the quadratic fit of network strength in predicting team creativity, which reveals that team creativity rose gradually with the growth of network strength, nevertheless after team creativity peaked with the value of strength around 0.55, it decreased as network strength increased. The inverted curve supports Hypothesis 4.

Figure 3. The inverted U-shaped graph between network strength and team creativity



Model 7 in Table 6, is a full model including the control variables and all the predictor variables. This explains 83% of the variance in team creativity. Model 8 in Table 6 is an adjusted full model that contains only the significant variables with the value of adjusted being .84.

In summary, this research proved that shared leadership network density is positively associated with team creativity, as opposed to network centralization that exerts a negative influence on it. Moreover, while we found that there is no evidence to support the positive correlation between network efficiency and team creativity, we demonstrated an inverted U-shaped between strength and team creativity in shared leadership networks.

4. Discussion

The result of this study offers support for the hypothesized positive relationship between network density in shared leadership structures and team creativity. It suggests that team creativity is increased where high levels of density in shared leadership networks exist. Here large number of interactions among team members can effectively accelerate the process of information flow, and consequently, promote team creativity. This finding is consistent with other studies such as Lee et al. (2015), who proposed that shared leadership exerts a positive effects on knowledge sharing and consequently on team creativity.

According to our analysis, the relationship between centralization in shared leadership networks and team creativity is negative as expected. This confirms earlier studies which also found a negative relationship between network centralization and team creativity (e.g., Leenders et al., 2003). This research focuses on leadership behaviors that are distributed among team members. The result implies that in shared leadership networks where centralization is strong, the level of interdependence and cooperation among team members is reduced, which hinders team creativity. In contrast, when networks have a lower level of centralization, larger members are engaged in the leadership process, as a result, accountability for the team performance is more equally distributed across the whole team which in turn helps to develop creative solutions to problems.

Our findings do not support the hypothesis that efficiency in shared leadership networks is positively related to team creativity. To our surprise, there is no statistical correlation between them. It means that efficient information exchange in shared leadership networks does not influence the creative performance of the team. This contradicts the findings of Leenders et al. (2003) who discovered that moderate efficiency in communication networks enhances the creativity of teams.

Finally, as expected we found that in shared leadership networks, there is an optimum level of strength in a network which contributes to creativity, however after this point increased strength levels may lead to the tendency to impede team creativity. This finding is broadly consistent with strength-of-weak-ties theory as outlined by Granovetter (1973) and those of researchers who have argued for an inverted U-shaped relationship between strength and team creativity (e.g., Kratzer et al., 2010; Perry-Smith & Shalley, 2003). Our findings have extended their work by demonstrating that a curvilinear relationship exists between network strength and team creativity in shared leadership networks. It suggests that in shared leadership networks, as links between two individuals grow stronger, group members come to know each other; and then, viewpoints held by others become shared and perhaps redundant. As a result, during this process team creativity increases gradually, after reaching the peak value and then downward trend appears.

5. Conclusions and future work

Previous studies have proven that a team does well when it relies on leadership provided by the team as a whole instead of being led by a single individual. With more focus on shared leadership, researchers have shown that this model has a positive influence on team performance, effectiveness and important team processes. Our study added to this conversation by exploring the relationship between shared leadership and team creativity. We found that network density, centralization and strength are all associated with team creativity in shared leadership networks. We also learned that network efficiency is not related to team creativity. This implies that high density, low centralization and appropriate strength of shared leadership networks promote team creativity for organizations in industries. These findings are important for many reasons. First, our research expands and deepens the debate in the area of shared leadership area by collecting empirical data in a new domain. Second, our findings have practical relevance for senior managers in industry who seek to implement best practice design structured in organizations. Third, as our study collected real data from functioning design teams (as opposed to an artificial setting in a laboratory) this study crosses the chasm from academia to industry.

However, this research is not without its limitations. First, we understand that self-report studies rely on a certain level of introspective ability from respondents to answer questions and despite all efforts to increase validity and reliability they may also be prone to response bias which could lead to deviation in the data. To combat this, future studies might consider including data from external assessments such as independent experts as well as self-reported data from internal respondents. Second, this study focused on two types of engineering design teams: chemical engineering and mechanical engineering employing a sample of 22 design teams in total. As this sample is not representative of all engineering design teams, the results do not accurately measure the entire population. Hence, future research could adopt a wider perspective and include more data from teams representing different engineering fields. Thirdly, as shared leadership networks are dynamic and subject to change as time goes by, particularly when new relations have just been built a longitudinal study may justified. Finally, future research could focus on examining whether there are some potential mediating factors in the relationship between shared leadership and team performance, effectiveness or team creativity. In this regard constructs such as team cooperation or team empowerment may be considered.

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Improving Innovation in University Spin-Offs. The Fostering Role of University and Region

*Christian Corsi *[1], Antonio Prencipe [1]*

Abstract: University spin-offs (USOs) are companies created to commercialize knowledge or technology developed in academia; thus, their major contribution to the knowledge economy is their ability to generate innovation. Following the Resource-Based View of the Firm and the Knowledge Spillover Theory of Entrepreneurship, it was stated that fostering mechanisms at university level and at regional level may positively influence the USOs innovation. Based on a sample of 621 Italian USOs, we show that the positive impact of the university context is more crucial compared with those of the regional context. In particular, the university affiliated business incubators and Science Parks, jointly with the university financial resources, seem to promote the innovation efforts of USOs. These evidences rise the need of a resilient partnership among all the contextual players involved in the spillover processes, mainly at regional level, in order to effectively exploit the potential innovative efforts of the university start-ups.

Keywords: University spin-offs; Innovation; University context; Regional context; Knowledge Spillover Theory; Resource-Based View

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Introduction

In the last decade, the interest of scholars in the dynamics of growth and mechanisms that promote university entrepreneurship, through University Spin-Offs (USOs), has improved (Fini et al., 2011; Sternberg, 2014; Rodeiro-Pazos et al., 2012). Indeed, these university start-ups are an effective tool in inspiring the establishment and development of knowledge-based economies (Sternberg, 2014). The determining factor related with their creation and growth have become strategic and vital matters in the policy actions concerning the dissemination and promotion of innovation in specific environmental contexts (Lockett et al., 2005). Indeed, the USOs are companies created with the aim to commercialize knowledge or technology developed in academia; therefore, their major contribution to the knowledge economy is their ability to generate innovation (Rodríguez-Gulías et al., 2015). Additionally, the contribution of innovation to growth has been well recognised in literature, both in theoretical and empirical perspective, becoming a pivotal and strategic element (Wong et al., 2005). Several studies emphasise that USOs usually have got a better performance in term of innovative activities in comparison with non-academic start-ups, especially in term of patent generation (Cantner & Goethner, 2011; Lejpras, 2014), pointing out as its original nature of academic environment significantly affects the innovation direction and dynamics of the spillover company. Nevertheless, other scholars reveal that USOs are no so effective in generating innovation, with a small impact in the socio-economic environment (Rodeiro-Pazos et al. 2014; Iacobucci & Micozzi, 2014). These considerations call for a more understanding of the fostering factors and mechanisms which encourage innovation activities in USOs. In this regard, the theoretical assumption of the resource-based view theory applied to the USO context (Rodeiro-Pazos et. al, 2012; Vinig & Van Rijsbergen, 2010) and the Knowledge Spillover Theory of Entrepreneurship (Acs et al., 2013) remarks the resources, capabilities and fostering mechanisms of university origin (Rasmussen et al., 2014), jointly with the features, the composition and the interactions of the regional context in which the USO is located (Sternberg, 2014; Rodríguez-Gulías et al., 2015) in supporting entrepreneurship activities, such as innovative ones. The assumptions above mentioned acquire a greater cognitive and exploratory value if we consider that innovation activities and outcome in USOs context have not been fully investigated, and only recently some scholars are contributing to explore some relevant issues regarding the innovative dynamics of academic entrepreneurship (Rodríguez-Gulías et al., 2015; Cantner & Goethner 2011; Lejpras 2014). Nevertheless, Cantner and Goethner (2011) and Lejpras (2014) have adopted a firm-centred approach in the investigation of the innovative performance of USOs, while only Rodríguez-Gulías et al. (2015) have adopted an interactionist approach, including the promoting role of the regional context in the study of USOs innovation. This study aims to enrich the knowledge gained with the cited studies in a complementary and cross manner through a two-level contextual approach of analysis: the university level and the regional level. The approach it was extensively used to investigate the success determinants of USOs in term of number of generated firms and firm performance (Rodeiro-Pazos et al., 2012; Fini et al., 2011), but never in term of innovativeness of the USOs. Hence, this paper aims to fill this knowledge gap in the USOs literature by hypothesizing that the university context and the regional context may partially determine the innovative performance of USOs. To this purpose, the study analyses a sample of 621 Italian USOs in 2014. Italy is one of the major European countries reporting a rapid expansion of the university spin-off phenomenon (Fini et al., 2011; Iacobucci & Micozzi, 2014). Indeed, according to the latest report Netval (Netval, 2015), at 31.12.2014, the spin-offs, by a public research surveyed in Italy are 1102 and that about 87.4% of them has been formed over

(1) Università degli Studi di Teramo, Teramo, Italy
*Corresponding author: ccorsi@unite.it

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the past ten years. The paper aims to provide a contribution to the knowledge – both in term of academic and managerial perspective - about the mechanisms fostering innovation in USOs, with reference to emerging contextual critical factors by applying multilevel analysis. Similarly, the paper wants to improve the understanding about the technology transfer activities and the related most suitable policy actions to rise their success and development, with the purpose to contribute to the economic diffusion of innovation, driving of the firm and economic growth.

Theoretical Background

University context and USOs innovation

There are several methods and mechanisms that can be engaged by universities to fostering innovation through spin-out processes. Following the theoretical arguments of the Resource-Based View of the Firm (Sirmon et al., 2007), which focuses on distinctive recipes of resources and capabilities, the effectiveness of spin-out processes and innovative activities by USOs (Rodeiro-Pazos et. al, 2012; Vinig & Van Rijsbergen, 2010) is closely linked to the financial assets, human capital, organizational and technological resource factors from the university (Rasmussen et al., 2014).

The role of technology transfer office (TTO)

Universities can foster technological innovation of USOs by establishing technology transfer offices (TTOs). Indeed, TTOs support technological diffusion by the licensing to industry of inventions or intellectual property generating in academia (Algieri et al., 2013). The innovation management literature argues that commercial resources provided by the TTOs have a complementary but significant role for the appropriation of research outputs and for improving innovative activities in academic entrepreneurship (O'shea et al., 2005). In order to spread innovative findings, TTOs support researchers encourage and control the university's intellectual property, contributing to create networks among academicians and venture capitalists, as well as with the industry (Berbegal-Mirabent et al., 2015), stimulating the financing and management support of the innovative activities of USOs with the sharing of vital tangible and intangible resources. In this regard, TTO staff facilitates innovation thanks to their better knowledge about technology and their marketability (Plewa et al., 2012) and TTO personnel skills are pivotal for the spinout process (Wood, 2011). For this reason, we constructed the following hypotheses:

H1a: There is a positive relationship between the number of TTO staff and the innovation performance of USOs.

The role of the university incubators and Science Park

University-affiliated business incubators are central actors in the value creation process of USOs (O'Shea et al., 2005; Berbegal-Mirabent et al., 2015). Indeed, literature remarks the vital support of these infrastructural fostering mechanisms of university entrepreneurship, especially during the early stage of USOs (Grimaldi & Grandi, 2005). Incubators accelerate the knowledge and technologies exploitation giving advanced professional facilities in the form of human skills, expertise, supporting infrastructure at the young university start-ups, reducing the gap between academia and industry and improving the growth and innovative directions of the firm (Etzkowitz, 2002). In this regard, the university incubators help the entrepreneur to overcome technical, management and market barriers for the full development of the innovative activities of the spin-off (Vinig & Van Rijsbergen, 2010).

H1b: There is a positive relationship between the existence of incubation services in the university and the innovation performance of USOs.

Another form of fostering support to the development and innovation of USOs is the university-affiliated science park (Minguillo et al., 2015). Indeed, Science Park are entrepreneurial organizations where knowledge spillovers could rise more simply among the universities and spin-offs, fostering the creation and exchange of technology and knowledge between them (Montoro-Sánchez et al., 2011). Therefore, USOs inside Science Parks may improve their innovative ability by linking their internal expertise with the knowledge provided by the parent organization, jointly with those derived by located firms (Díez-Vial & Montoro-Sánchez, 2015). University Science Parks are vital hubs that encourage and control the flow of knowledge and technology among academic institutions, supporting the development and growth of innovation-based companies, such as USOs. Hence, University science parks make available an idyllic milieu to generate, exploit and share knowledge and technological capability among all actors involved. These parks provide knowledge-building working area, generate business clusters, improve the efforts and the output of universities research policies, as well as bring high-tech companies and science-based business together, to better perform in the modern knowledge economy (Berbegal-Mirabent et al., 2015).

H1c: There is a positive relationship between the existence of university science parks and the innovation performance of USOs.

The role of university financial resources in research activities

An essential prerequisite for the start of technology transfer and, thus, for the optimal generation of innovation from university spin-offs, is the level of financial resources available in research activities (Declercq, 1981). The role of resources in R&D activities is central in encouraging innovative performance of USOs, providing the capability to engage external knowledge and be more innovative (Rodríguez-Gulías et al., 2015). About this aspect, some scholars have revealed that the university spin-offs activity and performance are positively related with the stock of research funding provided by the parent organizations (Van Looy et al., 2011). Indeed, the university research activity is pivotal in the success performance of the spin-off firms therein generated, because the higher the volume of university research activity, the higher the volume of technology to be exploited, which is directly associated to the university financial resources in research activities (Rodeiro-Pazos et al., 2012).

H1d: There is a positive relationship between the university financial resources in research activities and the innovation performance of USOs.

Regional context and USOs innovation

Several scholars remark the pivotal role of the geographical dimension and proximity in the understanding of the innovation process (Gittelman, 2007). Indeed, regional context has been recognised as a central argument for knowledge generation, in the current knowledge of economy (Florida, 1995), especially concerning the firm innovation (Audretsch & Feldman, 2004). In this view, the Knowledge Spillover Theory of Entrepreneurship is useful to clarify the level of entrepreneurial innovation system of a region (Plummer & Acs, 2014), as combining investments in knowledge by the universities to those by the regions, becoming suitable to evaluate the extent of entrepreneurial activity related to the universities (Acs et al., 2013). Hence, USOs can take advantage from the knowledge capability of a region and from other dynamics linked to the local spatial externalities (Guerini & Rossi-Lamastra, 2014).

The role of the regional R&D activities

The regional knowledge infrastructure is one of the central element in the knowledge/technology spillovers, stimulating innovative activities (Beugelsdijk, 2007). The regional knowledge infrastructure is a combination of R&D workforces and expenditures, jointly with other complementary elements (Fini et al., 2011; Audretsch & Feldman, 2004). In line with this consideration, external R&D activities can act as input for USOs (Raspe & Van Oort2009), which can benefit from the results achieved by the regional innovative efforts. This is in view of the mid-term effect from which high-tech firms can take advantage, element linked to the so-called spillover effect (Acs et al., 2013). These arguments are in line with the classic theoretical and empirical works that state a positive association between R&D and innovative outputs of the firm (Audretsch, 2003).

H2a: There is a positive relationship between the regional R&D expenditure and the innovation performance of USOs.

H2b: There is a positive relationship between the regional human resources in R&D and the innovation performance of USOs.

The role of the regional human capital

Additionally, the literature stressed as the formation and development of human capital, with specialized skills in the regional context, is a central source of external knowledge for the innovative activities high-tech start-ups, such as USOs (Audretsch & Feldman, 2004). The basic reason of the above-mentioned concept is linked to the argument that a well-educated labour force has several chances to absorb and use information and learning, thus understand, in a potentially systematic way, the complex dynamics of the socio-economic system, becoming a strategic feature of the regional knowledge economy (Raspe & Van Oort, 2008). Nevertheless, Florida (2005) claims that the geographic link from education to innovation output, in that same regional context, may no longer hold. This is due to the improved mobility of highly skilled and educated individuals within nations and even across borders. However, the human capital of a region remains crucial for a USO as its educational context of origin leads to keep and absorb the best-qualified and skilled regional workforce (Rodríguez-Gulías et al., 2015).

H2c: There is a positive relationship between the regional human capital and the innovation performance of USOs.

The role of the regional patenting activity

A key factor, associated to innovation performance of academic spin-offs, is represented by the innovation capacity of the region (Sternberg, 2014). The literature usually employs the patenting activity as an indicator of the technical knowledge of a region (Audretsch et al., 2008), and as a location of a spin-off, in an active region, it may bring benefits to the entrepreneurial development of intellectual property, generated therein and thereby, contributing to the entrepreneurship and innovation effort (Griliches, 1990). Furthermore, external patenting activity may potentially function as input for other firms due to the imitative behaviour of competitors (Van Oort & Raspe, 2009). Consequently, the innovative performance of USOs can be associated to external innovation of the regional entrepreneurial context.

H2d: There is a positive relationship between the regional patenting activity and the innovation performance of USOs.

Method

Sample

In order to test the research hypothesis above, it was analysed a panel sample of 621 Italian USOs extracted from Netval database at 31 December 2014, a database part of the project "Spin-off Italia" and run in collaboration with Netval, Università Politecnica delle Marche and Scuola Superiore Sant´Anna – Istituto di Management, which collect updated information about the full population of active spin-off in Italy; while data cover a period from 2004 to 2012. Additionally secondary data about USOs was performed by the analysis of financial statements and other corporate files extracted from Aida BdV database, an Italian subset of ORBIS database, which containing historical financial, biographical and merchandise data of about 700,000 Italian active companies. Precisely, financial information are provided by Honyvem who acquire and reprocesses all official accounts deposited with the Italian Chambers of Commerce. Information regarding the regional context were collected by extracting data from the records stored by the Italian National Institute of Statistics (ISTAT) and the Statistical Office of the European Communities (EUROSTAT), while data concerning the patent activity of universities were extracted from PATIRIS database. Lastly, data regarding university research funding, business incubators and Science Parks were collected from institutional websites of universities, MIUR (Ministry of Education, University and Research) and regional authorities.

Variable definition

Dependent variable

The dependent variable applied in this study, the innovation performance USO, was measured by a dummy variable that takes the value 1 if the USO had any patent activity and 0 otherwise (INNOVATION). Indeed, the patent is one of the major output of companies' ideas and novelty, representing a key milestone within the innovative activities of the spin-off. In addition, patenting activity is usually used to measure the innovation performance in spin-out process (Lejpras, 2014; Rodríguez-Gulías et al., 2015).

Independent variables

With the aim to predict the potential effects of the selected two-level contextual determinants, of innovation performance of USOs, three independent key variables are used in the multivariate analysis. Regarding the university context variables, according to Rodeiro-Pazos et al. (2012) and Vinig and Van Rijsbergen (2010), the technology transfer office support is measured by the number of full-time equivalents (FTEs) employed in the TTO (TTO STAFF). Second, in line with Berbegal-Mirabent et al. (2015), with the aim to evaluate the impact of the infrastructural support to innovation by university incubators and Science Parks, it has been used the number of university-affiliated business incubators (UNI INCUBATOR) and Science Parks (UNI SCIENCE PARK). Third, following Fini et al. (2011), we addressed university financial resources for research eminence by coding the amount of public research fund (in Euro units), which is part of the ordinary funding (FFO), a government funding that constitutes a major source of income for Italian universities (UNI R&D). With reference to the regional context variables, with the aim of estimating the prominence research resource of a region and, hence, the knowledge spillovers in the local context, it has been used, in line with Fini et al. (2011), a variable, stating the public R&D expenditure in the administrative region in thousands of Euros (REG R&D EXPEND); jointly with a variable, following Audretsch and Keilbach (2004), which measures the amount of regional personnel and researchers employed in R&D activities (REG R&D STAFF). In order to evaluate the human capital eminence of a region, it has been used a variable, stating the number of persons with tertiary education and/or employed in science and technology at regional level (REG HUMAN CAPITAL). Finally, in accordance with Baldini (2010), regional patenting activity - with particular reference to the entrepreneurial and competitive context of spin-offs - is measured by the high-tech patent applications to the European Patent Office in each region (REG PATENT).

Control variables

In line with Sørensen and Stuart (2000), it is control for the number of years that the USO has been active (AGE), jointly with the firm size, in accordance with De Cleyn and Braet (2012), determined by the number of USO's employees (SIZE). Following Berbegal-Mirabent et al. (2015), it is control for the effects of USO' industry, by a dummy variable for USOs in high-tech industries (HIGH-TECH) which takes the value 1 if the USO operates in high-tech industries and 0 otherwise. Since the success performance of USOs may be associated to the number of inventions generated by the university (O'Shea et al., 2005), it is control for the stock of patents for each university in the last 10 years (PATENT).

Analytical approach

In order to test research hypothesis it has been used a binary probit GLM in the estimation of parameters, which is extremely useful in case of dichotomous dependent variables (Pardo & Pardo, 2008). The use of ordinary least square (OLS) regression is inappropriate for this type of dependent variables because the possible range of values is confined to two sides of the interval [0-1] (Kieschnick & McCullough, 2003). Additionally, this statistical method is designed for a maximum-likelihood estimation of the number of rates of non-negative counts.

Results

Univariate analysis

Table 1 shows the descriptive statistics of the variables used in the models. The results indicate that the sampled USOs show a low degree of innovation performance, with a mean value of 1.9% of patenting activity and a moderate dispersion in the sample (S.D. = 13.77%). The number of TTO staff is a sample mean of 5.28, value this that is quite homogeneous in the sample (S.D. = 2.75). On average, universities show a number of about 1 affiliated business incubators (S.D. = 0.92), while the sample average of university-affiliated Science Park is very low, less than 1 (S.D. = 0.48), indeed the sample universities are linked with no more than one Science Park. Regarding the university financial resources in research activities, results show a sample mean of 13,952,122.41 euro, although these data are highly dispersed in the sample (S.D. =10,210,624.318). The number of persons with tertiary education and/or employed in science and technology at regional level show a sample mean of 746.90 but with a high-moderate dispersion in the sample (S.D. =515.20), while the high-tech patent applications to the European Patent Office in each region show a sample mean of 172.80 (S.D. =42.48). The public R&D expenditure in the administrative region shows an average of 340.199 thousands of Euros (S.D. =151.61), while the amount of regional personnel and researchers employed in R&D activities shows a low sample mean of 1.95, with a high dispersion in the sample (S.D. =4.96). Table 2 reports the bivariate Pearson correlations among all variables employed. Given the lack of sufficient high correlation among the independent variables, issues of nonsense correlation are not detected (Aldrich, 1995; Cohen et al., 2013). We checked for multicollinearity, formally using VIF statistics. We found that the VIF scores did not exceed 4.98 - which is not close to the rule of thumb "threshold" value of 10 (Hair et al., 1998) – and an average of 1.96; while the "tolerance" level shows an acceptable value higher than 0.10, suggesting that multicollinearity is not a serious concern, therefore multiple regression analysis can be used to test the hypotheses. It must be specified that our estimation methods, negative binomial regression, do not allow the estimation of VIF scores. Therefore, we report the VIF scores obtained from estimating the models through ordinary least squares (OLS).

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Table 1. Descriptive statistics

	N	Min.	Max.	Mean	S.D.	Variance
INNOVATION	5589	0,000	1,000	0,019	0,138	0,019
AGE	5589	2,000	78,000	8,594	6,520	42,510
PATENT	5589	0,000	408,000	93,766	94,480	8926,389
SIZE	5589	0,000	308,000	5,126	22,120	489,313
HIGH-TECH	5589	0,000	1,000	0,139	0,346	0,119
TTO STAFF	5589	2,000	15,000	5,278	2,750	7,563
UNI INCUBATOR	5589	0,000	3,000	0,834	0,922	0,850
UNI SCIENCE PARK	5589	0,000	1,000	0,360	0,480	0,230
UNI R&D	5589	0,000	44091501,000	13952122,410	10210624,318	104256848972077,000
REG HUMAN CAPITAL	5589	38,000	1902,000	746,896	515,199	265429,704
REG PATENT	5589	0,170	172,800	39,442	42,477	1804,326
REG R&D EXPEND	5589	58,500	855,900	340,199	151,610	22985,648
REG R&D STAFF	5589	0,400	71,460	1,951	4,960	24,606

Source: authors

Table 2. Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	INNOVATION	1												
2	AGE	0.064**	1											
3	PATENT	-0.005	0.196**	1										
4	SIZE	0.030*	0.071**	0.106**	1									
5	HIGH-TECH	-0.056**	-0.233**	0.046*	-0.007	1								
6	TTO STAFF	-0.050*	0.063**	0.137**	0.414**	-0.062**	1							
7	UNI INCUBATOR	0.000	-0.033*	-0.013	0.267**	0.046**	0.028	1						
8	UNI SCIENCE PARK	-0.057**	-0.001	-0.016	-0.030*	0.020	0.202	0.221	1					
9	UNI R&D	-0.001	0.004	0.009	0.575**	0.035**	0.067**	0.288	0.085**	1				
10	REG HUMAN CAPITAL	-0.020	0.115**	0.092**	0.335**	-0.002	0.118**	0.125**	-0.069**	0.247**	1			
11	REG PATENT	-0.031*	0.115**	0.085**	0.328**	0.010	0.144**	0.098**	-0.106**	0.201**	0.802	1		
12	REG R&D EXPEND	-0.063**	0.067**	0.062**	0.307**	0.009	0.019	0.177	-0.020	0.316**	0.506	0.407	1	
13	REG R&D STAFF	0.008	0.013	-0.005	0.003	-0.016	0.013	-0.029*	0.007	0.000	-0.005	-0.002	0.050**	1

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; (all two-tailed tests). Source: authors

Multivariate analysis

Table 3 shows the results of the binary probit GLM in the estimation of innovation performance of USOs, referring to the university context effects. The regression analyses are performed in a step-wise manner. Model 1 includes all the control variables; Model 2, 3, 4 and 5 refer to the four principle effects, entered one by one, while Model 6 represents the full model. H1a remarks a positive relationship between the number of TTO staff and the innovation performance of USOs. In the Model 2, the estimated coefficient on TTO STAFF is positive but not statistically significant. Thus, these results do not support H1a. H1b states a positive relationship between the existence of incubation services in the university and the innovation performance of USOs. In the Model 3, the estimated coefficient on UNI INCUBATOR is positive and statistically significant (coeff. = 0.311, $p< 0.05$), so confirming H1b. H1c indicates a positive relationship between the existence of university science parks and the innovation performance of USOs. In the Model 4, the estimated coefficient on UNI SCIENCE PARK is positive and statistically significant (coeff. = 6.726, $p <0.001$), providing support to H1c. H1d states a positive relationship between the university financial resources in research activities and the innovation performance of USOs. In the Model 5, the estimated coefficient on UNI R&D is statistically significant but irrelevant in practical term (coeff. = 0.000, $p < 0.05$). Thus, the evidence not allow to confirming H1d.

Table 3. GLM binary probit regression estimation predicting the effect of university fostering mechanism on USO innovation

Variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	S. E.	B	S. E.	B	S. E.	B	S. E.	B	S. E.	B	S. E.
Control variables												
AGE	-0.075***	(0.0110)	-0.74***	(0.0112)	-0.76***	(0.0108)	-0.081***	(0.0130)	-0.072***	(0.0115)	-0.080***	(0.0117)
PATENT	0.010***	(0.0018)	0.010***	(0.0019)	0.011***	(0.0018)	0.004***	(0.0008)	0.006***	(0.0017)	0.000	(0.0014)
SIZE	-0.011	(0.0360)	-0.011	(0.036)	-0.012	(0.0352)	0.002	(0.0413)	-0.008	(0.0367)	-0.005	(0.0098)
HIGH-TECH	4.889***		4.884	(5.4719)	5.044	(4.4033)	4.925	(3.4759)	4.949	(5.1436)	5.534***	
Hypothesized effects												
TTO STAFF			0.005	(0.0262)							-0.081	(0.0476)
UNI INCUBATOR					0.311*	(0.1290)					0.400***	(0.1148)
UNI SCIENCE PARK							6.726***				6.839	(12.4309)
UNI R&D									0.000*	(0.0000)	0.000*	(0.0000)
Likelihood-ratio chi-square	55.975***		55.987***		60.298***		81.375***		58.608***		108.545***	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; (all two-tailed tests). Source: authors

Table 4 shows the results of the binary probit GLM in the estimation of innovation performance of USOs, referring to the regional context effects. Also in this case, regression analyses are performed in a step-wise manner. Model 1 includes all the control variables; Model 2, 3, 4 and 5 refer to the four principle effects, entered one by one, while Model 6 represents the full model. H2a states a positive relationship between the regional R&D expenditure and the innovation performance of USOs. In the Model 2, the estimated coefficient on REG R&D EXPEND is not positive and not statistically significant, thus, not supporting H2a. H2b remarks a positive relationship between the regional human resources in R&D and the innovation performance of USOs. In the Model 3, the estimated coefficient on REG R&D STAFF is negative and not statistically significant. Hence, these results do not support H2b. H2c indicates a positive relationship between the regional human capital and the innovation performance of USOs. In the Model 4, the estimated coefficient on REG HUMAN CAPITAL is negative not statistically significant; thus, not supporting the H2c. H2d states a positive relationship between the regional patenting activity and the innovation performance of USOs. In the Model 5, the estimated coefficient on REG PATENT is negative and not statistically significant, hence, not supporting the H2d.

Table 4. GLM binary probit regression estimation predicting the effect of regional fostering mechanism on USO innovation

Variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	S. E.	B	S. E.	B	S. E.	B	S. E.	B	S. E.	B	S. E.
Control variables												
AGE	-0.075***	(0.0110)	-0.072***	(0.0119)	-0.069***	(0.0127)	-0.072***	(0.0019)	-0.074***	(0.0110)	-0.016***	(0.0038)
PATENT	0.010***	(0.0018)	0.010***	(0.0018)	0.010***	(0.0018)	0.010***	(0.0018)	0.010***	(0.0018)	0.001	(0.0006)
SIZE	-0.011	(0.0360)	0.003	(0.0398)	0.002	(0.0431)	0.025	(0.0432)	0.022	(0.0370)	0.003	(0.0023)
HIGH-TECH	4.889***		4.914	(4.4232)	4.780***		4.862***		4.894***		5.276***	
Hypothesized effects												
REG R&D EXPEND			0.000	(0.0011)							0.001*	(0.0006)
REG R&D STAFF					-0.331	(0.3379)					-0.006	(0.0078)
REG HUMAN CAPITAL							-0.001	(0.0004)			-0.001	(0.0003)
REG PATENT									-0.023	(0.0196)	0.006	(0.0032)
Likelihood-ratio chi-square	55.975***		58.766***		61.872***		59.119***		58.638***		25.362**	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; (all two-tailed tests). Source: authors

Results discussion and conclusion

The paper aimed to study the impact of some contextual determining factors on the innovation performance of USOs. In detail, and based on existing literature, it was stated that pivotal mechanisms both at university level and at regional level may positively influence the degree of innovativeness of the start-ups university. In order to test the developed hypotheses, a sample of 621 Italian USOs was investigated during an exploration period of nine years, from 2004 to 2012. The results show that the positive impact of the university context is more central and significant compared with those of the regional context. In particular, regarding the determining factors of the university level, the university affiliated to business incubators and Science Parks seems to have an effective and proactive impact on the innovation performance of USOs. These findings are in line with those of Soetanto and Jack (2015), remarking how the incubation support offered by the university is an essential and determining element of the effective innovation strategy, enhancing the full exploitation of USO innovation opportunities. Additionally, also the availability of suitable financial university resources contribute to improve the innovation efforts of USO; an evidence that emphasizes the role of university research funding, in innovative activities, with a more signal compared to the empirical findings, related to the role of the same mechanism in supporting the entrepreneurial success performance – not in term of innovation - of the spin-off, as reported in previous studies (Fini et al., 2011; Rodeiro-Pazos et al., 2012). Nevertheless, the role of technology transfer office seems to be a form of support not so active and imperative in ensuring an optimal exploitation of the innovative activities carried out by the USO. With particularly reference to the regional level determining factors, instead, the results indicate as their promoting impact on innovation performance of the USOs looks actually absent. Indeed, for the whole regional mechanisms, taken into account in the study, namely the regional R&D activities, the regional human capital and the regional patenting activity, the empirical evidence reports a null effects, remarking as marginal or vague role of the local context in fostering the innovative efforts of the university start-ups. This is in contrast with the previous findings of Rodríguez-Gulías et al. (2015), which remark the pivotal role of regional condition to catalyse innovation in USOs, but also of those of Bellmann et al. (2013) for comparable companies. The reason beyond our empirical evidence may be potentially and partially due to the specific features of the Italian regional context, but also due at different evaluation of regional supporting factors compared with the previous studies. Regarding this last case, the study opens new issues to better asses the effective role of the regional context on the innovation performance of the USOs. The study has some interesting practical and policy implications. Due to the limited role of regional context in fostering innovation performance in USOs, in order to exploit all the potential innovative efforts of the university start-ups and better actualize their innovative strategies, it is essential a strong and collective partnership between all the regional players involved in the spillover and innovative processes. In detail, it is fundamental the function of local governments which have to act more as facilitators in the interchange of knowledge and technology, by scheduling strategy actions that identify the prominence of network and relationships, towards a new innovative regional environment. This is a key precondition in order to improve economic development, since the concept of "entrepreneur as innovator" is a key figure in driving growth, both at firm and regional-national level (Vincett, 2010). Nevertheless, the study is not free of limitations. The empirical study is based only on patent data as measure of USOs innovation, which can potentially undervalue the innovative performance of university start-ups, since not all innovation output are patented by USOs (Cantner & Goethner 2011), also because of administrative restraints (Bellmann et al., 2013). Therefore, the developed model can be considered as a basic starting point with the aim to develop more extensive studies that are able to intercept, in a comprehensive and systemic way, the impact of contextual factors on USOs innovation. In this view, further researches could expand the evaluation of USOs activities into other indicators, related to innovation input, as R&D intensity, a relevant proxy of firm innovative performance (De Cleyn & Braet, 2012); jointly with the use of output measures of innovation (Hagedoorn & Cloodt, 2003), as product and process innovation.

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Knowledge Organisations and High-Tech Regional Innovation Systems in Developing Countries: Evidence from Argentina

*Carolina Pasciaroni**

Abstract: In the globally and knowledge based economy, the universities and other knowledge organisations are valued for their ability to contribute to the regional innovation processes. This is particularly relevant for the developing countries in South America since their R&D spending is highly concentrated on the public knowledge infrastructure. However, there are few studies examining the role of knowledge organizations at regional level in Latin America. The proposed study aims to analyse the role played by knowledge organisations in the formation of a high-tech Regional Innovation Systems in Argentina. This country has a number of attractive features relative to the positive evolution of its R&D spending and the recent implementation of a policy that promotes cooperation between firms and knowledge organisations among high-tech sectors. As evidenced in developed regions, the organisations under study play a key role in the promotion of a high-tech Regional Innovation Systems. However, this prominent role is not based on those local factors identified in the literature, such as organisational and institutional local assets, but on national science and technology policies and individual initiatives conducted by the faculties involved.

Keywords: Knowledge Organisations; Links between Universities/I+D Centres and Firms; Regional Innovation Systems; Science and Technology Parks; High-Technology; ICT; Developing Countries

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1. Introduction

In today's knowledge based economy, universities, R&D centres, and similar knowledge organisations are valued as sources of new knowledge and innovation (Anselin et al, 2000; Bercovitz & Feldman, 2006; Etzkowitz, 2003; among others). In addition, regions are conceived as privileged sites for the rise of innovation and competitive advantages (see Scott & Storper, 2003). Thus the empirical evidence shows successful examples of cooperation between firms and research organisations in the well-known regions of Silicon Valley (USA), Boston (USA) and Cambridge (England).

In opposition, studies on National Innovation Systems (NISs) in South America reveal considerably few links between firms and knowledge organisations (Arocena & Sutz, 2006). In an attempt to complement these studies carried out at national scale, the present manuscript adopts a regional/local perspective for the innovation processes. The Regional Innovation Systems (RISs) theoretical approach is an appropriate framework for analysing the role played by universities, R&D laboratories, science and technology (S&T) centres in less development regions. It should be stressed that the RIS approach is not widely disseminated in studies of innovation in Latin America (Llisterri & Petrobelli, 2011).

The study focuses, particularly, on the factors that determine the capacity of knowledge organisations to promote the creation of *high-tech RISs* in developing countries. Using the case study methodology, the public knowledge infrastructure of the city of Bahía Blanca (Argentina) is discussed, along with its recent initiatives in the field of ICTs: the creation of an S&T Park on high-complexity electronics.

The selection for the case study is based on several factors. First, in NIS of Argentina, the relation between knowledge organisations and firms is deficient, but stronger in comparison to other countries in South America. In addition, there is a growing interest from the national public sector to promote such links. Second, the organisations under study have a long tradition in knowledge generation and diffusion to the local productive sector.

Following the introduction, this manuscript is structured as follow. Part 2 presents the theoretical framework and a literature review. Part 3 discusses the interactions between knowledge organisations and firms in the NIS of Argentina in comparison to other countries in South America and developed countries. Part 4 describes the case under study and Part 5 analyses the contribution of local knowledge infrastructure to the emergence of a high-tech RIS. Finally, the summary and conclusions are presented.

Literature Review.

While there is no generalised consensus over the definition (Asheim & Coenen, 2005) a Regional Innovation System (RIS) can be defined as an interactive knowledge generation and exploitation, connected with other global, regional and national systems (Cooke, 2004 in Asheim & Coenen, 2005, p. 1174). The background to this approach is divided into two main schools of thought: the New Regional Science and the National Innovation System (NIS) approach (Cooke et al., 1998). Following Cooke et al (1998) and Cooke (2002), the emergence of a regional system of interactions, through which the actors exchange tacit and codified knowledge, depends on: 1) *local institutional factors*, such as a cooperative culture, association, learning

Departamento de Economía, Universidad Nacional del Sur (UNS), Instituto de Investigaciones Económicas y Sociales del Sur (IIESS), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). San Andrés 800, Bahía Blanca (Provincia de Buenos Aires), Argentina.
*Corresponding author: carolina.pasciaroni@uns.edu.ar

predisposition, associative consensus; 2) *organisational factors* at the *firm level* (labour relations) and *organisational factors of policy and governance* (propensity among the policy makers to inclusivity, delegation and networking)*;* 3) it could be added *organisational and institutional factors at the level of universities and other kind of knowledge organisations*, for example formal and informal rules relating to the transfer of knowledge or the presence of Technology Transfer Offices (TTOs) (Bercovitz & Feldmann, 2006); 4) *external influences* such as the policies and instruments of the National Innovation System, the link with other RISs and international organisations (Cooke, 2002).

The present work suggests that the RIS approach provides an appropriate theoretical framework to investigate the contribution of knowledge organisations to regional dynamics of innovation in developing countries. First, universities, R&D centres, laboratories, S&T institutes, are prominent in the analytical structure of the RIS. According to Cooke (2002) and Asheim & Coenen (2005), an RIS can be represented as a system comprised of two subsystems linked by interactive learning processes. On the one hand, a subsystem of knowledge generation and diffusion involving universities, R&D laboratories and similar knowledge organisations. On the other, a knowledge application and exploitation subsystem comprised by firms and their relation to suppliers, customers, and other businesses.

A second element supporting the use of the RIS approach to study knowledge organisations in regional contexts is related to the different types of RIs identified (Asheim & Coenen, 2005; Cooke, 2006). Asheim & Coenen (2005) provide empirical evidence for a differential function of knowledge organisations depending on whether the RIS is based on synthetic knowledge (mature industries) or on analytical knowledge (ICTs, biotechnology, nanotechnology). In the latter case, the knowledge infrastructure not only supports local innovation processes but drives *ex-ante* the creation of high-technology systems through the development of spin-offs and the attraction of high-technology firms. High-tech RISs may comprise clusters, technopoles, or S&T parks.

A third analytical advantage of the RIS approach is that it can be applied to the study knowledge organisations in regions with low innovative potential, less R&D intensity, low-tech production structures, and a weak endowment of knowledge organisations and firms (Tödtling & Trippl, 2005). Studies on high-technology regions in developed countries show a number of common features: the leadership of a university or an R&D centre; the presence of venture capitalists; public policies that promote the R&D activities in the fields of ICT and biotechnology (Cooke, 2002; O' Shea et al, 2007; Saxenian, 1996; among others). By contrast, in the case of Latin America, the function of universities and regional research centres is limited to the training of qualified human resources; there are few cases of collaboration with companies that have the potential to achieve greater impact on local economy (CEPAL, 2010; Llisterri & Petrobelli, 2011).

In sum, the study of RISs becomes useful to confirm the presence/absence of the elements involved in the processes of knowledge generation, production and dissemination in less regions and developed countries, including the behavioural analysis of the agents, the institutional framework and governance mechanisms (Llisterri & Pietrobelli, 2011). Nevertheless, in Latin America, the concept of RIS is quite pervasive, partly due to the scarcity of statistical data and the lack of representativeness surveys on regional innovation (*op. cit.*). Before discussing the role of knowledge organisations in the local context under study (Bahia Blanca, Argentina), in the next section we will discuss the characteristics that assume knowledge organisations in the NISs of Argentina.

3. Knowledge Organisations in the National Innovation System of Argentina.

According to the data provided in Table 1, cooperation between universities, R&D centres and firms are not prolific among South American countries. However, Argentina standing out with rates similar to those recorded for Japan and Norway. While this is encouraging, the cooperative initiatives do not involve the generation of new knowledge: the domestic industries do not carry out R&D activities in collaboration with research organisations (INDEC, 2005). By contrast, the testing of new products and processes, quality control and technical problem-solving are the main objectives for companies establishing links with the national knowledge organisations (Arza, 2012).

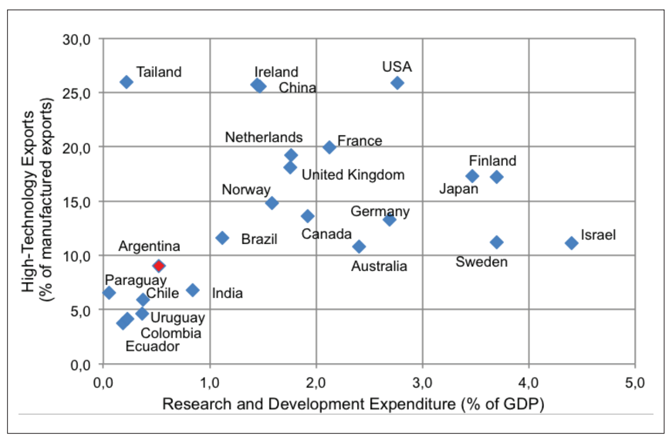
Table 1. Percentage of Manufacturing Firms that Cooperated with Universities (or Other Higher Education Institutions) and the Government or Public Research Institutes.

Links between Firms and Knowledge Organisations		% Universities	% Public Research Institutes	%Total
High	Finland	33,8	24,84	58,64
	Norway	14,33	18,12	32,45
	Argentina	14,47	16,08	30,55
	Japan	15,71	14,38	30,08
Medium	Sweden	18,27	8,81	27,08
	Germany	17,12	8,12	25,24
	France	13,23	10,77	23,99
	Ireland	13,05	10,03	23,08
Low	Spain	7,26	9,71	16,98
	Colombia	11,16	5,3	16,46
	Brazil	6,3	..	..
	Ecuador	5,71	3,04	8,75
	Italy	5,29	2,16	7,46
	United Kingdom	4,73	2,52	7,25

Source: UNESCO, 2010. Note: Data for Argentina for the year 2007; data for Brazil, Ecuador and Japan for year 2011.

The weak link between firms and knowledge organisations in the NIS of Argentina, and in South America in general, is explained by a number of factors. First, these countries have a low expenditure on R&D as percentage of gross national product (GDP), combined with a low share of high-technology sectors in manufactured exports. Figure 1 shows the differential position of South America in comparison to developed countries. Still, Argentina, and especially Brazil, achieves a relatively higher position. Secondly, unlike developed countries, in South American countries, R&D spending financed by the government –through its public universities and R&D centres– exceeds the expenditure recorded for the private sector (Table 2). In the case of Argentina, the public knowledge organisations concentrate 76.1% of expenditure on R&D. The low share of private companies in national R&D expenditure is consistent with the high percentage of companies investing in machinery and equipment (80.4%). The high representation of government R&D spending, along with a few historical cooperative initiatives between public knowledge organisations and firms, derived in the following observation: "outside the firms, there is capacity for research and technological consultancy which could be built upon in order to overcome their innovative disadvantages" (Arocena & Sutz, 1999)

Figure 1. Percentage of High-Technology Exports and Research and Percentage of Development Expenditure



Source: World Bank, 2010. Note: Data for Thailand for the year 2007; Ecuador for 2008; Peru for 2004; Ecuador for 2011.

Table 2. Percentage of R&D Financed by Firm, HigherEducation and Government.
Percentage of Manufacturing Firms that Engaged in Acquisition of Machinery, Equipment and Software

Country Firm		% R&D financed by			% of manufacturing firms that engaged in acquisition of machinery, equipment and software
		Higher Education	Government		
South America	Argentina	22,3	3,4	72,7	80,4
	Brazil	45,4	1,9	52,7	34,1
	Chile	35,4	10,3	37,3	….
	Colombia	31,9	18,3	39,5	68,6
	Ecuador	8,5	1,4	89,6	..
	Paraguay	4,3	18,9	57,8	….
	Uruguay	47,1	26,6	22,9	78,2
Developed Countries	Canada	46,4	7,9	35,6	..
	Finland	66,1	0,2	25,7	69,7
	France	53,5	1	37,1	61,3
	Germany	65,6	….	30,3	..
	Japan	75,9	5,7	17,2	..
	Norway	44,2	0,4	46,5	57,9
	Sweden	57,3	0,9	27,7	81,9
	UK	44	1,2	32,3	..
	USA	57,2	3	32,6	…

Source: UNESCO, 2010. Note: Data for Ecuador for the year 2008; Paraguay, Japan and Sweden for 2011.

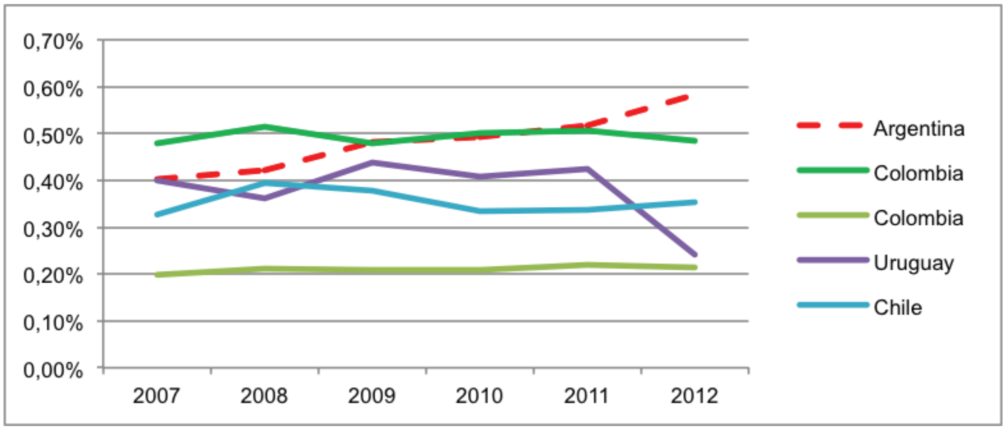
A third factor explaining the few or weak links with the private sector is the founding mission of public knowledge organisations, not oriented to the knowledge diffusion to the productive sector. Following Arza (2012), public universities in Latin America were founded before public R&D centres, and their mission was oriented exclusively to graduate education. Later, R&D centres resulted from the development policies that proliferated after the Second World War. Most of these centres were focused on basic and applied research, and a few of them were oriented to assist strategic productive sectors. Argentina experienced a similar historical process. In 1950, the main public S&T centres were created:

1) the Institute of Agricultural Technology (INTA, acronym in Spanish) and the National Institute of Industrial Technology (INTI, acronym in Spanish) with the mission to generate and transfer knowledge to the agricultural and industrial production sectors, showing a limited success;

2) the National Atomic Energy Commission (CNEA, acronym in Spanish) and the National Research Council (CONICET, acronym in Spanish). The creation of the National Atomic Energy Commission responded to military strategy, but later encouraged the emergence of a group of firms with a high level of technological sophistication (next section). The National Council of Scientific and Technological Research was created within the academic community in order to professionalise scientific activity, following the model of French CNRS. Historically, its operating logic was based on the linear model of innovation, privileging basic research (especially biomedical sciences, physics and chemistry). Its relation with the production system was "not only poor, but rather resisted" (Lopez, 2002, p. 67).

Beyond the common historical process in the development of R&D centres, Argentina has a number of distinctive features compared to other countries in South America. Excluding Brazil –the only country in the region whose R&D expenditure exceeds 1% of GDP– Argentina shows a steady growth of this indicator (Figure 2), recording a growth rate of 45.34% between 2007 and 2012. This is the result of a new S&T policy aimed at strengthening the NIS.

Figure 2. South America. Evolution of Percentage of R&D Expenditure to GDP



Source: Compiled by the author based on RICYT (Red de Indicadores de Ciencia y Tecnología -Iberoamericana e Interamericana) data.

Following Brazil in chronological order, Argentina is the second country in the region prioritising its S&T policy through the creation of the Ministry of Science, Technology and Productive Innovation (MINCYT). In general, its S&T policy adopted a *laissez-faire* philosophy, with very few exceptions, such as a policy aimed at achieving informatics autonomy in the 80s (Chudnovsky, 1999). In the 90s, in a context where neoliberal macroeconomic policies gained strength, activities of innovation in the private sector were promoted, as well as cooperative initiatives between public knowledge organisations and the productive sector. From the first half of the 2000s, new deviations from the historical *laissez-faire* tradition are recorded:

1) the Ministry of Science, Technology and Productive Innovation is created in 2007 and related science, technology and productive innovation plans are formulated;

2) links between public knowledge organisations and productive sector are promoted by developing training programs in the field of technology transfer. In addition, new financing modalities are introduced for cooperative projects of innovation involving companies and knowledge organisations;

3) knowledge areas (biotechnology, ICT and nanotechnology) and socio-productive nuclei (agribusiness, environment and sustainable development, social development, energy, industry and health) are promoted because they are considered strategic for economic development. The creation of The Argentinean Nanotechnology Foundation and the introduction of new public financing lines for biotechnology, nanotechnology and renewable energy (FONARSEC Funds) are an example of it;

4) a more equitable distribution of S&T activities is pursued at regional level.

As this study adopts a regional analysis approach, it should be noted that science, technology and productive innovation policies and programs in Latin America are designed by the national authorities and applied throughout the country (Llisterri & Petrobielli, 2011). National authorities also design programs oriented to decentralise policies in science, technology and innovation. However, these programs are designed and implemented in the absence of agreements between different levels of government on priorities and resources needed to carry out such decentralised policies (op. cit.).

4. Methodology: Case Study Analysis.

In this work, the case study methodology is applied which is widely used in the RISs approach. As discussed in Section 2, the NIS of Argentina has some specificity that encourages the study of knowledge organisations at regional level. In this scenario, the knowledge organisations of the city of Bahía Blanca are selected as case study. Secondary information from institutional reports was combined with primary information collected through interviews with faculty researchers and local actors. Briefly, Bahía Blanca is a medium-sized urban centre (300.000 inhabitants according to the latest population census) located in the Province of Buenos Aires (main economic and demographic area of the country). The city concentrates a varied public S&T infrastructure, including the National Southern University (UNS, acronym in Spanish) and its 12 S&T centres, also dependent on the National Research Council (CONICET, acronym in Spanish). This public university, founded in the mid-50s has shown a marked vocation towards R&D activities.

The choice of the proposed case study was based on the following:

1) *Long-standing trajectory in knowledge diffusion to the productive sector.* The local knowledge infrastructure has a history of networking dating back to the 70s, starting with the performance of the PLAPIQUI Institute (Chemical Engineering Pilot Plant) as an external laboratory for important firms of the city belonging to the petrochemical industry. This experience was considered an exceptional phenomenon in the NIS (Chudnovsky & López, 1996). Currently, the knowledge infrastructure of the city provides services and technical consultancy to local and extra-local companies in various productive sectors, especially medium and low knowledge intensity sectors. Conversely, collaborative R&D projects between companies and local faculty researchers are scarce.

2) *Breakthroughs in the ICT field*. As will be discussed below, Bahía Blanca stands out in the national scenario for the promotion of a high-technology innovation system: a S&T Park in high-complexity electronics. The good performance of this Park would allow counteract the specialisation of the city in productive sectors of medium and low knowledge intensity, such as the petrochemical, food and beverages, furniture manufacturing and commercial activities.

5. Promoting a Local System of High-Complexity Electronics: Impulses and Limitations.

This decade, the public knowledge infrastructure of the city of Bahía Blanca experienced *its first university spin-off*, while it promoted the construction of the *first S&T Park in high-complexity electronics in the country*. In Argentina, unlike universities and R&D centres from developed countries, spin-offs are not a widespread phenomenon among knowledge organisations. They have occurred in a few public universities, like the University of Buenos Aires, the University of Córdoba and the National University of the Littoral, along with National Atomic Energy Commission (see Lugones & Lugones, 2004). The firms involved fall within the fields of biotechnology and ICT, most of which have developed since the 90s.

In the case of Bahía Blanca, its first spin-off belongs to the field of Electronic Engineering and is the result of collaborator work on an R&D project between a group of local faculty researchers and the University of Sydney (Australia). This R&D project originated from a request by a large mining company to the University of Sydney, with the aim of improving work safety on their mines. Thus, the local spin-off began in 2008 and specialised in the development of systems oriented to improve work quality in hostile environments.

Later, the same group of local faculty researchers promoted the construction of an S&T Park called "Technological Platform for Systems of High-Complexity Electronics Technology" (TEAC, acronym in Spanish). This S&T Park has high-complexity infrastructure and equipment. Its aim is to encourage the development of high-tech firms and create an innovative environment for the interaction between universities and firms for the holistic production of prototyping complex circuits with macro, micro and nano electronic. Accordingly, the Park aims to offers electronics SMEs: infrastructure equipment, S&T knowledge, human resources and tax-free imports and exports. The creation of this S&T Park formally began in 2011 with the efforts of purchasing equipment. Equipment purchases were completed in 2014 and were conducted through public tenders. In late 2012, the building investments were made, and the laboratories were opened in October 2013 (TEAC, 2015).

It should be noted that the electronics industry in Argentina dates back to the 60s, and since then, it has geographically concentrated in the densely inhabited Buenos Aires (Capital City) and its metropolitan area. Therefore, the creation of the aforementioned S&T Park was not based on a pre-existing large group of electronics firms in the city under study. As Asheim & Coenen (2005) states, in high-technology RISs, knowledge organisations play a foundational role: promoting the emergence of new industries in the city.

The local S&T Park in highly complex electronic circuits is particularly relevant when taking into account the fact that circuits are key elements in the value chain of the electronics industry. Moreover, the importance of this S&T Park can be based on certain features of the domestic electronics industry. With this in mind, a report by the Ministry of Science, Technology and Productive Innovation (MINCYT, 2013) indicates:

- a persistent and increasingly negative trade balance. Briefly, the electronic industry in Argentina consists of about 740 firms and "industrial electronics" is the main segment. The imports focus on communications and data processing;

- around a third of the national market (excluding the assembly industry in Tierra del Fuego) is supplied with printed circuit boards from abroad. These imports are led by national companies that assemble products developed abroad or develop electronic systems·

- the domestic electronics industry is currently far from microelectronics. It is necessary to strengthen the offer of services related to the microelectronics industry to meet the requirements of companies without internal capacity to develop integrated circuits. In addition, it becomes relevant to increase the number of human resources in Electronic Engineering, specifically in the management of design tools;

The proposed case study, and its comparison with successful experiences in developed countries, allows identifying factors fostering and limiting the emergence of high-tech systems of innovation in peripheral regions (Table 3). The following factors involved in the local case are presented below: a) high quality of the local academic staff; b) local organisational weakness; c) lack of integration between institutional frameworks at different scales and d) availability of national public funds.

Table 3. Local Knowledge Organisations and High-Tech RISs

Local Knowledge Organisations	Developed Countries	Case Study
Human Resources	Academic excellence	Academic excellence
Organisational Factors	Long-standing active TTOs	Recently created internal TTO
	Strong networks with the industry through collaborative R&D projects	Weak networks with firms in the field of Electronic Engineering. Strong academic networks with foreign universities and S&T centres. Internal fragmentation.
Institutional Factors	Strong leadership. Foundational values oriented to the knowledge transfer. Policies promoting interaction with firms and entrepreneurship.	Foundational values not oriented to the knowledge transfer. Incipient "Institutional reflexivity. Scarce incentive to networking and entrepreneurship.

Source: Compiled by the authors based on Asheim and Coenen (2005); Cooke (2002); O'Shea (2007); Bercovitz and Feldmann (2006); Tödtling and Trippl (2005).

5.1. a. Quality of the Academic Staff. The exceptionally well developed scientific research is one of the main features of high-technology RISs in developed countries (Cooke, 2002). In particular, O'Shea et al. (2007) notes that a key ingredient for successful technology transfer at MIT is its distinguished faculty, the quality of its faculty, and their ability to generate radical innovation conducive to commercialisation.

In the present case, the promotion of a RIS on electronics in based on the pre-existence of a university –The Southern National University–, which offers degrees and postgraduate degrees in Electronic Engineering and has extensive experience in R&D in this discipline. In the 60s, the Southern National University and the University of Buenos Aires were the only academic institutions in the country with projects based on the creation of a computer. These projects have positioned Argentina as the only Latin American country with a long track record of knowledge in the area of information technology (Erbes et al, 2006).

Currently, the local knowledge infrastructure integrates the set of national and public centres with research groups and laboratories involved in microelectronics (The Catholic University of Córdoba, the National Institute of Industrial Technology, the National Atomic Energy Commission, the National Technological University, the University of Buenos Aires and the University of San Martín). The local faculty research group stands out nationally for: a) the completion in 2007 of the first doctoral thesis in microelectronics in the country and, b) micro chip designs in 3D technology, in collaboration with foreign universities (The Johns Hopkins University in the USA and the University of Sydney in Australia) and leading international firms in electronic circuits manufacturing.

Within the knowledge infrastructure of Bahía Blanca, the field of Electronic Engineering shows above-average values for its number of trainees and papers per teacher-researcher. Although there is empirical evidence for a negative relationship between the number of papers and academic spin-offs (Landry et al. 2006), the lagging character of the NIS in comparison to countries leading the introduction of technological innovations makes it relevant to consider the number of papers published as an indicator of enough knowledge accumulation to develop technology capable of being commercialised. A distinctive aspect relates to the willingness of this researchers group to carry out their academic activities in collaboration with foreign universities and companies is remarkable. Thus, they link with important companies of integrated circuits, universities and S&T centres of USA, Australia and Taiwan.

5.2. b. Local Organisational Weakness. Numerous studies analyse Technology Transfer Offices (TTO), its structure and other kinds of internal factors affecting its performance (Bercovitz et al, 2001; Siegel et al, 2003). In the case of more complex mechanisms of technology transfer, such as the creation of spin-off firms, longitudinal analysis on US and Europe universities provide evidence supporting the positive relation between human resources dedicated to knowledge transfer activities and the number of academic spin-offs (Gomez Gras et al, 2008; O 'Shea et al, 2005). In turn, O'Shea et al. (2007) attributes the good performance of MIT (USA) to the early creation of an Office of Technology Licensing (OTL), its active performance in the management of intellectual property; and the search for capital risk to finance start-ups. This type of organisation facilitates the interaction between faculty researchers and venture capitalists, while providing technical, legal and administrative assistance for the establishment of firms.

In the present case, until 2007 the local knowledge infrastructure lacked *internal* TTOs dedicated to managing and promoting knowledge diffusion. Therefore, the process of spin-offs development took place prior to the creation of this type of offices. It should be noted that, for more than two decades, the local knowledge infrastructure has had 'Technological Network Units' (UVTs, acronym in Spanish), defined as non-state entities, *external* to knowledge organisations, which have the task of facilitating the dissemination of technology and technical assistance to the productive sector. However, local UVTs did not participate, or did so only marginally, in the development of the spin-off and the S&T Park in high-complexity electronics. In general, these UVTs do not have human resources staff specialised in the development and management of academic spin-offs.

In this scenario, faculty researchers in Electronic Engineering, who promoted the first local spin-off and the creation of the S&T Park, asked for assistance not only to the UVT but especially to professionals outside this organisation (UNS, 2011). The support was requested 1) for the development of the business plan, the economic evaluation, and the compliance with the legal requirements for the creation of the spin-off, and 2) for the observation of the requirements of the public funding involved in the construction of the local S&T Park.

On the other hand, in terms of cooperation and organisational proximity (Boschma, 2005), local experience shows a "fragmentation" or a lack of interactions and local networks (Tödtling & Trippl, 2005), that reveals in the following aspects: 1) the local researchers group do not have a long tradition of knowledge generation and diffusion to the productive sector. By contrast, the gestation of the first local spin-off arises from the academic ties with a foreign university, linked to a large mining company and 2) the creation of the S&T Park did not involve interaction between the R&D group under study and the remaining teacher researchers from the career of Electronics Engineering.

5.3. c. Lack of Integration between National and Local Institutional Frameworks. In the systemic approach, institutions, comprising rules, regulations, conventions, and routines, condition the emergence and development of learning and innovation processes (Cooke et al, 1998; Lundvall & Johnson, 1994). Similarly, the literature on academic spin-offs indicates that the formal and informal norms regulating knowledge organisations; their founding mission; their corporate culture are key institutional factors in the development of entrepreneur projects of this kind (Moray & Clarysse, 2005; Landry et al, 2006; O'Shea et al, 2007). It is important to note that the contribution of universities to regional innovation processes depend on the degree of interaction and mix of the different levels of policies and governance, including the national, regional, local and university level (Charles, 2006). In the case under study, no interactions between these levels of governance and policies are verified.

At national scale, specially, in the complex formed by national universities and research centres of the National Research Council (CONICET, acronym in Spanish), institutional factors do not stimulate interaction between knowledge organisations and firms:

1) some resistance is met in the relation with the productive sector, based on rooted prejudice, ideological and political differences, and with the conception of knowledge as a public good, not as something that can be privately appropriated (Lugones et al, 2006);

2) academic productivity is evaluated by the number and quality of the papers published, disregarding to some extent the relevance of networking activities. This evaluation system operates in detriment of more complex networking activities, especially the creation of academic spin-offs. On the one hand, a spin-off involves a greater time commitment compared to the provision of technology services;

3) there is no specific regulation governing the participation of faculty researchers in firms arising from R&D projects, or determining whether faculty researchers may own a company, collect royalties and/or profits, or participate in its management, etc.

The specificities of local knowledge organisations can compensate the scarce encouragement towards the creation of networks stemming from the type of evaluation system used and the institutional vacuum (Siegel et al, 2003; Charles, 2006). By contrast, in the case under study, the local institutional environment does not promote interactions between the academic and the productive sectors. This translates into an absence of a "reflexive logic" (Wolfe & Gertler, 2002) to allow knowledge organisations to foster the creation of new knowledge-intensive production sectors The absence of strategic and planned local policies is revealed in the lack of local university-industry strategies at the level of local government; the recent creation of an internal TTO at the level of local knowledge organisations and the recent formulation of a regulatory framework to mend the institutional vacuum on the participation of faculty researchers in academic spin-offs (UNS, 2011).

Institutional reports on the local S&T infrastructure indicate that most of the academic departments and annexed S&T institutes are involved in networking activities. However, these activities "(...) result mainly from the natural predisposition of certain teaching and research sectors, which work cooperatively with the authorities of the departments and institutes in search of scientific-technological networking lines, rather than central planning" (UNS, 2004, p. 69).

Regarding the faculty researchers involved, they decided to create a spin-off and promoted the creation of a high-complexity S&T Park with the aim of promoting the national electronics industry, increasing the number of students in Electronic Engineering, and spreading the entrepreneurial spirit among academics and students (UNS, 2011). Such initiatives are not trivial if we consider that the tradition of knowledge transfer in universities or S&T centres favours future researchers' capacity to identify marketing opportunities and get the necessary resources to start up a firm (Rasmussen et al, 2014).

5.4. d. The Impulse of National Public Funding. This manuscript focuses on the early phase of an S&T Park in a peripheral region. In this regard, two inductors factors or sources (Martin & Sunley, 2010) arise from the analysis of this process of formation: 1) the deliberate action of local faculty researchers, and 2) the grant of public funding. As noted in Part 3, the national S&T policy has recently turned to promoting socio-productive nuclei and strategic knowledge areas for economic development. In this new S&T context, the local faculty researchers were granted the Telecommunications Sector Fund (FS TICs 2010) for the formation of the of the previously mentioned S&T Park. This kind of funds is given to public-private partnerships to improve competitiveness in the ICT sector. The local beneficiaries include the previously mentioned researchers, the National Institute of Industrial Technology (INTI), public-private entities and ICT firms.

As indicated above, the first laboratories were inaugurated in 2013, and the specialised equipment purchases were completed in 2014.

As the S&T Park is located in a free zone of import and export taxes, in early 2014 the first efforts were made to achieve an agile mechanism for the entry and exit of inputs and prototypes (TEAC, 2015). Moreover, following the creation of this S&T Park, a micro and nanoelectronics centre was settled. This centre depends on the National Institute of Industrial Technology (INTI, acronym in Spanish) and specializes in the design and verification of integrated circuits. To date, the local S&T Park made progress in human resources training, in constituting an alliance with the local government for technological prospective and in setting up projects with high-tech private companies (TEAC, 2015). Given the recent establishment of the Park, these advances seem insufficient to analyse its performance. It should be noted that the experiences with some degree of success in the NIS (see Lugones & Lugones, 2004) suggest that knowledge supply plays a major role in achieving cooperation with the productive sector. This should be considered by those responsible for the local S&T Park, taking into account that: a) the high-tech sectors not proliferate in the local and national structure production and 2) the firms usually not rely on knowledge organisations as a source of innovation.

7. Summary and Conclusions.

The proposed study gathers evidence about the leading role of knowledge organisations in the shaping of high-technology RISs in developing countries. The case study methodology was applied, based on the public knowledge organisations of the city of Bahía Blanca, Argentina. The selection of this case study responds to: i) the differential characteristics assumed by the NIS of Argentina in comparison to other countries in South America, and ii) the long tradition of knowledge transfer from the knowledge organisations of Bahía Blanca to the local petrochemical industry, coupled with the recent creation of its first academic spin-off –a rare phenomenon in the NIS– and the first and only S&T Park in high-complexity electronics in the country.

It is still premature to assess the performance of the Park. However, local experience allows us to understand the factors behind the promotion of high-tech developments in peripheral regions. As in high-technology regions of developed countries, the S&T infrastructure under study was central in the creation of the previously mentioned S&T Park. This key role is based on a recent national S&T policy which encourages cooperation between public and private sectors; on the academic excellence achieved by the local S&T infrastructure in Electronic Engineering; and on the initiative of the researchers involved in the project. However, as opposed to the successful experiences recorded in developed countries, there are production, organisational and institutional obstacles, at national and local levels, hindering the generation and dissemination of knowledge from universities and R&D centres to the local productive sector.

At a national scale, this work presents empirical evidence to demonstrate that companies and universities in Argentina show stronger interaction than others Latin American countries. While these data are encouraging, the cooperative initiatives are based mainly on assistance and technical services, rather than on more complex knowledge diffusion mechanisms. This weakness of this link responds to a low technology productive structure and institutional factors. The low technology productive structure hinders the emergence of a strong demand for the services offered by the S&T Park of high-complexity electronics under study. Furthermore, teacher researchers from the NIS organisations have a long tradition of resistance to cooperation due to strongly held prejudice, ideological reasons and the fact that the evaluation of teaching and research activities does not involve an assessment of the knowledge-transfer initiatives.

Locally, aside from the initiative of the R&D group under study, no organisational or institutional specificities could be identified for the local S&T infrastructure which could offset the previously mentioned obstacles. In this sense, the local S&T infrastructure lacks a "reflexive logic" for the creation of active TTOs and the formulation of strategic policies aimed at encouraging interactions with productive sectors, entrepreneurism among students and the faculty, and a higher impact on local economy. Likewise, there is a certain degree of fragmentation and absence of organisational proximity in terms of cooperation with the local S&T infrastructure.

In sum, the case study falls within the following observation by Arocena & Sutz (2006): "Innovation clusters are 'cells' within Innovation Systems. In the North, they are numerous and varied; they are well-connected with each other and with other components of the "system; they are often protected, and they have a long-standing track record. In the South, the picture is different; innovative clusters often have to defend their existence in the interstices of dominant power relations and, more often than not, they succumb."

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Country Context and University Affiliation: A Comparative Study of Business Incubation in the United States and Brazil

Aruna Chandra [*1] *and Chia-An Chao* [1]

Abstract: This study compared university affiliated and non-university affiliated business incubators in the United States and Brazil in order to assess the impacts of country context and affiliation on incubator funding sources, direct financial assistance to client firms and internal versus external service mix through use of quantitative and qualitative data. Affiliations with external entities can provide life giving resources; however, it may also transfer external shocks to the new venture calling for buffers. Results indicated that incubators in the United States have a higher number of funding sources, are more likely to provide direct financial support, and offer more external services relative to Brazilian incubators; whereas Brazilian incubators are more inclined to connect incubatees to external financial resources but provide services in-house. The study results suggested that incubators in both countries use "bridges" and "buffers" to ameliorate resource deficits driven by environmental exigencies.

Keywords: business incubators in Brazil and United States; incubator affiliation; funding; financial support; services

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Introduction

Business incubators are relatively new strategic intervention organizational forms that have gained popularity in countries around the world for their potential for nurturing new ventures leading to economic growth (Abetti, 2004; Birch, 1981; Carayannis & von Zedtwitz, 2005; Smilor & Gill, 1986). As hub organizations that inhabit a unique organizational space, one key measure of their success is their capacity to link their clients to business partners, sources of funds, and other networks (Totterman & Sten, 2005). Incubators that are better able to connect with partners and share resources and capabilities in the network are presumably better at providing the types of services with higher added value to their client firms (Black & Boal, 1994; Brush, Green, Hart, & Haller, 2001). Several studies have focused on internal networking amongst incubator clients (Soetanto & Jack, 2013; Uzzi, 1997); however, networking by the incubator has also been identified as a critical part of the incubation process (Hackett & Dilts, 2004; Scillitoe & Chakrabarti, 2010). Hansen, Chesbrough, Nohria, and Sull (2000) point out that the primary role of the incubator is to provide a rich array of networking connections to client firms, since these network contacts could serve as potential sources of knowledge and resources. In order to provide clients with relevant network connections, the incubator has to develop its network via affiliations with other organizations. The incubator's network could include a variety of organizations ranging from universities (Mian, 1996; Vedovello & Godinho, 2003), different levels of government organizations (Phillimore, 1999) and businesses (Bakouros, Mardas, & Varsakelis, 2002).

This study makes a fine grained distinction between networking and affiliation (tie) viewing the latter as a building block or step in the process of networking, since it is the diversity and density of these ties (Burt, 2002; Granovetter, 1973) that determine the potential of a given network. Incubators seek to develop affiliations leading to networks to link firms under their wing to resource-rich environments in order to usher them through early stage death valleys. They mediate the venture's relationship with the environment, which paradoxically can serve as a source of life-giving resources as well as deadly environmental shocks leading to early mortality. Hence, as an intermediary that seeks to moderate the new ventures relationship with its environment, the incubator serves to both buffer (cocoon) and bridge (connect) the new venture to the environment, driven by internal demands of the clients as well as external contextual contingencies in the environment (Amezcua, Grimes, Bradley, & Wiklund, 2013).

Business incubators affiliated with university (AU) and not affiliated with university (NAU) in the United States and Brazil was the focus of this study. These two countries were chosen since the United States has a relatively more mature, denser incubation marketspace and Brazil is a relatively younger, yet fast growing incubation market. Previous research on the affiliation patterns of United States and Brazilian incubators has indicated that incubator affiliation—in particular, whether an incubator affiliates with a university—matters to a range of incubator services as well as the incubator's own funding (Chandra, Chao, & Astolpho, 2014). The paper traces the trajectory of incubation growth and evolution in the two countries along with differences in incubator affiliations as they influence incubator funding patterns, service mix and financial services in order to assess the impact of contextual conditions on this support mechanism for new venture creation. Qualitative and quantitative data were collected on the key dimensions of the study in order to triangulate results.

Why United States and Brazil?

As business incubators gain ubiquity in various parts of the developed and developing world, incubator models have evolved in

(1) Management, Information Systems, and Business Education Department Scott College of Business, Indiana State University, USA.
*Corresponding author: Aruna.Chandrasekaran@indstate.edu

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sophistication, variety and complexity. The services that are offered and the configurations they take vary widely, since they are highly sensitive to local environmental conditions and to the unique entrepreneurial ecosystem in that country (Lalkaka, 2003). While incubators have been in existence in the United States since the 1960's, business incubators in developing countries have really only been in evidence in any significant way in the last decade (Scaramuzzi, 2002). By contrast, the United States has a much longer history of incubation and has served as a model for many countries engaging in this form of intervention to support new venture creation. The United States has the oldest and largest incubation system with approximately 1400 incubators, which has evolved into an incubation ecosystem with a plethora of incubator models ranging from public to private incubators. With over 400 incubators, the Brazilian incubation market is counted as the 4th largest in the world after the United States, Germany and China. This study compared the oldest and largest incubation system with an emerging, yet innovative incubation market. Of particular interest in this study is the concept of incubator affiliation and its impact on service mix and resource access.

The institutional context in a country shapes the environment for incubation, and this holds true for almost any country in the world. Capital scarcity, lack of awareness of the incubator as a support mechanism, lack of private investment and high dependence on government for survival along with the lack of well-developed market for risk capital in the later stages of a new firm's growth were cited as major barriers to growth in Brazil. The world of incubation is not well-known in Brazil even with nearly 400 incubators in existence and the venture capital market is still in its infancy (ANPROTEC, n.d.). In a similar vein, the Global Entrepreneurship Monitor 2013 Report on Brazil (Da Silva, Furtado, & Zanini, 2013) indicates that the main obstacles to businesses are capital scarcity and high cost, bureaucratic interference in the form of heavy taxes and regulatory burden, lack of coordinated and easily accessible information on entrepreneurial support systems / programs, and an educational system that does not foster an entrepreneurial spirit. Moreover, Brazilian culture tends to be risk-averse encouraging people to prefer the security of a formal job with a large company over an entrepreneurial career fraught with risk and uncertain outcomes (Da Silva et al., 2013).

Incubator Affiliation

The incubator's affiliation is a critical factor that affects the incubator's ability to access funding for its set-up and operations by forming effective networks with other entities. Furthermore, the incubator's affiliation may also affect the nature and level of tangible and high value services and support it can provide its incubatee firms, particularly its ability to access or link incubatees to sources of capital. Affiliation, as defined in this study emphasizes formal, strong ties, or direct connection / cooperation between a BI and other BIs and/or a university. This definition builds on the concept of the one-to-one transactional network where value growth is much faster, since each new member brings its own potential set of connections to the entire network, thereby enhancing the value of the entire network (Reed, 2001). Affiliation or forging links to external partners for beneficial exchanges may be viewed as part of a process of building a network, where the incubator serves as a 'hub' connecting and mediating relationships between partners. As Burt (2002) noted, a network consists of both interaction and linkages that are in a constant state of renewal and growth to repair bridge/tie decay. Network renewal and growth is accomplished via the mechanism of adding new ties (i.e., affiliations) and upgrading or dropping old ties (Elfring & Hulsink, 2007).

Peters, Rice, and Sundararajan (2004) view the incubator's role as 'broker', arguing that its value derives from its role as an intermediary to a much larger set of networks. Affiliation may be viewed as a form of inter-organizational relationship built to connect client firms to new resource pools to ameliorate initial resource deficits (Van de Ven, 1993) for the new venture and to buffer it from competition for resources. In addition, affiliation that creates links to multiple networks ensures greater network stability in terms of resource access by providing some measure of insurance against weaknesses in any one network as well as reducing dependence on any one network (Ramachandran & Ray, 2006). In addition to serving as a bridge to external resources, the initial resource access enabled by affiliation may serve to buffer the new firm from environmental shocks inherent to a firm's formative period (Amezcua et al., 2013) allowing more time for it to strengthen its resource base to fuel its growth. Hence, incubators may use the affiliation mechanism to both build bridges for resource access and to buffer the new venture from external shocks by reducing their resource dependency, bringing us to the issue of whether the country context mediates the incubator's affiliation strategy in resource seeking and service offering. In the following sections, the broad effects of university affiliation regardless of country context is considered first, followed by country effects of affiliation on service mix and resource access.

University Affiliation

As nodes for knowledge transfer and diffusion in regional innovation systems, universities serve as hubs that connect actors in the triple helix of government, business and academia (Etzkowitz, 2002). Hence, affiliation with a university affords an incubator access to university resources including university faculty, their cutting edge research, their students, other high-quality employees (Mian, 1996; O'Neal, 2005), and other knowledge-based assets (Rothaermel & Thursby, 2005). Besides the 'knowledge spillover' effect benefiting new ventures housed in a university incubator (Acs, Audretsch, & Feldman, 1994; Jaffe, Trajtenberg, & Henderson, 1993), the incubator benefits from the parent university's hub status as well as its own boundary spanning location at the nexus of linkages between various actors in the triple helix. University business incubators are considered as a separate category of incubator by many (Grandi & Grimaldi, 2004; Peters et al., 2004) due to these distinguishing features.

Another impact of affiliation on fundraising ability is the locational advantage of certain incubators, in particular, incubators affiliated with universities (AU). These incubators are positioned at a strategic crossroads between various actors which also facilitates the building of the network and subsequent increase in the number of ties, as these incubators are better able to tap into proximate resource pools as they get more established over time (Autio & Klofsten, 1998). The university-industry linkages enable formal and informal interaction between academics and industry facilitating exchanges of innovative ideas and resources from the local environment (Gibb, 2000). As boundary spanning organizations, AU incubators are situated at the nexus of multiple networks by virtue of their affiliations as well as their position as a hub connecting isolated stakeholders. Over time, they are expected to become more adept at accessing and leveraging multiple resources.

While the effect of university affiliation has been the subject of previous studies (Mian, 1996), it is not clear whether the impact of university affiliation holds true in different country contexts. This study seeks to answer this question by pooling responses from university affiliated and non-university affiliated incubators from both countries to assess differences, if any, between the two groups in terms of raising funds from a variety of sources. Also, given their different affiliations, strategic focus, and resource access, AU and NAU (not affiliated with universities) tend to differ in their services to and financial support for their clients (Chandra et al., 2014). However, is this observation valid across national boundaries? In the next section, current research on United States and Brazilian incubator funding patterns, financial services to incubatees, and service mix is examined, along with this study's research questions.

Incubator Funding Patterns and Financial Sponsorship

BIs around the world are usually funded at inception by a coalition of government agencies, universities, private institutions, research centers, or a mixture of all those. Typically, funding for incubator inception (capital costs) and operations (day-to-day) come from different sources. Incubator startup costs are typically funded by synergistic efforts of the organizations from federal, state and local levels of government, universities and public organizations. (Chandra, He, Fealey, 2007; Chandra & Fealey, 2009; Scaramuzzi, 2002).

In terms of ongoing operations, BIs typically utilize a combination of the following three types of revenue models:

a. rental income and client fees
b. equity positions in promising clients with the expectation of future income
c. on-going funding from sponsors, i.e., university, federal/state/local government, private industry, private foundation support (*info*Dev, 2010; Lalkaka, 2003).

Incubator Funding - United States

The United States had a diversity of non-profit and for-profit incubation models, along with an attendant diversity of funding sources for these incubators. While many incubators in the United States are government funded, through federal, state and local level sources, county grants and corporate sources added to the range of funding for incubators Chandra & Fealey, 2009). In addition to rental income and service fees, in a few cases some incubators generated revenue by cashing in on their equity positions in their successful incubatees. Other sources of funds for incubators were federal agencies, such as the United States Department of Commerce, state and local economic development agencies interested in job creation, local banks interested in creating a potential business relationship with incubator clients, the local Chamber of Commerce, and corporate and community foundations (Knopp, 2007).

Several types of formal and informal support were available to incubators in the United States. Formal support included capital funds from the State's legislative allocation for incubator infrastructure, competitive grants from the State to select incubators, matching grants for service support for new ventures and funds that were channeled through the State Economic Development Agency (Knopp, 2007). Informal sources of support included tax incentives in the form of tax credits to businesses investing in incubators, low interest loans to local government agencies to support investment in incubators, and private partnership funding where incubators raised money from a coalition of businesses and banks for operational funds. In addition, some incubators had seed fund programs that invested in new ventures in the early stages (Knopp, 2007).

Incubator Funding - Brazil

Universities played a pivotal role in the creation of incubators in Brazil (Almeida, 2005). Government agencies at the federal and state levels played an important role in supporting incubators, but appeared to work synergistically with universities and industry associations. A representative example was the CIETEC incubator created in 1998 and housed in the University of Sao Paulo. CIETEC, a technology based incubator center was created as a partnership among the following organizations (Universidade de Sao Paulo, n.d.): the Ministry of Science and Technology; the Science, Technology and Economic Development Secretary of the State of Sao Paulo; University of Sao Paulo; Nuclear and Energy Research Institute; Institute of Technological Research; and SEBRAE (Brazilian Support Service for Micro and Small Business), along with support from National Council for Scientific and Technological Development (CNPq), Research Support Foundation of the State of Sao Paulo (FAPESP), and Financing Agency for Research and Projects (FINEP).

As stated, Brazilian incubators received support from a broad spectrum of federal agencies, such as FINEP, public-private entities like SEBRAE, strong national incubator associations, such as ANPROTEC (National Association of Incubators and Science Parks) as well as local, state and city governments. FINEP, a division of the Ministry of Science and Technology has a program, the PNI, to support Brazilian national incubation. It is linked to the Ministry of Science and Technology and is instrumental in formulating policy for business incubators (InfoDev Study, 2010). SEBRAE (www.sebrae.com) is a non-profit public-private entity that supported incubator and small business development by a utilizing a mix of funds from government payroll taxes and private sources. Initially, SEBRAE provided infrastructure funding for many incubators in the first round and is now focused more on providing start-up funding and training to new

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ventures. The interaction between government, universities and industry appeared to be synergistic and relatively well-coordinated with incubator industry associations playing a boundary spanning role (Scaramuzzi 2002).

Extant literature on United States and Brazilian incubator funding as well as interviews with incubator managers in both countries suggest some unique funding patterns in each country; however they also share some similarities in the variety and sources of funding. In addition, university affiliated incubators appear to share certain commonalities across countries when compared with non-university affiliated incubators. Hence, the first pair of research questions to be addressed in this study is as follows:

1a. Are US and Brazilian business incubators different in their funding variety and sources?
1b. Are AU and NAU business incubators different in their funding variety and sources?

Incubator Financial Services

Financial Services – United States

Incubators in the United States provided a range of financial services to their incubatees, including assistance in securing grants from various government agencies at the federal, state and local levels (Chandra & Fealey, 2009). During the early growth stage, bank loans were an option for a financially viable business. To secure bank loans, a strong business plan that included credible financial projections was a necessary part of the process. In most cases, United States incubators provided assistance in business plan development. A network of relationships, built by the incubator with banks and other service providers, also helped facilitate access to funding from banks for the venture by providing some added credibility. Angel investors may step in at the early stages to fill the growth capital gap in some cases. In the later stages of the venture's life cycle, the incubator may use the power of its network to connect the venture with venture capitalists. Once the growing venture had reached profitable maturity, it had several exit options such as an IPO or acquisition. Even with fewer gaps in the financing chain in the United States, new venture failure is quite high, partly due to financing gaps in the seed to early stages when the new venture was most vulnerable. Several incubators in the United States had seed funds that invested directly in their incubated firms with the expectation of realizing gains upon the success of the incubated firm. Incubators in the United States seem to have moved past the landlord model to a second generation model of incubation, hence may be more risk tolerant in providing start-up capital to their more promising incubatees with the expectation of a profitable exit. Rose Hulman Ventures, for instance, is set up a separate entity from the Rose Hulman Institute of Technology and operates quite entrepreneurially supporting its operations with grants and investment income.

Financial Services - Brazil

In the early stages of a new venture's life cycle, bank loans are difficult to secure due to the lack of collateral, high interest rates, and a general distrust of the banking system by Brazilian entrepreneurs. The federal agency, FINEP, provided money for projects done in conjunction with a university or research institute. Since Brazilian law does not allow direct flow of government funds to a company, the money went to the university to finance projects within the company (Chandra & Fealey, 2009). FINEP addressed the need for financing at various stages of firm growth from inception with a 0% interest program to stimulate firm growth in early stages. BNDES (Bank for Social Development) which used to support only big companies now has a support program for micro-enterprises. Bank loans were not a feasible alternative for small companies in Brazil, since high interest rates made it difficult for micro enterprises to borrow money. The INOVAR Project led by FINEP was a consortium of local and foreign VC firms for establishing an institutional structure for promoting the capacity and culture of venture capital. The goal was to set up a $200 million fund for tech-based ventures, a web site for information and virtual matchmaking, which is a Venture Forum and network to support high potential entrepreneurs (Lalkaka, 2003). In general, there was a mix of state, federal, some private funds / venture capital and some seed money, but there clearly were gaps in the financing chain for seed / early to mid-stage growth capital that needed to be addressed.

Brazilian incubators rarely invested their own money in their client firms, though some incubators were experimenting with this approach, such as moving from a service model where the incubator offered services, infrastructure and management services in return for rental fee to a "partnership" model where the incubator took a financial stake in the firm in lieu of rent and the payoff for the incubator would come in the form of profit sharing However, most Brazilian incubators followed a more conservative model of linking client firms to potential investors (Chandra & Fealey, 2009).

To understand the impacts of country context and affiliation, the second set of research questions to be addressed in this study is as follows:

2a. Are US or Brazilian business incubators more likely to provide direct financial support to incubatees?

2b. Are AU or NAU business incubators more likely to provide direct financial support to incubatees?

Incubator Service Mix

Incubators provide a spectrum of services ranging from the tangible to intangible, generally classified into categories such as physical/administrative, in-house consulting/business assistance and networking (Mian, 1996; Peters et al., 2004). Incubator performance and

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success is expected to be influenced by the type of service and manner of delivery, with variation in service type largely dependent on sponsor objectives and incubator type ("Benchmarking of Business Incubators," 2002). The impact of various categories of services on incubatee survival and growth has been studied extensively (Colombo & Delmastro, 2002; Fang, Tsai, & Lin, 2010; Rothaermel & Thursby, 2005). Networking is considered a high-value service in the incubation process (Hackett & Dilts, 2004) since it enables an incubator to connect its client firms to sources of knowledge or other scarce resources to fill resource gaps that may hinder its survival and growth.

This study classifies services into two categories: internal and external (Chandra et al., 2007). Internal services, offered on the incubator's premises are location specific, whereas external services are associated with linking the incubatee to external organizations. In the newer, second generation models of incubation, enterprise development is no longer heavily dependent on internal, tangible administrative services (Hackett & Dilts, 2004), as in the older, first generation landlord model of incubation with its emphasis on rental space as well as tangible, administrative services designed to lower incubatee cost of doing business and to lend credibility of a physical location to a young, fledgling venture. External intangible services, such as networking that link the incubatee to new knowledge wells of human capital and to other resource pools in the triple helix, is gaining in importance (Peters et al., 2004).

Services - United States

The service mix in United States incubators varied with the strategic agenda of the sponsor's motives and the type of incubator model. University-affiliated incubators were focused on technology transfer and commercialization and tended to draw upon the resources and networks of the parent university to assist incubated firms. Since faculty is a rich source of expertise, these incubators tended to emphasize the consulting and networking dimension to a larger extent. In general, incubators in the United States were moving toward a service mix that emphasized higher, value-adding services such as networking, which is now recognized as more valuable in the service continuum of incubators. Hence, incubators are transitioning to greater emphasis on external intangible services conducive to the creation of a positive overall environment for incubation (Hackett & Dilts, 2004). Moreover, US incubators given their age and level of maturity may have higher resource endowments garnered from a more heterogeneous, relatively more resource munificent environment.

Services - Brazil

The Brazilian incubator movement is defined by its provision of unique and specialized services to support new businesses by providing an innovative environment for their growth through guidance, consulting, in addition to physical space and operational infrastructure (Universidade de Sao Paulo, n.d.). Particular services provided include traditional services, i.e. physical services, access to university labs and infrastructure, and training courses sponsored by SEBRAE. In general, Brazilian business incubators offer more internal services, such as subsidized office space, secretarial support, training and consulting services. This fits the pattern of a younger incubation market relative to the United States that is moving on the path to a second generation emphasis on higher value services derived from affiliation with other actors.

The third set of research questions to be empirically tested and answered in this study is as follows:

> 3a. Do US and Brazilian business incubators differ in internal / external services they provide to their incubatees?
> 3b. Do AU and NAU business incubators differ in internal / external services they provide to their incubatees?

Methods

Both qualitative and quantitative data collection methods were used in this study of business incubation in the United States and Brazil. In-depth, semi-structured interviews with managers of nine incubators in the United States and managers of six incubators in Brazil were conducted to identify key dimensions of relevance for the study. Each interview lasted around 40 minutes and was digitally recorded and transcribed. Key themes / findings that emerged from the interviews were used to develop quantitative survey instruments, as well as to corroborate findings from the empirical data.

United States business incubators who participated in the survey were identified from the National Business Incubators Association's (NBIA) membership directory. Incubator managers of these incubators were the study's key informants as these individuals were most likely to have knowledge of the strategic focus as well as range/scope of services provided by the incubator. Both general business incubators and university incubators were included for a final sample of 121 general business incubators and 67 university-based incubators. The survey instrument along with a cover letter and a self-addressed, postage-paid return envelope was mailed to the 188 incubator managers. As a reminder, a second survey packet was sent out at a one-month interval. This was followed by three more waves of mailings in a four-month period. In addition, phone calls were made by the researchers to stimulate response. In the final count, 84 surveys were returned yielding an overall response rate of 44.6 percent.

The quantitative data collection instrument used in Brazil was a web-based survey in Portuguese. The survey instrument was developed after an extensive literature review and interviews with BI managers and policy makers in key cities in Brazil to specifically understand issues relevant to incubation in Brazil, and to triangulate them with findings from the literature. The authors' prior experience with incubator research in the United States, China and Brazil also informed survey development. The survey instrument was first developed in English, translated into Portuguese and back-translated into English. Researchers, academics, incubator managers, and SEBRAE (Agency for Support of Small Businesses) personnel in Brazil pre-tested the survey and provided feedback, which was incorporated into the revised instrument. The Brazilian survey respondents came from a pool of 63 SEBRAE affiliated incubators in the State of Sao Paulo.

These BI managers received an email invitation requesting their participation and assuring confidentiality of data, with the incentive of sharing aggregate results in return for survey completion. Subsequent telephone calls and reminder e-mails along with the survey link were sent after two weeks and four weeks to spur responses. The quantitative sample was limited to the state of Sao Paulo, since incubation in this state is quite representative of Brazilian incubation efforts, as well as the fact that the research was funded in part by a Fulbright-FAPESP Science and Technology Grant from the State of Sao Paulo and the United States Fulbright Commission. A total of 49 completed responses to the survey were received yielding a response rate of 77.7%.

Characteristics of United States survey early respondents (the first 20 percent of the business incubators that returned the surveys) were compared to the late respondents (the last 20 percent) to test non-response bias (Dooley & Lindner, 2003). The independent sample t-test comparing the two groups showed no significant differences in (1) the number of incubatees (t = .554, df= 32, p= .583), (2) the number of employees (t = 1.550, df= 32, p= .131), and (3) years in operation (t =-.150, df= 32, p= .882). Similarly, no difference were found between the early and late respondents of the survey conducted in Brazil. The independent sample t-test showed no significant differences between the two groups in (1) the number of incubatees (t = 1.48, df = 18, p = .154), (2) the number of employees (t = –1.25, df = 17, p = .226), and (3) years in operation (t = –1.04, df = 18, p = .313). The affiliation status of early and late respondents was also compared and no difference was found.

Key variables

Key variables examined in this study are as follows.

Affiliation Status. Affiliation refers to an incubator's direct and formal association with an external entity with transactional intent. In this study, incubator managers were asked to respond to questions related to their incubator affiliation with a university and/or with other types of organizations, including foundations, other BI(s), state agencies, and companies.

Funding Sources. Incubators managers were asked to indicate their major sources of funds, by selecting from one or more categories: federal government, state government, local government, university, private institutions, and user fees. Funding sources included regular income (such as user fees) and renewal-based support (such as grants from state and local agencies).

Financial Assistance to Incubatees. Incubator managers were asked to indicate whether the incubator provided any forms of financial assistance for the incubatees, such as arranging, or assisting in obtaining loans or grants.

Incubator Services. The survey included 21 potential services in three categories: 11 physical infrastructure/services, 6 traditional/basic in-house consulting services, and 4 specialized services offered by external firms. Physical services were tangible services such as receptionist, on-site computer facilities, and access to meeting and research facilities. In-house consulting and external specialized services were intangible services. In-house consulting services—such as technical, accounting, financial, marketing, and general business consultation—were services provided by the incubator personnel. External, specialized services were services that an incubator provided based on its relationship with outside providers by way of referrals for the convenience of the client firms. Examples of specialized services include marketing research, legal advice, and venture capital. A complete list of these services is in the Appendix.

Results

Demographic Information of United States and Brazilian Business Incubators

At a glance, United States and Brazilian BIs appeared to be rather similar; there was no statistically significant difference in their sizes as measured by the number of incubatee firms and the number of employees those firms employed. On average, a US BI housed 17.7 firms and the firms employed 84 staff members, whereas a Brazilian BI housed 16.2 firms and the average number of firm employees was 66. As shown in Table 1, the F-tests for the two-way ANOVA comparing the country and affiliation major effects on the two incubator size measures were not significant. United States BIs, however, were significantly older than their Brazilian counterparts. The average years in operation of BIs in the United States were 9.5 compared to Brazil's 6.9 years.

Table 1

Business Incubator Size and Age by Country and Affiliation

	Number of Incubators		No. of Firms		No. of Firm Employees		Years in Operation	
			Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Brazil	NAU	22	14.71	14.07	81.65	155.29	5.79	3.57
	AU	27	17.31	11.52	52.22	57.53	7.79	4.34
	Total	49	16.15	12.64	65.91	113.42	6.89	4.10
United States	NAU	34	19.32	19.75	76.94	83.36	9.79	9.16
	AU	50	16.56	15.48	88.86	96.72	9.25	6.57
	Total	84	17.68	17.28	84.04	91.22	9.47	7.69

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Total	NAU	56	17.56	17.80	78.69	113.92	8.26	7.74
	AU	77	16.82	14.18	77.32	87.59	8.74	5.91
	Total	133	17.13	15.73	77.90	99.21	8.54	6.72
2X2 ANOVA			*df* = 1,130		*df* = 1,126		*df* = 1,129	
Country			*F*= 0.44, $p > .05$		*F*= 0.72, $p > .05$		*F*= 4.97, $p < .05$*, Partial $\eta^2 = .038$	
Affiliation			*F*= 0.00, $p > .05$		*F*= 0.22, $p > .05$		*F*= 0.35, $p > .05$	
Interaction			*F*= 0.84, $p > .05$		*F*= 1.21, $p > .05$		*F*= 1.08, $p > .05$	

* Significant at the .05 level

While United States BIs were older than Brazilian BIs, there was no difference in age or size between United States AU (Affiliated with University) and NAU (Not Affiliated with University) BIs. Likewise, Brazilian AU and NAU BIs had similar demographics.

Total Number of Funding Sources

Incubators rely heavily on public and private funding. To answer the first pair of research questions on possible differences between countries and university affiliations in funding variety, the total number of funding sources incubators received was analyzed. From a list of six possible funding sources—three from the government (federal, state, and local), and the other three from university, private, and user fees—incubator managers indicated the sources from which the incubator received their current funding. Table 2 shows the average number of funding sources United States BIs (AU and NAU combined) received was significantly higher than that of Brazilian BIs. Likewise, AU BIs' (United States and Brazil combined) funding numbers significantly surpassed those of NAU BIs. While the two main effects in the two-way ANOVA—country and affiliation—were significant, the Country*Affiliation interaction effect was not. To further examine affiliation differences within each country, independent sample *t*-tests were performed, which found no significant difference between United States AU and NAU BIs, but the difference between Brazilian AU and NAU BIs was approaching significance ($p < .10$). The study results provided support for the positive effect of university affiliation on obtaining funding from more diverse sources along with difference between United States and Brazil.

Table 2

Business Incubator Funding Variety by Country and Affiliation

	Affiliation	Mean	SD	t-test comparing AU vs. NAU in each country
Brazil	NAU	1.32	1.09	Brazil: $t(1, 47) = -1.84$, $p = .07$
	AU	1.96	1.32	
	Total	1.67	1.25	
United States	NAU	2.15	1.13	United States: $t(1, 82) = -.793$, $p = .43$
	AU	2.36	1.26	
	Total	2.27	1.21	
Total	NAU	1.82	1.18	
	AU	2.22	1.28	
	Total	2.05	1.25	
2X2 ANOVA				
Country	$F(1, 132) = 7.76$, $p < .01$**, *partial* $\eta^2 = .057$			
Affiliation	$F(1, 132) = 3.80$, $p < .05$*, *partial* $\eta^2 = .029$			
Interaction	$F(1, 132) = 0.96$, $p > .05$, *partial* $\eta^2 = .007$			

* Significant at the .05 level

** Significant at the .01 level

Sources of Funding

Further analysis of funding to determine whether country context and affiliation played a role in the specific sources of funds BIs received was conducted using Chi-square tests. As shown in Table 3, significantly higher percentages of United States BIs (AU and NAU combined) received state government and university funding and collected user fees than Brazilian BIs. On the other hand, significantly higher percentage of Brazilian BIs received local government funding.

Differences in funding sources were also noted among AU and NAU incubators (United States and Brazil combined). Not surprisingly, significantly higher percentage of AU BIs than NAU BIs received university funding, and higher percentage of AU BIs received state government funding (the difference was approaching significance (p < .10)). Another difference approaching significance (p < .10) was higher percentage of NAU BIs than AU BIs received local government funding.

Further examination of sources of funding for AU and NAU BIs in each country found additional differences. A significantly higher percentage of NAU BIs in the United States received local funding while such difference was not observed between Brazilian AU and NAU BIs, as relatively high percentage of Brazilian BIs in both group received local funding. This highlighted the importance of local government funding to Brazilian BIs. Another pattern from the analysis was the clearly differentiated funding source for United States BIs: university funding for AU BIs and local government funding for NAU BIs.

Table 3

Business Incubator Source of Funding by Affiliation and Country

Funding Source	AU vs. NAU (% of BI Receiving Funding)		Brazil vs. United States (% of BI Receiving Funding)		Within Country AU vs. NAU Comparison		$\chi 2$ test
Federal	NAU	16%	Brazil	8%	NAU	9%	$\chi 2 = .046$,
					AU	7%	$p = .83$
	AU	14%	United States	19%	NAU	21%	$\chi 2 = .088$,
					AU	18%	$p = .77$
	$\chi 2 = .08$, $p = .78$		$\chi 2 = 3.87$, $p = .09$				
State	NAU	21%	Brazil	12%	NAU	5%	$\chi 2 = 2.2$,
					AU	19%	$p = .138$
	AU	35%	United States	39%	NAU	32%	$\chi 2 = 1.15$,
					AU	44%	$p = .283$
	$\chi 2 = 2.91$, $p = .09$		$\chi 2 = 10.91$, $p = .001$**				
Local	NAU	52%	Brazil	63%	NAU	59%	$\chi 2 = .299$,
					AU	67%	$p = .59$
	AU	36%	United States	31%	NAU	47%	$\chi 2 = 6.93$,
					AU	20%	$p = .008$**
	$\chi 2 = 3.15$, $p = .07$		$\chi 2 = 13.19$, $p = .00$**				
University	NAU	5%	Brazil	10%	NAU	0%	$\chi 2 = 4.54$,
					AU	19%	$p = .033$*
	AU	44%	United States	38%	NAU	9%	$\chi 2 = 20.75$, $p =$
					AU	58%	$.000$**
	$\chi 2 = 24.3$, $p< 00$**		$\chi 2 = 11.99$, $p = .001$**				
Private	NAU	36%	Brazil	37%	NAU	32%	$\chi 2 = .415$,
					AU	41%	$p = .519$
	AU	43%	United States	42%	NAU	38%	$\chi 2 = .277$,
					AU	44%	$p = .59$
	$\chi 2 = .69$, $p = .41$		$\chi 2 = .31$, $p = .58$				
User Fees	NAU	52%	Brazil	37%	NAU	27%	$\chi 2 = 1.54$,
					AU	44%	$p = .215$
	AU	49%	United States	58%	NAU	68%	$\chi 2 = 2.039$, $p =$
					AU	52%	$.153$
	$\chi 2 = .077$, $p = .78$		$\chi 2 = 5.78$, $p = .016$*				

* Significant at the .05 level
** Significant at the .01 level

Direct Financial Support to Incubatees

The second set of research questions focused on direct financial support (loans or any other form(s) of financial assistance) to incubatees from the incubators and possible differences between the countries and between AU and NAU BIs. As shown in Table 4, the results of the Chi-square analysis showed a higher percentage of United States BIs offered direct financial assistance to their firms than Brazilian BIs (23% vs. 10%), and the test was approaching significant (p < .10). From the perspective of affiliation, higher percentage of NAU offered direct financial support than AU (26% vs. 13%), and the Chi-square test was approaching significance (p < .10).

Table 4

Business Incubator Financial Support to Incubatees by Country and Affiliation

AU vs. NAU (% of BI Provided Funding)		Brazil vs. United States (% of BI Provided Funding)		Within Country AU vs. NAU Comparison		χ^2 test
NAU	26%	Brazil	10%	NAU	9%	$\chi^2 = .054$,
				AU	11%	$p = .82$
AU	13%	United States	23%	NAU	36%	$\chi^2 = 5.63$,
				AU	14%	$p = .018$*
$\chi^2 = 3.35$, $p = .067$		$\chi^2 = 3.34$, $p = .068$				

* Significant at the .05 level
** Significant at the .01 level

Delving deeper into the country and affiliation factors, significantly higher percentage of NAU BIs than AU BIs in the United States offered loans / other financial assistance to incubatees. On the other hand, very few Brazilian BIs offered direct financial assistance to incubatees (only five among all 49 Brazilian BIs surveyed did), and there was no significant difference between Brazilian AU and NAU. The statistical analyses provided some evidence of United States over Brazil and NAU over AU in the likelihood of direct financial assistance to tenants, and the evidence was the strongest within the United States between NAU and AU.

Services to Incubatees

The third pair of research questions asked: Do BIs in different countries and of different affiliation differ in their services to incubatees? In the survey instruments, services were grouped into three categories: physical infrastructure; basic, in-housing consulting services; and specialized/external services. Under each service, incubator managers were asked to indicate whether each service was (1) offered by the incubator or an external provider on-site and the cost of the service included in rent; (2) offered by the incubator or an external provider on-site but required extra payment; (3) offered off-site by an external service provider with payment directly to the provider; or (4) not offered. Different weights were assigned for each of these four levels of services: an on-site service included in the rent received 3 points; an on-site service requiring extra payment received 2 points; an off-site service requiring additional cost received 1 point; and a service not offered received no points. Points under each service category were then averaged to provide an overall indicator of the number and level of service offered by each incubator. This was used as a measure of service intensity.

As shown in Table 5, the country main effect in the two-way MANOVA was significant, while the affiliation main effect was approaching significance ($p < .10$), indicating significant effect of the country context and university affiliation on incubator services. Further analysis of between-subject effects found that Brazilian BIs (AU and NAU combined) offered more and higher level of basic, internal services than United States BIs, whereas AU BIs (Brazil and United States combined) offered more and higher level of specialized, external services than NAU. There was no significant different between the countries and affiliation in physical infrastructure.

Table 5

Business Incubator Services to Incubatees by Country and Affiliation

	Country	Affiliation	*Mean*	*SD*
Physical Infrastructure	Brazil	NAU	1.74	0.29
		AU	1.95	0.40
		Total	1.85	0.36
	United States	NAU	1.82	0.36
		AU	1.75	0.51
		Total	1.78	0.46
	Total	NAU	1.79	0.33
		AU	1.81	0.49
		Total	1.80	0.43
Basic, Internal Services	Brazil	NAU	2.35	0.53
		AU	2.27	0.54
		Total	2.31	0.53
	United States	NAU	1.93	0.49
		AU	1.73	0.57
		Total	1.81	0.55
	Total	NAU	2.10	0.55
		AU	1.90	0.61
		Total	1.98	0.59
Specialized, External Services	Brazil	NAU	1.07	0.75
		AU	1.31	0.94
		Total	1.20	0.85
	United States	NAU	1.16	0.68
		AU	1.53	0.64
		Total	1.39	0.67
	Total	NAU	1.13	0.70
		AU	1.46	0.75

2X2 MANOVA	Country	Affiliation		
Main Effect	*Wilks' λ* = .831, *F*(3, 104) = 6.94, *p* =.000**, *partial η²* = .169	*Wilks' λ* = .934, *F*(3, 104) = 2.40, *p*=.072, *partial η²* = .066	Interaction	*Wilks' λ* = 974, *F*(3, 104) = .922, *p* =.433, *partial η²* = .026
	Internal Services	External Services		
Between Subject Effects	*F*(1, 104) = 19.06, *p*=.000**, *partial η²* = .155	*F*(1, 104) 4.19, *p*=.043*, *partial η²* = .039		

* Significant at the .05 level
** Significant at the .01 level

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To determine whether AU and NAU BIs in each country differed in their services, separate MANOVA tests were performed. No statistically significant differences were found between AU and NAU BIs in Brazil (*Wilks'* λ = 850, F(1, 36) = 1.99, p =.13, *partial* η^2 = .150) and between AU and NAU BIs in in the United States (*Wilks'* λ = *912, F*(1, 68) = 2.13, p =.10, *partial* η^2 = .088). Also, the between subject effects comparing the three categories of services in Brazil showed no difference, indicating Brazilian AU and NAU BIs offered similar number and level of services in all three categories; whereas United States AU BIs offered significantly higher number and level of specialized, external services (F(1, 68) = 5.21, p=.026*, *partial* η^2 = .071).

Discussion

This study compared the impact of university affiliation and country context on incubator funding variety and sources of funds, direct financial assistance to incubatees, and service mix of the incubator in terms of internal and external services. University affiliated incubators are considered a separate category of incubators across the world that share certain similarities by virtue of their public sponsorship as well as boundary spanning location at the nexus of the triple helix of government, industry and academia (Etzkowitz, 2002). Hence, the study classified incubators into two broad groups—university versus non-university affiliated—and drew comparisons between the two groups while also considering the influence of country context.

The first research question sought to assess the effect of university and country affiliation on incubator funding variety and source, since an incubator's sources of funds along with its variety largely determine its strategic direction (von Zedtwitz, 2003). Findings indicated that university affiliation does in fact have positive effect on the number of funding sources available to the incubator relative to the non-university affiliated incubator. Unsurprisingly, significantly more university affiliated incubators get funding from their parent universities. Of note was the fact that in addition to university funding, AU incubators also secured more funding from the State compared to the non-university affiliated incubators, who as a group seemed to get more local funding. The greater availability of State funding to AU in general could be explained by the fact that many universities are State funded across countries and hence have a stronger link to State governments compared to their NAU counterparts, who are more rooted in their local contexts with an emphasis on creating local jobs.

The incubator funding picture seemed to undergo a change when differences between the AU and NAU groups were examined within a specific country context. Results indicated that a greater number of United States business incubators received funding from State, university and user fees relative to Brazilian incubators that were predominantly reliant upon local funding. This finding could be explained by the fact that incubators in the United States could have enhanced abilities to tap into a range of funding sources, regardless of affiliation.

Another explanation could be that the United States has a greater diversity of funding sources and a more mature venture capital market relative to Brazil.

The second research question examined differences between the two countries and general impact of university affiliation on direct financial support provided by the incubator to their client firms. Results seem to hint at a pattern where non-university affiliated incubators were more likely to provide direct financial assistance to their start-up firms, with the Chi-square tests approaching significance. However, a clearer picture emerged when comparing university versus non-university affiliated incubators within each country, with more NAU in the United States providing direct financial assistance to their clients. Brazilian incubators (AU and NAU) tended to abstain from providing this form of risk capital to their client firms. This finding may be explained by the fact that in the United States, universities are predominantly publicly funded entities that do not or cannot use monies from the public purse to invest in risky start-ups, no matter how promising, whereas the non-university affiliated incubators do not face similar constraints. As for Brazil, a risk-averse culture and the availability of funds from the other sources, typically governmental seed funds may explain this finding. However, it is notable that in the Brazilian context, both AU and NAU incubators receive funding from local government with the objective of stimulating the local economy, yet they do not invest some of these funds into the startups. Again, government funds typically come with strings attached, and incubators may not be allowed to invest in risky startups with no track record or collateral to secure the loan.

The third research question examined differences between countries and university affiliation on service mix. Overall, there were no notable differences between AU and NAU in terms of physical and internal services; however, the AU group provided a higher level of external, specialized services. Country context seemed to play a role in the provision of internal versus external services: Brazilian incubators provided a higher level of basic, internal services in house, while United States incubators tended to link incubatees to external service providers. Myriad rules and regulations involved in starting a business may be one reason why Brazilian incubators provide more internal services. Many Brazilian entrepreneurs opted to remain in the informal economy due to bureaucratic barriers, since incorporating a new business requires 15 procedures, three times more than in the United States. New companies had to register with the appropriate government agency, apply for licenses and permits from several state and federal departments, such as environment and labor, register for taxes at multiple levels of government and provide evidence of membership in relevant trade organizations, all of which can easily take more than 5 months. Similarly, a recent survey of Brazil in The Economist points out that, the average firm in Brazil takes 2600 hours to process its taxes and opening a business requires 17 procedures and 152 days, putting Brazil in the 115th place in the ease of doing business in a league of 175 countries ("Special Report on Brazil," 2013).

Considering all findings, the advantage of university affiliation in fund raising, while observed in both countries, is more pronounced in Brazil, possibly due to the fact that universities and faculty have played a vital role in the origin and growth of incubators in Brazil (Etzkowitz, 2002). University affiliation also affects whether or not the incubator offers direct financial support to client firms, as NAU are more likely to do so than AU. Universities around the world are typically publicly funded entities, and this finding could be explained by the fact that monies from the public purse are typically not invested in risky ventures, however promising.

As intermediaries that moderate the impact of the environment on new ventures and mediate their connection to the outside world, incubators employ both buffering and bridging strategies (Amezcua et al., 2013). One contribution of this study is that it demonstrates the impact of country context on incubator strategic decisions to offer financial support and internal or external services to client firms and attendant strategies to use bridges or buffers to suit environmental contingencies. Bridges created via affiliations enable resource munificence, while the harsh environmental shocks requires the incubator to develop mechanisms to create protective internal buffers for their young, vulnerable ventures. It is noteworthy that in the United States, over a third of NAU incubators provided direct financial support compared to just nine percent of NAU incubators in Brazil. Brazilian incubators unaffiliated to universities tended to prefer to link their clients to external sources of funds, perhaps due to a dearth of risk capital. This strategy of reaching out to external sources of funding could be an example of the incubator using its affiliations to ameliorate its internal resource deficits. However, the same Brazilian incubators seem to prefer to provide services in house, perhaps as a way of buffering client firms from external forces. This suggests that incubators in Brazil use both bridging and buffering approaches as determined by contextual needs. By contrast, incubators in the United States offer more services externally, but are also more likely to provide direct financial support to client firms suggesting that they too use bridging and buffering to suit environmental exigencies. The adaptive response of incubators to their environment in their strategic choices and service provision is clearly evidenced in this study, which serves as a foundation for future cross-country comparative studies.

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Appendix – Incubator Services

Physical Infrastructure

1. Receptionist Switchboard
2. Onsite Stenographic/Duplication Services
3. Onsite Computer Facilities
4. Email Facilities
5. Onsite Business Materials
6. Onsite Library-Technical Trade Publications
7. Onsite Mailroom/Shipping Services
8. FedEx/UPS or Other Overnight Shipping
9. Bus Furniture / Equipment Rental
10. Small Conference Room
11. Onsite Research Lab

Basic, Internal Consulting Services

12. Onsite Technical Consultation
13. Onsite General Business Consulting
14. Onsite Accounting Assistance
15. Onsite Financial Consultation
16. Onsite Marketing Consultation
17. Export Assistance

Specialized Services Offered by External Firm

1. Marketing Research Firm
2. Advertising Agency Referral/Access
3. Legal Firm Referral/Access
4. Venture Capital Firm

Relationships between Innovations and Productivity in the Services in the Slovak Economy

Viera Kubičková [*1], *Dana Benešová* [1], *Daniela Breveníková* [2]

Abstract: A key factor of increasing performances of service enterprises and in effect, that of the entire economy is the introduction of innovations. However, it is the final effect of the process that is important, rather than the type of innovation introduced by an enterprise. The aim of the paper is to verify the validity of the relationship between the innovation activity of service enterprises in Slovak Republic and their economic performance. Results of analysis have not demonstrated unanimously a positive relationship between innovations and the productivity of business service . The reason for that is in the so far low innovation performance of services as well as in the low time-related homogeneity of the implementation and the effect of innovations.

Keywords: innovations; performance indicators; productivity; service enterprises; enterprises with technology innovation

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Introduction

In recent years, the Slovak economy has passed significant structural changes. Despite the key role of automobile, engineering and the electrical engineering industries, the position of services has been strengthening. At the same time, we can mention that the economic power of industry supports the development of the service sector in particular through intermediary consumption. The tertiary sector represents the largest sector of the national economy, as evidenced by its share on the national economy. According to the Slovak Statistics (2015) services in Slovakia employ as many as 65.4% employees. The share of the service sector on the creation of value added is at present 62.73%. It is therefore justifiable to deal with the issues of the application of innovations in the service sector of the SR as the driving factor of its economic development.

Innovation performance in SR's services may be evaluated by means of selected European Service Innovation Scoreboard (European Commission, 2015) indicators. During the period monitored (2012), the value of almost all the indicators achieved in the SR was below the European Union's average. Merely the share of the turnover from launching new innovations onto the market was higher than in the EU. Slovakia is considerably lagging behind the European Union in the innovation performance of the service sector. A more detailed analysis of applying innovations in Slovakia's service sector is carried out by the Slovak Statistics in the report on "Innovation activity of enterprises in the Slovak Republic during 2010 – 2012" (the Slovak Statistics, 2014). The document informs that the share of service enterprises with innovation activities of the total number of service enterprises in the years 2010 – 2012 was 35.8%. As much as 64.2% of enterprises in the years 2010–2012 did not implement any innovation activities, although the innovation performance of service enterprises was higher than that of enterprises in industry. The highest share of enterprises with technology innovation in industry and services was scored by successfully innovating enterprises. Only 2.8% of them were enterprises with incomplete or suspended innovation activities. 42.1% of enterprises in industry and services conducted non-technology innovations (marketing, organizational) innovations. The highest share of innovation activities was recorded in large enterprises (250 and more employees). However, the mentioned materials fail to provide the analysis into economic consequences of innovation activities. Despite that, they have become the starting point materials for the scientific intent of the present paper.

Based on numerous theoretical sources and empirical experience with the real-life economic practice, we can identify the assumption of a positive relationship between innovations and economic performance. It is logical that in the effort for the sustainable development, expenditures on innovations are confronted with accompanying effects, while at the same time, these pragmatic procedures are required on the enterprise level as well as on that of the country's economy. The economic benefit of innovations is a crucial stimulus for innovation investment.

When considering the methodology applied in the European Commission Report on the results of innovation performance of countries in the year 2014 (European Commision, 2014), it can be said that the countries recording the highest expenditures on innovation activities (Germany, Sweden, Denmark, Finland) are at the same time leaders in the area of innovations in Europe. On the ladder of global of competitiveness, they occupy the first twelve positions (World Economic Forum, 2016). Innovations are clearly a factor that influences the country's economic growth. As a rule, innovations arise in enterprises, and thus influence their competitiveness and growth. Competitive enterprises are beneficial for the GDP growth and contribute to the change in its economic structure (Sedláček, 2014). Effective

(1) University of Economics in Bratislava, Faculty of Commerce, Department of Services and Tourism, Dolnozemská cesta 1, Bratislava, Slovak Republic.
(2) University of Economics in Bratislava, Faculty of Applied Languages, Department of Lingistics and Translatology, Dolnozemská cesta 1, Bratislava, Slovak Republic.
*Corresponding author: viera.kubickova@euba.sk

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production is therefore an aspect of competitiveness. Exploring relationships between investments in research and innovations, in terms of scope of innovation activity and economic effectiveness is thus a relevant research intent.

The influence of innovations on performance of American enterprises of commercial business services were explored by Mansury and Love (2008), who investigated into the differences between the level of innovations in service enterprises, to what extent the service enterprises utilise external innovations and the influence of the introduction of external innovation on the enterprise performances. Results indicate that the introduction of innovations in service enterprises have permanently recorded a favourable influence on growth, rather than on the production of services. Brawn and Mawson (2013) identify innovations as growth stimulus in enterprises. The academic and professional public are convinced that the innovation of services substantially affects the enterprise performance and are a key factor of adaptation, sustainability and growth (Rhee, Park and Lee, 2010).

Specific characteristics of services however, bring many queries regarding the methodology and application into the problems of the relationship between innovations and their economic effects. They focus in particular on determining the unit of performance in services; the influence of the client performance on the process of service production; mutually linked efficiency of individual types of service innovation; broad-range ICT effects in service innovation activities; as well as on the relationship between productivity and quality.

In the present paper, the productivity of labour expressed in terms of volume of turnover on an employee and the gross value added per an employee are used as an indicator of economic performance. The aim of the article is to identify the relationship between the innovation activity of enterprises and the productivity of labour in services in the Slovak economy.

Literature Review

Productivity in Services

Until recently, productivity of services was conceptionally underdeveloped (Corsten, 2001). Most of the definitions are derived from the classic concept of productivity (Sink, 1985); however, as a result of impalpable and intangible nature of services, a simple transfer of the traditional productivity concept from industry producing tangible goods into services, is inaccurate and misleading (Corsten, 2001, Baumgartner, Bienzeisler, 2006, Lasshof, 2006, Grönroos, Ojasalo, 2004, Johnston, Jones, 2004). The intangible nature of services results from the impalpability of the output of service production, as well as the heterogeneity of services as another service property complicates the creation of a generally valid conception of productivity of services. Services are highly diversified, broad-range, covering services starting from public services through services for enterprises, which are predominantly knowledge-intensive, up to personal services. These have various properties, consequently it is difficult to determine significant productivity factors and their specificities (Lasshof, 2006, Ojasalo, 1999, Baumgartner, Bienzeisler, 2006).

Apart from that, the customer integration and their involvement in the process of value creation is the main element in the production of services (Lasshof, 2006, Michalová and Krošláková, 2014). It means that the customer, who has to be in some way integrated and involved in the measuring of service productivity, is inevitably a key factor for service providers. This is in contrast to the classical concept of productivity, when the customer is usually not an inseparably part of the value creation, and commercial processes are often closed systems (Grönroos and Ojasalo, 2004). It means that the production in the course of value creation, i.e. in during production and selling, cannot and must not be influenced by the customer.

Existing conceptual approaches to the productivity of services consider several factors affecting its measuring (Lasshof, 2006, Grönroos and Ojasalo, 2004, Johnston, Jones, 2004, Corsten, 1994, Gummesson, 1998). However, nowadays there is no unified definition of the productivity of services, nor a generally applicable method of its measuring (Johnston, Jones 2004). The problem involved in defining the method of measuring productivity lies in the specific nature of services, as well as in the difficulty of quantifying the customer participation in the service production process (Nachum, 1999, Vuorinen, Järvinen, Lehtinen, 1998, Grönroos and Ojasalo 2004, Jääskeläinen, 2010).

The method of measuring productivity is currently worked out and utilised for the production of the manufacturing industry (Den Hartigh and Zegveld, 2011, Brown and Chávez, 2014), where productivity is defined as the ratio of production outputs and inputs. In contrast to it, the measuring of productivity of services has not been precisely and consistently defined to date. Identifying service productivity is not however unsubstantiated, as the service production (in contrast to manufacturing) to a great extent requires the participation of people, technologies, internal and external stakeholders mutually linked in the value creation and sharing information. As a result of this, there is no universal definition of the productivity of services (Hilke, 1989, Maleri and Frietzsche, 2008).

The model of productivity of services according to Grönroos and Ojasalo (2004) is one the main existing conceptions in scientific literature (Balciet al., 2011), enhancing the classical concept of the productivity of services. It is based on the process approach and defines the productivity of services as a complex of various funkctional components. From the aspect of the service provider, productivity of services is determined by three main factors: internal, external and capacity utilisation.

The internal efficiency is identified by the internal structure of the service production, including the service provider's and customers' inputs; the external efficiency depends on the quality of outputs, mainly from the service quality as evaluated by customers and the output quantity; an efficient capacity utilisation means an optimum utilisation of enterprise capacities in relation to the production quantity. The utilisation of capacity is optimal, if the demand and the supply are in equilibrium. What is important is the service provider's ability to maintain cost-effectiveness (internal efficiency) and the coordination of sources with customer expectations regarding the quality (external efficiency) together with the utilisation of an enterprise's capacity (capacity efficiency) (Balci et al. 2011).

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This way the traditional model of service productivity was enhanced by the customer (Vuorinen; Järvinen; Lehtinen, 1998). If the quality and customer satisfaction are included into the concept of productivity, service enterprises can anticipate a higher customer loyalty, higher profit and a higher customer participation (Grönroos, Ojasalo, 2004). However, if we take into consideration the customer participation in the process of service production, their role does not lie only in the quality assessment, since in some services the customers are directly involved in the process of service production, and thus their role is equally important as as that of the service provider (Grönroos; Ojasalo, 2004).

"In view of properties of services and the process of service production, the managing of external efficiency of the performance (identification of the quality of services), has to be an inseparable part of the concept of productivity of services" (Grönroos and Ojasalo, 2004). A purely quantitative approach fails to capture all the specific characteristics of service production and does not express the effectiveness of a service. It means that it is necessary to focus on the quality of outputs. Productivity is evaluated only or mainly from the aspect of a service provider. However, the main role is played by the customer satisfaction. The better is the assessment of the service quality (How is it viewed by the customer? – Is the customer satisfied or not?), for the production of which a certain amount of inputs was expended, the better is the external efficiency, which results in the improvement of production of services (Grönroos and Ojasalo, 2004).

As far as the relationship between the productivity of services and the quality of services is concerned, some researches claim that productivity and quality are inseparable parts of the whole (Grönroosand Ojasalo, 2004, Gummesson, 1998), while others argument that productivity is independent of quality and may be perceived *per se* as an expression of the qualitative benefit, which is distinct from the quantitative result (Lasshof, 2006, Nachum, 1999). However, all scholars agree that it is the customer who determines the quality of service (Lasshof, 2006; Grönroos and Ojasalo, 2004).

According to Lasshof (2006), productivity is influenced to a crucial extent by the customer, who assesses the quality of service (one aspect of quality). This parameter measures and evaluates production effectiveness. Since the customer is a crucial factor of the service provider's success, it is necessary to exert parallel pressure on the production effectiveness and customer satisfaction, (Lasshof, 2006). The increase in both magnitudes at the same time, leads to general advantage. Lasshof (2006) also suggests that the reflections on productivity also ensue that the effectiveness of production and productivity expressed in quantitative terms may be evaluated separately from one another (Lasshof, 2006).

There are therefore two different views of the productivity of services. In one approach the productivity of services is viewed as part of effectiveness, even though it emphasises the importance of customer satisfaction.

As a result of this, productivity is expressed in terms of the quantitative performance indicator and is separated from the component of qualitative result. On the other hand, the other approach views productivity and the complex integrating efficiency and performance. In accordance with this view, productivity cannot be separated from quality.

It is also assumed that there remains a large number of various factors in existence, which influence the productivity of services. However, only few of these factors for determining productivity have been examined in greater detail to date. For these reasons, we apply the quantitative approach to defining the productivity expressed as the share of turnover per an employee.

Factors of enforcing innovations in services

An intangible nature of services, requiring the customer's participation and a variable, inevitably leads to a continuous and consequential innovation focused on the customer satisfaction. Success of the innovation introduced in services depends from a clear understanding of customer needs (Chesbrough, and Spohrer, 2006). Enterprises that are able to identify customer needs and harmonise them with key competences are more profitable and innovative than those that cannot do that (Fuller and Matzler, 2007). Service innovation is a process that is highly demanding for each employee of a service enterprise.

Likewise technologies and of them especially information technologies play an important role in the service production. A fast boom of the Internet and a mobile links made marketing specialists focus on the speed, planning and electronic access, and in this way accelerate the process of producing or selling services. The customer wishes to obtain the service at any time, that is why the pressure exerted on the production of ICT (information and communication technologies) as the source of technology innovations in services is increasing. Online marketing, technologies for increasing the effectiveness enterprise activities, planning enterprise resources, managing relations with customers and with suppliers and others enable or facilitate service enterprises to innovate their processes, products, change corporate culture and enterprise's organisational structure. These technology innovations introduced largely in the past decade have significantly transformed the service sector.

In several studies there was explored a strategic role of information technologies (IT) in innovations (including innovation of services); these studies confirm that IT have considerably facilitated the innovation of services in numerous service industries (e.g. in health service, financial services, technical services, in management consultancy) (Kuo and Chao, 2014). Froehle and Roth (2004) list five ways of explaining the diversity of technology – mediated contacts with customers or the relationship with the customer in relation to technology. They include the entire spectrum of relationships between the provider and the client: ranging from the technology supporting the direct contact with the customer up to self-service technology.

Services are in general easy to imitate; protection against imitation has been little efficient to date. For this reason, for a service enterprise, a suitable way of acquiring a competitive advantage and asserting itself on the market is to introduce innovation in the process of service production, which differentiates it from its competitors and enables it to win the customer loyalty. That is why it is important to continuously innovate, so that the competitive advantage in a service enterprise might be not only achieved but also maintained. This concerns each party involved in the process of service production, customers, employees, and suppliers. Each of them plays an important role in the innovation of services. (Xiao and Ruoya, 2007).

A crucial moment in the production of services is involving the client in the process of providing services and developing relationships with the customer. Likewise, marketing and service delivery at the right time is an important moment appreciated by the customer. Creating rapport with the customer via the Internet and mobile networks is a fast growing trend, IT advancements enable the implementation of new technology innovations in services and support generating new ideas.

It is then no longer so decisive which type of innovation the service enterprise introduces. Raymond and St-Pierre (2010) confirm that even though the innovation of products and services is often examined separately as completely distinct, these two innovation types are mutually linked in the course of implementing the innovation process into the enterprise value chain (Fuller and Matzler, 2007).

Method

The paper deals with the relation between the innovation activity of service enterprises and the economic effectiveness expressed in terms of productivity of labour in services. It uses the method of correlation between the enterprise innovation activity and the productivity of services in the service sector. For this purpose, one research question and one hypothesis were formulated.

Research question: *Is the scope of enterprise innovation activities a determinant of the productivity of labour?*

Hypothesis: *Innovation expenditures in enterprises with technology innovation in selected service divisions in Slovakia influence the productivity of labour in these enterprises.*

The verification of these statements was conducted by means of the correlation analysis. Via this analysis, we assessed links between individual variables, which enabled to us to test the initial problems identified. We used Spearman's correlation coefficient, which expresses the rate of dependence of two variables X and Y. It can assume the values -1 (negative correlation), +1 (affirmative correlation) and 0 (there exists no relationship between the variables).

The formula for Spearman's correlation coefficient is:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1}$$

where:

$\boldsymbol{d_i}$ = difference between pairs of rank

$\sum \boldsymbol{d}_i^2$ sum of differences brought to a square

$\boldsymbol{n}$= scope of set

The subject of exploration was the service sector in the SR. In the first part of results, we compared values of the productivity of labour achieved in services in the SR and average values achieved in EU countries in the year 2012. The given result is the starting-point for exploring the relation between innovation and productivity. In this comparison the productivity of labour is expressed in terms of gross added value per an employee. The given parameter is compiled from the most recent data of the Eurostat database (2016).

In the second, results part of the paper we used the publication of Slovak Statistics on the innovation activity of enterprises in the Slovak Republic (the Slovak Statistics, 2014) as a source. The document focuses on the research in industry and in selected divisions of services. The research was conducted in the year 2013 and concerned the referential period of 2010 – 2012; simultaneously, it is the most recent information base of relevant measurement. The effects of innovations expenditures on the productivity of labour was studied in the settings of exclusively technology innovators, namely for reasons of relevant data accessibility. As many as 4,122 reporting units were involved in investigation. The statistical unit was an enterprise. The data processed are provided in answers gained from 2,897 respondents. For the needs of our investigation, we used data for the following decisions of the service sector classified after SK NACE:

· 46 Wholesale trade except the repair of motor vehicles
· 49 – 53 Transport and storage
· 58 – 63 Information and communication
· 64 – 66 Financial and insurance services
· 71 Architectural and engineering activities, technical testing and analyses
· 72 Scientific research and development
· 73 Advertising and market research

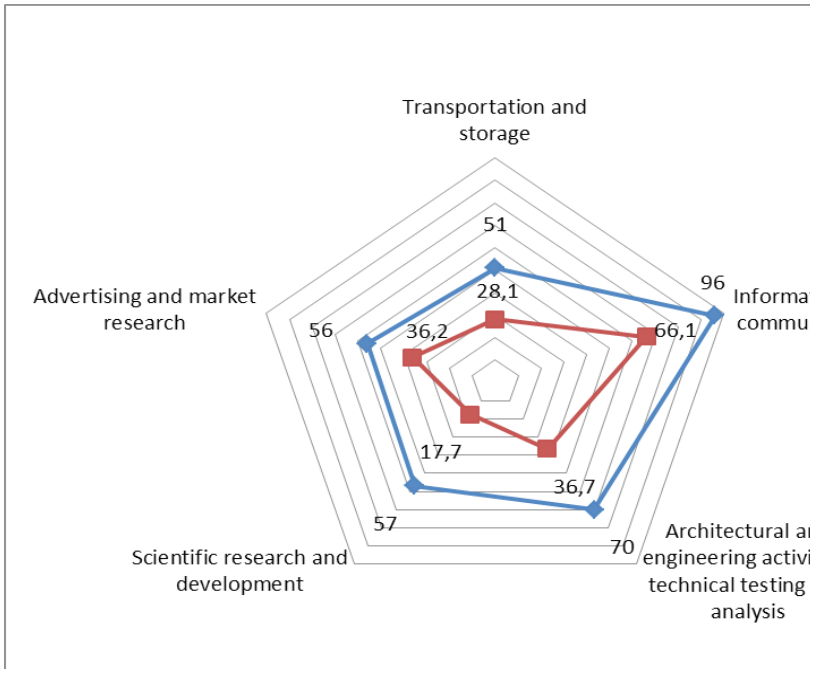
The research classifies enterprises in terms of scope and character of innovation activity. It defines enterprises with innovation activity as well as those without the innovation activity and the enterprises with completed technology innovation and non-technology innovation. Productivity of labour is expressed in the volume of sales on one employee.

The aim of the article is to identify the relation between the innovation activity of enterprises and the productivity of labour in services in the Slovak economy.

Results and discussion

We consider the comparison of values of productivity achieved in selected services in Slovakia's economy and average values achieved in EU-28 to be a starting argument in favour of next exploration into the causes of this condition. Graph 1 documents below the average selected parameter values in all the selected services in the SR, in comparison with the EU average. The most distinct difference may be observed in the field of Scientific research and development, further in the field of Architectural and engineering activities. Despite the fact that the highest value of the productivity of labour achieved in the SR is recorded in the Information and communication field, its difference from the average value for the EU is considerable.

Figure 1. Gross value added per employee in services, comparison of the EU and the SR, 2012, in € thousand



Own processing, data from Annual enterprise statistics for special aggregates of activities (NACE Rev. 2) . Eurostat (2016)

Verification of the research question: *Is the scope of innovation activities of enterprises a determining factor of the productivity of labour in the service sector ?*

Table 1. Productivity of labour in individual divisions of Slovakia´s services for the year 2012

Enterprises involved in innovation activities			
	Turnover (in thousand €)	**Employees**	**Productivity of labour (thousand € /employee)**
46 Wholesale trade except repair of motor vehicles	8 909 201	26 061	341, 86
49 – 53 Transport and storage	3 064 358	58 873	52,05
58 – 63 Information and communication	2 514 345	18 812	133,66
64 – 66 Financial and insurance activities	5 382 680	26 504	203,09
71 Architectural and engineering activities, technical testing and analyses	206 805	2 687	76,97
72 Scientific research and development	35 081	614	57,14
73 Advertising and market research	295 636	2 058	143,65
Services total 46 – 73	20 408 106	135 609	150,49
Enterprises without innovation activities			
	Turnover (in thousand €)	**Employees**	**Productivity of labour (thousand € /employee)**
46 Wholesale trade except repair of motor vehicles	12 254 930	35 797	342,35
49 – 53 Transport and storage	3 142 732	34 549	90,96
58 – 63 Information and communication	2 155 924	13 507	159,62
64 – 66 Financial and insurance activities	1 848 327	3 862	478,60

71 Architectural and engineering activities, technical testing and analyses	435 620	5 769	75,51
72 Scientific research and development	2 673	129	20,72
73 Advertising and market research	255 078	1 941	131,42
Total services 46 – 73	20 095 284	95 554	210,30
All enterprises			
	Turnover (in thousand €)	**Employees**	**Productivity of labour (thousand € /employee)**
46 Wholesale trade except repair of motor vehicles	21 164 131	61 857	342,15
49 – 53 Transport and storage	6 207 090	93 422	66,44
58 – 63 Information and communication	4 670 270	32 319	144,50
64 – 66 Financial and insurance activities	7 231 007	30 365	238,14
71 Architectural and engineering activities, technical testing and analyses	642 425	8 456	75,97
72 Scientific research and development	37 753	743	50,81
73 Advertising and market research	550 714	3 998	137,75
Total services 46 – 73	40 503 390	231 160	175,22

Own processing. Data from the Slovak Statistics. Inovačná aktivita podnikov v Slovenskej republike 2010 – 2012 (2014)

Spearman's test for correlation

	Enterprises involved in innovation activities	**Enterprises not involved in innovation activities**
Scope of set	n = 7	n = 7
Sum of differences brought to a square	$d_i^2 = 4$	$d_i^2 = 4$
Level of significance	$\alpha = 0,01$	$\alpha = 0,01$
Spearman's correlation coefficient: $r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$	$r_s = 1 - \frac{6\ (4)}{7\ (48)} = 0,929$	$r_s = 1 - \frac{6\ (4)}{7\ (48)} = 0,929$

Acquired affirmative values point to the existence of a positive dependence between the total productivity achieved in the service industry and the productivity of labour achieved in innovative or non-innovative enterprises. To investigate statistical significance, we used the level of significance $\alpha = 0,01$. Since the scope of set of investigated magnitudes was smaller than 30, we used testing statistics. For the level of significance $\alpha = 0,01$ and n = 7, we acquire the critical value of $r_0 r_0 = 0,8929$. Since $r_s r_s > r_0 r_0$, we refuse the zero hypothesis. However, based on the correlation analysis results, it cannot be claimed that in the year 2012 the productivity of labour in selected service divisions influenced the innovative enterprises to a greater extent than the enterprises without innovation activity, since the values are the same.

When comparing the enterprises with innovation activities and those without innovation activity, we find that a higher

productivity of labour is generated in enterprises without innovation activity. However, in certain service divisions the productivity of labour is higher in enterprises with innovation activity. These are mainly knowledge-intensive services. The scope of innovation activity is therefore a determinant of the productivity of labour only under specific production conditions. This holds for the following service subsectors: architectural and engineering activities, technical testing and analyses; scientific research and development; advertising and market research. A knowledge-intensive nature of production in these service divisions influences the productivity of labour by means of applied innovations. Innovations are in this way a determinant of the productivity of labour mainly in the knowledge-intensive services.

Reflections on the influence of innovations on the productivity of labour in services, however, run against the fact of heterogeneity of services. This is characteristic of differences in processes of service production in terms of a differing share of live and materialised labour. A high share of human work performance determines the effects from innovation implementation, in particular in product and organisational innovations. In fact, product creation and organisation are the areas the most influenced by human performance.

Verification of hypothesis No. 1: *Expenditures on innovations in enterprises with technology innovation in selected service divisions in Slovakia influence the productivity of labour in these enterprises.*

Table 2 Expenditures on innovations in enterprises with technology innovation in the year 2012 in selected service divisions in the SR (in thousand EUR)

	Expenditures on internal research and development	Expenditures on external research and development	Expenditures on the provision of machinery, equipment, software and buildings	Expenditures on the provision of external knowledge	Expenditures on other innovation activities	Total expenditures on innovations
Services 46 – 73	55 873	18 290	162 749	1 666	7 905	246 482
46 Wholesale trade except repairs of motor vehicles	3 249	1 174	20 166	17	2 821	27 425
49 – 53 Transport and storage	3 325	1 025	99 391	121	235	104 097
58 – 63 Information and communication	33 637	6 125	21 480	745	1 480	63 467
64 – 66 Financial and insurance activities	9 923	9 734	18 179	472	2 440	40 747
71 Architectural and and engineering activities; technical testing and analyses	3 309	100	898	145	169	4 621
72 Scientific research and development	2 247	79	1 696	132	6	4 160
73 Advertising and market research	184	53	940	35	754	1 966

Own processing. Data from the Slovak Statistics. Inovačná aktivita podnikov v Slovenskej republike 2010 – 2012 (2014)

The highest expenditures on innovations in the Slovak Republic were spent in the year 2012 by large enterprises. In selected services their share of the total expenditures accounted for 64.5 %. The highest expenditures on innovations in selected services were into the following areas:

· Provision of machinery, equipment, software, and buildings (66.03 %);
· Internal research and development (22.67%);
· External research and development (7.42 %);
· Expenditures on all other innovation activities (3.21%);
· Provision of other external knowledge (0.67 %) (the Slovak Statistics, 2014).

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Table 3. Database for the calculation of the relation between innovation expenditures per employee in enterprises with technology innovation and the productivity of labour in these enterprises, selected service divisions, SR, 2012

	Rank by productivity of labour in enterprises with technology innovation	**Rank by the volume of expenditure on employee in enterprises with technology innovation**	**Difference d_i**	**d_i^2**
46 Wholesale trade except motor vehicle repair	6	1	-5	25
49 – 53 Transport and storage	1	7	6	36
58 – 63 Information and communication	3	6	3	9
64 – 66 Financial and insurance services	5	5	0	0
71 Architectural and engineering activities, technical testing and analyses	2	4	2	4
72 Scientific research and development	4	3	-1	1
73 Advertising and market research	7	2	-5	25
				100

Own processing. Data from the Slovak Statistics. Inovačná aktivita podnikov v Slovenskej republike 2010 – 2012 (2014)

Scope of set $n = 7$

Sum of differences brought to a square $d_i^2 = 100$

Level of significance $\alpha = 0{,}01$

Spearman's test for correlation

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} = 1 - \frac{6\,(100)}{7\,(48)} = -0{,}78$$

This correlation analysis does not validate the dependence between the volume of expenditures on innovations per one employee and the productivity of labour in enterprises with the introduced technology innovation. The volume of expenditures on innovations is not in the direct positive relationship to the volume of the total of generated sales per an employee.

These findings, however, accept the time factor only partially. Time plays a key role in the rise of effects from implemented service innovations. Apart from the logical time interval between implementation and efficiency of innovations, there exists in services a phenomenon of consumption based on trust. This way the consumption reacts to innovation with the time-lag, which affects delayed economic effects expressed in terms of turnover.

Conclusion

Innovations are under conditions of competition a key instrument of sustainable development of the firm and the entire national economy. According to the theory, a leading role is ascribed to innovations in the processes of achieving competitiveness and economic performance of the firm. They are means of differentiating from the competition, cost cutting instruments, and those of satisfying customers. However, are they going to create space for increasing productivity under conditions of service production? The sector of market services has an important position in Slovakia's economy. Within comparison values with EU countries, however, Slovakia is lagging behind the average values in the areas of performances as well as innovation activity. The correlation analysis described in the paper demonstrates a positive relation between the productivity of labour in individual service subsectors and the total productivity of labour achieved in Slovakia's economy. However, there is no difference between the influence of productivity of labour in innovative service enterprises and in non-innovative service enterprises to a parameter of the total productivity of labour. Knowledge-intensive services, however, achieve a higher productivity of labour, as long as innovate. Thereby, innovations are determinants of the productivity of labour in knowledge-intensive services; however, they are not decisive parameters for achieving the productivity of labour in the service sector in total.

Another relation explored was the relation of volume of expenditure on innovations on the productivity of labour in service sectors with introduced technology innovation. The correlation analysis applied did not corroborate the dependence between the volume of expenditures on innovations and productivity of labour in enterprises with introduced technology innovation. The volume of expenditure on innovations is not in direct positive relation to the volume of generated total sales per an employee.

For a deeper understanding of the phenomena explored, in the next research it will be relevant to incorporate the time factor in the study by means of correlation and regression analyses. Time plays a crucial role in efficiency indicators of implementing innovations in the service sector.

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SMEs' Innovation and Export Capabilities: Identification and Characterization of a Common Space Using Data Spatialization

*Manon Enjolras *[1], Mauricio Camargo [1], Christophe Schmitt [2]*

Abstract: Numerous publications try to identify and test empirically the link between innovation and export to explain firms' competitiveness. But it seems that several ways of thinking coexist, without a real consensus. This article proposes a different approach, by considering innovation and export not in terms of impact of the one on the other, but rather as two complementary activities mobilizing common capabilities (resources, skills, knowledge). These common capabilities represent the capabilities that a company needs to mobilize as a priority to improve its performance regarding innovation as well as export. This article aims to identify the common spaces between innovation and export in terms of current practices within SMEs. Initially, the innovation and export practices were identified in the literature and through a set of interviews with business managers. Then an analysis of similarity put forward the common practices between the innovation and export processes. A data spatialization shows that the common practices concern at least: (1) network management, (2) consideration of the customer, (3) the acquisition of information, (4) skills management, (5) the capitalization of knowledge, (6) the global strategy, (7) the follow-up of the projects, (8) the intellectual property, and finally (9) the corporate culture.

Keywords: Export; Innovation; SME; capabilities; common space; data spatialization

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Introduction

Globalization changed the rules of the game regarding competitiveness for small-sized companies. Export was identified as one of the main drivers of economic growth (Pla-Barber and Alegre, 2007). According to a study by BPI France (French bank of public investment), innovative SMEs are the most present on foreign markets (PME 2011 - Rapport sur l'évolution des PME, 2011). This observation puts forward the existence of a close relationship between innovation and export. Indeed, the study of the link between innovation and export in the context of SMEs represents a very important research area in the current scientific literature (Love and Roper, 2015). More precisely, numerous research works are interested in the direction of causality concerning the impact of the one on the other. This paradigm is supported by two theories: self-selection (Boso et al., 2013; Monreal-Pérez et al., 2012; Raymond and St-Pierre, 2013) and learning-by-exporting (Golovko and Valentini, 2014; Kafouros et al., 2008). These theories demonstrate respectively that innovation has a positive impact on export and vice versa. The theory mainly accepted seems to be self-selection, according to which the innovation can be considered as a necessary but not sufficient condition for export. However, this approach is debatable, mainly because there is no real consensus on the direction of this causality. Indeed, although the theory of self-selection seems to predominate, it coexists with the learning-by-exporting theory and findings are inconsistent from one study to another. On the other hand, certain studies put forward a bidirectional relation through which there seems to be a mutual strengthening of export and innovation, but this strengthening takes a different form according to the direction of the causality considered. The impact of innovation on export is not an exact mirror of the impact of export on innovation (Filipescu et al., 2013). So, the link between innovation and export does not seem to limit itself to a simple cause-and-effect relationship. This study suggests envisaging the relation between innovation and export through an original point of view. Instead of considering innovation as a requirement or a necessary condition for export, this study suggests considering innovation and export as two complementary activities integrating a common space. This common space can be considered as an interface between these two activities, representing the capabilities that an SME has to mobilize primarily in order to create value simultaneously in terms of innovation and export. The development of these capabilities allows the mobilization of joint resources, joint skills and joint knowledge and thus makes it possible to minimize the necessary effort for the improvement of SMEs' performance by acting on two levers at the same time. This makes sense in the context of SMEs, for which the resources are limited.

The objective of this study is therefore to identify the joint capabilities composing this innovation/export common space. The presence or absence of these capabilities within SMEs directly reflects their global capability to innovate and to export. To begin, the appropriate capabilities were identified in the literature, in terms of innovation and export respectively. They were then validated through a series of interviews with business managers and experts in the domain. Then, a similarity analysis highlighted the joint capabilities between innovation and export. However, the results of the similarity analysis were difficult to exploit because they represented a large amount of data. In order to avoid this difficulty, a data spatialization was then realized so as to represent visually the existing similarities between the joint capabilities which were identified. This analysis has led to the characterization of a common space between innovation and export, composed of several dimensions including capabilities associated with both activities.

(1) Université de Lorraine, ERPI (Equipe de Recherche sur les Processus Innovatifs), France.
(2) Université de Lorraine, CEREFIGE (Centre Européen de Recherche en Economie Financière et Gestion d'Entreprise), France.
*Corresponding author: manon.enjolras@univ-lorraine.fr

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Literature review

This literature review concerns two main dimensions: first, an overview of the studies concerning the link between innovation and export, and the theories on which they rely; second, an analysis of the literature of data visualization. Thus, in a first section, the correlation between innovation and export will be approached with the aim of validating the chosen scientific positioning. Then, the characteristics and the contributions of data visualization will be put forward in order to validate this methodological choice.

The correlation between innovation and export: a causal relationship?

Numerous publications concern the study of the correlation between innovation and export. This literature review was conducted on more than a hundred scientific publications, mainly stemming from the management sciences.

Few documents concern SMEs in particular but some make comparisons between SMEs and large companies. Certain authors validate the self-selection theory, according to which innovation has a positive impact on the international performances of companies. Others support the learning-by-exporting theory, which considers that the knowledge and the acquired experiences on the international markets improve the innovation capability of companies. And finally, certain studies consider that innovation and export have a mutual positive impact, in the form of virtuous circle. The empirical validation of these theories is mainly made by the analysis of data of existing inquiries (Spanish Business Strategy Survey SBSS; Product Development Survey, PDS) (Love and Roper, 2001)).

Self-selection: the dominant theory

In a general way, most of the reviewed publications concern the self-selection theory. Innovation confers a competitive advantage on the company, which allows it to acquire a more important general performance and to improve its resources. It allows the company to be more competitive on foreign markets and facilitates its internationalization. Innovation is thus a necessary condition for export (Fig. 1).

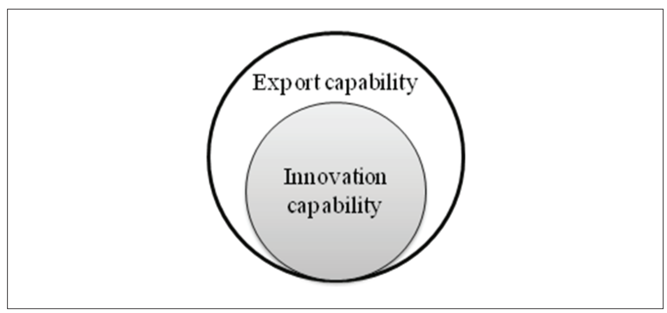
Pla Barber and Alègre (2007) validate this theory, through a study of 120 French companies of any size, stemming from the biotechnological sector. In the same way, Roper and Love (2002) also studied the impact of innovation on the international performance of German and English companies. The main finding is that the nature of the impact of innovation on export depends on the context of the company (country of origin, size, and business sector). These findings are confirmed by Altomonte et al. (2013). It is, however, important to underline that in its two studies, innovation is only considered from the perspective of product innovation.

Van Beveren and Vandenbussche (2010) highlight the importance of the correlation between product innovation and process innovation. The launching of a new product or process in an isolated way does not considerably encourage exportation, but the introduction of both simultaneously has a stronger positive impact (Becker and Egger, 2013). This way, companies prepare their arrival on foreign markets by reducing costs (process innovation) and by increasing the quality of the products (product innovation).

Concerning the innovation type (product or process innovation[1]), the results of Caldera (2010) show that, in general, innovation fosters export in companies but that process innovations have a less important impact than product innovations. This result is explained by the fact that product innovation allows strong differentiation from competitors on foreign markets as well as higher quality of products, which provides a bigger competitive advantage compared to process innovation, the objective of which is rather to reduce costs.

Concerning SMEs in particular, the innovation / export link is also validated by diverse articles (Cassiman et al., 2010; Cassiman and Golovko, 2011; Higón and Driffield, 2011) within the framework of product innovation. Le Roy and Torres (2001) propose an additional element, by proving that the positive impact of product innovation on the international activities of SMEs does not depend on the geographical area of the target market.

Figure 1. Graphical representation of the self-selection theory



The self-selection theory thus seems mainly accepted in the literature. However, certain studies tend to qualify this paradigm.

Bellone and Guillou (2013) analyze the innovation / productivity / export link. The main result is that innovation is not the only cause of productivity gain and export. Other factors are to be taken into account. On the other hand, Deng et al.(2014) consider that the link between innovation and export can be negative and that it is necessary to take into account the heterogeneity between companies. They demonstrate that, for the Chinese industrial companies, the innovation has a positive impact on the intensity of export, but its impact is not necessarily positive for the survival on foreign markets. Finally, Oura et al. (2015)international experience and export

(1) Process innovation means the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software). By extension, process innovation also concerns new improvements regarding how products are delivered to customers.

performance of SMEs in Brazil»,»container-title»:»International Business Review»,»source»:»ScienceDirect»,»abstract»:»Innovation capacity and international experience are factors often related to the internationalisation process of firms, with export activities as the first stage of the process. However, firms from emerging countries seem to show advantages and follow patterns of international expansion that may differ from firms based in developed countries, where the internationalisation models were created. Specifically, exporting firms from emerging countries tend to have limited resources, especially small firms (e.g., for investing in R&D also test the impact of innovation capability on the export performance of Brazilian SMEs. However, they advance that innovation capability is mainly considered as an essential factor to improve the performance of companies on foreign markets, but little attention is paid to international experience as a factor equally as important as innovation capability. They prove that international experience has a greater impact on export performance than innovation capability. Thus, the self-selection theory is counterbalanced by another theory, “learning-by-exporting.”

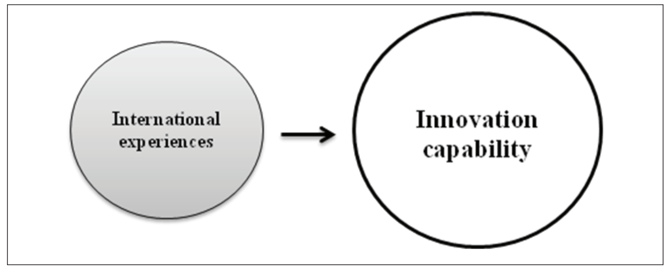
The learning-by-exporting theory: exploitation of the experience acquired on foreign markets.

The “learning-by-exporting” theory relies on the hypothesis according to which export allows the improvement of innovation within a company. The discovery of a foreign market allows the company to acquire a large amount of information and knowledge. The acquired knowledge urges the company to adapt itself and thus to innovate to be successful on this new market (Fig. 2). Lileeva and Trefler (2010) adopt this point of view. Their findings indicate that within Canadian industrial firms, the access to foreign markets favors innovation and in particular product innovation.

Kafouros et al. (2008) give the main implications of export concerning the innovation capability and the appropriability of innovation. The notion of threshold is approached: Exportation positively influences innovation (and more particularly the return on investment of innovation) only if the international activities of the company reach a certain threshold (degree of internationalization: DOI (Kotabe et al., 2002)).

Finally, Golovko and Valentini (2014) make a comparison between SMEs and large companies concerning learning-by-exporting. Large companies are more able to develop process innovations subsequent to their entrance on foreign markets (two years later approximately) while SMEs instead develop product innovations one year before their entrance on foreign markets, even more so during the year of their entrance and until two years later. In the same way, Salomon and Shaver (2005) are interested in the time after which export has a positive effect on patent application or on product innovation through the study of Spanish industrial companies. So, export has a positive effect on product innovation approximately two years after the beginning of the company’s international activities. A notion of time and of type of innovation thus appears and the results vary according to the size of the company.

Figure 2. Graphical representation of the learning-by-exporting theory



The self-selection theory is therefore questioned by learning-by-exporting. However, despite the fact that these two theories describe an opposite direction of impact, they are not incompatible. A bidirectional innovation / export relation even seems possible.

The virtuous circle theory: a bidirectional impact

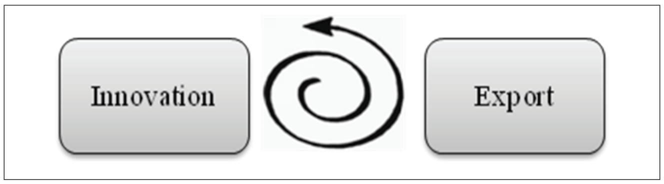
By going farther, Monreal-Perez et al. (2012) study the bidirectional link between innovation and export within Spanish industrial companies. They simultaneously test both hypotheses of self-selection and learning-by-exporting so as to verify whether the innovation / export correlation takes the form of a virtuous circle (Fig. 3). Their results show that the exporters develop more innovation activities and invest more in R&D. They develop and accumulate more product innovations. According to them, innovation has a positive impact on export. On the other hand, the learning-by-exporting hypothesis is not validated. An explanation: the geographical and cultural distance, which favors learning-by-exporting, does not intervene much in this study because Spain largely exports to EU countries that are culturally close.

In the same way, Damijan et al. (2010) propose an empirical test of the bidirectional innovation / export relation in Slovenia. The results confirm that export encourages process innovation but the other hypotheses are not significant enough to be verified. The results seem valid only for medium and large companies. The theory of the virtuous circle is thus not validated in the conditions of this study. However, Damijan and Kostevc (2010) propose another study in which they study the “learning-by-trade” theory within the Spanish companies (by including importation AND exportation, and not only exportation). This study led to the proposal of a sequence: import / innovation / export / innovation (1) or export / innovation / import / innovation (2). The sequence (1) was retained because the empirical results seem more significant. Import urges companies to innovate (product and process innovations but mainly product innovation) and to begin to export. Finally, export is introduced by innovation and ultimately urges companies to launch new products, but not necessarily new processes. This finding is also verified for small companies.

Finally, Filipescu et al. (2013) propose a study which concerns the reciprocity between export and innovation in the Spanish context. Export is measured according to two categories: the scope of the export activity and its intensity. Innovation is represented by product and process innovation and by the intensity of R&D. The main conclusion is that the impact of innovation on export is not an exact mirror of the impact of export on innovation. There is a mutual strengthening of export and innovation (Filatotchev and Piesse, 2009) but this strengthening takes a different form according to the direction considered. This study gives an interesting point of view concerning the impact of one activity on the other. It puts forward that the link between innovation and export does not seem to limit itself to a simple cause-and-effect relationship.

Regarding SME in particular, Halilem et al. (2014) propose a study of industrial Canadian SMEs and empirically validate the bidirectional link between innovation and internationalization. This study considers product and process innovation as well as import and export.

Figure 3. Graphical representation of the virtuous circle theory

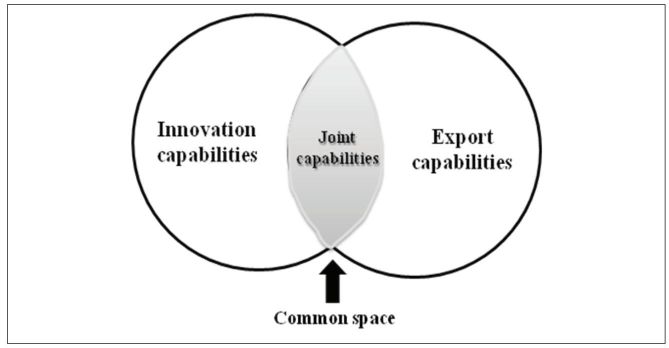


In the same context, Golovko and Valentini (2011) propose a study with a slightly different objective. Instead of studying the impact of one activity on the other, these authors try to show that innovation and export are complementary: if a commitment is made in one of the activities, it facilitates the commitment in the other one (by reducing costs or by increasing profits). The findings show that Spanish manufacturing SMEs that invest in innovation and in export at the same time have better growth than those who invest either in innovation or in export or in neither. Moreover, the return on investment of an activity increases with the performance level of the other activity. This study is interested in the innovation / export link in terms of complementarity and not in terms of impact.

Scientific positioning: a relationship based on complementarity

In summary, there is no real consensus concerning the link between innovation and export. The majority of the studies consider this link in terms of the impact of innovation on export (self-selection). However, the direction of the impact also takes other forms: the learning-by-exporting theory or the virtuous circle (bidirectional relation). In a general way, and whatever the direction, this impact seems more or less strong according to the business sector, the size, the country of origin … For SMEs it would seem that product innovations are very widely prevalent. They appear before their entrance on the market (self-selection) but also later and in a more important way (learning-by-exporting). Thus, the notion of temporality also seems essential. So, when we consider the innovation/export link in terms of impact, it is difficult to reach a consensus. This literature review proves that, in the context of SMEs, innovation cannot be considered as a simple necessary condition for export. In the same way, export cannot limit itself to a prerequisite for innovation.

Figure 4. Scientific positioning of this study



This study thus aims to consider innovation and export as two complementary activities. The coupling of both creates a common intersection (Fig. 4). This intersection includes joint capabilities (activities, resources, skills) common to innovation and to export. An SME has to mobilize these joint capabilities primarily in order to decrease the necessary energy to progress simultaneously in terms of innovation and export. This intersection represents a space common to the innovation and export capabilities, which must be characterized.

Data spatialization

According to William S. Cleveland (1993), visualization is an essential aspect of data analysis. It reveals the complex structure of data which could be understood in no other way. It allows the discovery of unexpected results and makes it possible to question the expected conclusions.

So, visualization appears as one of the best ways to explore and to try to understand a large quantity of data. It is a visual summary of statistical data that easily provides a general trend. It is, however, necessary to keep in mind that a graphical representation remains, in essence, a simplification of the reality. The multiple parameters of a graphical representation are so many factors which can, deliberately or not, lead to a distortion of reality. It is therefore important to use appropriate tools and methods in order to obtain the representation closest to reality (Yau, 2012).

So, Rodrigues et al. (2006) propose a taxonomic model of the main components of data visualization methodologies. They consider that elements to be taken into account are: the shape, the color, and the position. In other words, it is necessary for data visualization methodologies to allow a visual stimulation (shape / color) and a spatialization of the data (position). However, the color and shape are elements which are sometimes difficult to make clearly interpretable. The positioning has a much more important impact (Skupin and Fabrikant, 2003). Interpreted in the broad sense, data spatialization implies transforming something which is not spatial into something which is spatial. The result is a geometrical representation in a small-dimension space, generally in two or three dimensions, which is intended to make it possible to detect trends and relations which are invisible in a large-dimension database.

The several spatialization methodologies can be described as follow (Rodrigues et al., 2006):

- **Patterned:** This is the simplest methodology of spatialization. It consists of associating certain aspects of the considered data with visual properties of geometrical forms (for example, bar charts, pie charts…).
- **Projection:** Projection corresponds to a display of the data through the representation of functional variables. In other words, the position of an element of data is defined by a known or implicit mathematical function. Principal Component Analysis (PCA) is an example of spatialization by projection.
- **Reproduction:** The positioning of data comes from an observed phenomenon. This type of spatialization aims to connect the considered data with the physical world. For example, a geographical spatialization through maps is an example of reproduction.
- **Structure exposition:** This type of spatialization concerns networks and data showing a hierarchical structure. Tools such as mind maps, trees, or force-directed layout can be used.

The types of data spatialization methods are numerous and they must be used according to the available data, the possible correlations existing between these data and the expected results. It is important to select the appropriate data spatialization methodology so as to be able to exploit the data in the most relevant way possible. For this study, the objective is to characterize a common space between innovation and export capabilities. This analysis aims to visualize similarities, so a structure exposition seems to be a suitable spatialization methodology.

Objective and methodology

Objective of the study

The objective of this study is to characterize the common space between the innovation and export capabilities of SMEs. SMEs generally have difficulty mobilizing the necessary resources for the development of innovations, as well as for their success on the international markets (Etemad, 2004). The highlighting of capabilities that are common to these two activities allows the identification of high-priority methods of improvement for companies, requiring reduced effort in terms of resources and time. For this study, capability is defined as the ability of an SME to lead a certain activity in touch with innovation and/or export.

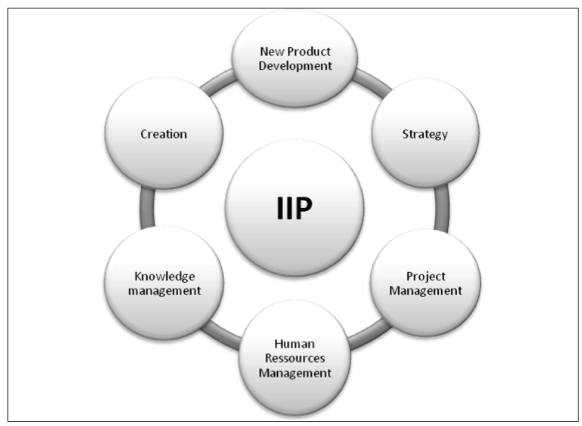
It is thus necessary to identify what the capabilities are within SMEs specific to innovation and to export respectively. Once these capabilities have been reviewed, it is necessary to compare them and to identify which one can be considered as common to both activities. These joint capabilities represent the common space between capabilities of innovation and capabilities of export, which will be visualized through a spatialization of the collected data.

Theoretical framework: The potential Innovation Index (PII)

In recent years, several studies were conducted in regard to the management processes of innovation in companies. Indeed, a large number of researchers tried to define indicators to estimate the innovation capabilities in companies (Adams et al., 2006). The measures of innovation capabilities have evolved by defining two major principles. Firstly, indicators have to measure the internal processes of companies related to innovation in order to understand how companies use the mobilized resources to improve their results. It is necessary to be interested in the practices of companies. Secondly, innovation depends on multiple dimensions. Indicators must therefore be structured on the basis of a multicriteria approach involving various sub-processes (Chiesa et al., 1996). In view of these two major principles, this study leans on the theoretical framework of the Potential Innovation Index (PII), developed by the Research Team on Innovative Processes (ERPI) in France. The PII appears as a relevant indicator for our study because it was tested and validated both theoretically (Boly, 2004; Boly et al., 2014; Rejeb et al., 2008) and empirically on French, Argentine and Chilean SMEs (Galvez et al., 2013; Sepulveda et al., 2010).

It relies on the six most important dimensions mentioned in the literature regarding innovation (Fig. 5): creativity, new product design, human resources management, strategy, project management and knowledge management (Corona, 2005).

Figure 5. The 6 dimensions of the Potential Innovation Index



Each of these dimensions includes several capabilities, which themselves include a number of observable phenomena (Fig. 6). An observable phenomenon may be defined as a routine activity within the company, requiring allocation of resources (time, money, and personnel) and producing a tangible and verifiable result. The observable phenomena thus play the role of indicators allowing the estimation of the considered capability. If these observable phenomena are present within the company, the capability which they characterize can be considered as good.

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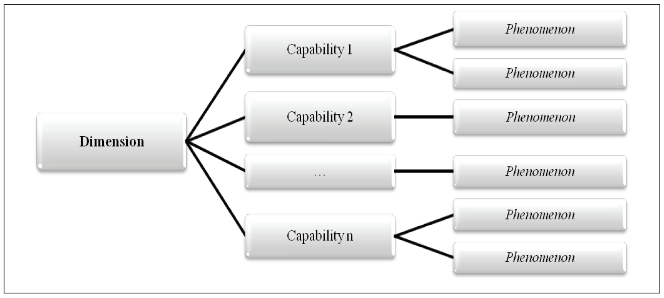
Figure 6. Structure of the Potential Innovation Index



Approach

As explained previously, this study relies on the PII methodology. This index provides a solid theoretical framework concerning the capabilities that are specific to innovation. Relying on this theoretical basis, this study took place in five phases:

- The first phase consisted of identifying dimensions and capabilities related to export within the scientific literature.
- The collected data were then structured according to the same model as the PII: dimensions / capabilities / observable phenomena (Fig. 5 and 6).
- Then, the identified data were validated within international SMEs and with experts of exportation (researchers, consultants, business advisors).
- Then, a similarity analysis was conducted at the level of the innovation and export capabilities so as to identify those who could be considered as common.
- Finally, a methodology of data spatialization was used so as to obtain an exploitable representation of the data with the aim of better visualizing the results obtained.

Results

Identification of the export best practices.

The first phase of this study consisted of reviewing dimensions and capabilities related to export within the scientific literature. This bibliographical research was conducted on about fifty scientific articles. After a descriptive analysis of these publications and the structuring of the collected data, eight dimensions concerning export were put forward and characterized in the form of capabilities and observable phenomena (Tab. 1).

Table 1. Theoretical dimensions and capabilities

Dimensions	Publications mentioning this dimension	Related capabilities
Information, knowledge management	33	Information and knowledge acquisition
		Capitalization and sharing
Internal skills management	9	Language skills
		Technical and business skills
		Administrative skills
Cultural and human aspects management	22	International culture of the company / manager profile
Mobilization of external skills	18	Communication / translation
		Research of support and funding
		Payments / international trade / insurance
		Legislation / Standards
		Transport and customs duties
		Partnerships
Strategy	19	Formalization of the international strategy
		Intellectual property
		Identification and mobilization of dedicated resources
Project management	5	Management of the project process
		Selection / prioritization of the projects
		Organization / allocation of responsibilities
Supply chain management	12	Supplier management
		Production management
		Transport
		Distribution strategy
Communication / marketing	7	Adaptation of the product
		Marketing mix
		Customer relationship

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Then, several interviews (Tab. 2) were conducted with managers of international SMEs, as well as with experts in the internationalization of SMEs (researchers, consultants, advisors…). These interviews made it possible to validate the theoretical data identified in the literature so as to obtain as realistic a model as possible. Eight theoretical dimensions were validated and these interviews in particular made it possible to complete and to specify capabilities and associated observable phenomena.

Table 2. Description of the interviews

Interview	Contact person
1	Exporting SME (medium-high technology[1])
2	Exporting SME (medium-high technology[1])
3	Exporting SME (low-medium technology[1])
4	Exporting SME (medium-high technology[1])
5	Exporting SME (medium-high technology[1])
6	Exporting SME (medium-high technology[1])
7	Exporting SME (low technology[1])
8	Exporting SME (medium-high technology[1])
9	Exporting SME (medium-high technology[1])
10	Business Advisor (private sector)
11	Business Advisor (public sector)
12	Researcher
13	Researcher
14	Researcher
15	Business Advisor (public sector)
16	Researcher
17	Business Advisor (public sector)
18	Business Advisor (public sector)
19	Business Advisor (private sector)

[1] *According to the classification by technological level, source: Hatzichronoglou (1997)*

Identification of the common space between innovation and export

The following phase of this study concerned the identification of the common space between innovation and export capabilities. The previous phases provide a frame of reference that includes dimensions, capabilities and specific observable phenomena associated with the activities of innovation and export respectively (Tab. 3). This frame of reference arises from the scientific literature, but it was also validated empirically for innovation as well as for export.

Table 3. Reference framework: dimensions / capabilities

INNOVATION		
Dimension	**Related capabilities**	**Code**
Creativity	Use of tools to assist creativity	I1
	Integration of customers and suppliers during the design process	I2
	Organization, gathering and management of the external information	I3
New product design	Use of design-support tools	I4
	Existence of design-support methodologies	I5
	Information and communication technologies	I6
Strategy	Integrated strategy to favor innovation	I7
	Network operation	I8
	Customer importance	I9
	Funding	I10
Human resources management	Management of the company's skills and know-how	I11
	Innovation stimulation	I12
Project management	Project management	I13
	Project portfolio management	I14
	Organization of the tasks related to innovation	I15
Knowledge management	Continuous improvement of the innovation process	I16
	Intellectual property management	I17
	Knowledge capitalization	I18

EXPORT		
Dimension	**Related capabilities**	**Code**
Information, knowledge management	Information and knowledge acquisition	E1
	Capitalization and sharing	E2
Internal skills management	Language skills	E3
	Technical and business skills	E4
	Administrative skills	E5
Cultural and human aspects management	International culture of the company	E6 (/E7)[1]
Mobilization of external skills	Communication / translation	E8
	Research of support and funding	E9
	Payments / insurance	E10
	Legislation / Standards	E11
	Transport and customs duties	E12
	Partnerships	E13
Strategy	Formalization of the international strategy	E14
	Intellectual property	E15
	Identification and mobilization of dedicated resources	E16
Project management	Management of the project process	E17
	Selection / prioritization of the projects	E18
	Organization / allocation of responsibilities	E19
Supply chain management	Supplier management	E20
	Production management	E21
	Transport	E22
	Distribution strategy	E23
Communication / Marketing	Adaptation of the product	E24
	Marketing mix	E25
	Customer relationship	E26

Sources: Galvez et al. (2013) and our study

(2) The bibliographic analysis, as well as the data collected during the interviews with experts in export highlighted the difficulty of identifying observable phenomena for capacity E6 (/E7). The initiation of an export process impacts the company in its entirety. When a company deals with foreign customers / partners, the cultural aspects must be managed on a day-to-day basis. The manager has to be a driver of this initiative but he also has to see to it that a real international culture is broadcast within the company. So this capability concerns several aspects: the culture of the company (E6) and the personality of the manager (E7). This last aspect contains a human dimension, and it is difficult to estimate the personality of a manager in the form of verifiable and quantifiable indicators. That is why E7 is not a part of the retained capabilities for this analysis, despite the fact that the manager profile remains an extremely important point to take into account, especially in the context of SMEs. However, the corporate culture (E6) is considered as a capability of export for this study.

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Similarity analysis

In order to identify a common space within this framework, a similarity analysis was conducted (Degenne and Vergès, 1973). The objective of this analysis was to identify similar capabilities by comparing pairwise the innovation capabilities and the export capabilities. For greater accuracy, the comparison was made at the level of observable phenomena (Fig. 7), so as to create a similarity matrix (Fig. 8).

Figure 7. Principle of the similarity analysis

Dimension	Capabilities	Phen.	DI 1							
			I1				I2			...
			PO1	PO2	...	POn	PO1	PO2	...	...
DE 1	E1	PO1								
		PO2		X					X	
		...				X				
		POp								
	E2	PO1	X		X					
		PO2						X		
		...				X				
	...	...		X						

X = Similar observable phenomena
DI1: Dimension 1 concerning innovation
DE1: Dimension 2 concerning export
POx: observable phenomenon n°x

The objective is to identify the number of common observable phenomena for each pair of capabilities. This number of common observable phenomena makes it possible to calculate a similarity degree. Equation 1 shows the definition of this similarity degree: I represents an innovation capability including n observable phenomena, and E represents an export capability including p observable phenomena. When I and E are compared, the number of common observable phenomena k between p and n makes it possible to calculate the similarity degree D between I and E.

$$D_{I,E} = \frac{k}{(p+n)} \qquad \text{(Equation 1)}$$

This analysis extends to the matrix represented by Figure 8.

For the continuation of the study, it was decided to consider only the similarities with a degree greater than 0.25, the lower similarities being less representative.

Figure 8. Similarity matrix

	DE1		DE2			DE3	DE4						DE5			DE6			DE7				DE8			
	E1	E2	E3	E4	E5	E6	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	E26	
I1	0,07	0,08																								
I2	0,07	0,08																	0,14			0,13	0,63			DI1
I3	0,56	0,19																								
I4																										
I5																										DI2
I6		0,10																								
I7		0,08											0,80		0,14		0,13					0,13		0,38		
I8	0,23						0,50			0,20	0,33	0,78							0,50		0,14	0,43				DI3
I9		0,17																					0,63		0,43	
I10								0,40							0,25											
I11		0,18	0,43	0,43	0,20							0,11			0,17			0,29								DI4
I12						0,78																				
I13		0,14											0,08		0,33	0,64										
I14													0,60		0,14		0,63									DI5
I15		0,25													0,14			0,75								
I16	0,07	0,77														0,30										
I17														0,40												DI6
I18	0,06	0,93											0,08			0,17										

Similarity degree
between 0 and 0,25
between 0,25 and 0,50
between 0,5 and 0,75
between 0,75 and 1

Data spatialization by using force-based algorithms

The similarity matrix (Fig. 8) gives an indication of the capacities which can be considered as similar, though its interpretation remains difficult. Indeed, this matrix puts forward pairs of capacities having a more or less strong degree of similarity and this degree of similarity is important to take into account for this study. However, this representation does not enable the identification of clusters taking into account existing links between the data and strength of these links. But this visualization is necessary for the definition of a common space between the SMEs' innovation and export capabilities. Therefore, the decision was made to realize a "structuring" data spatialization through the Gephi software, so as to highlight the links between the considered data.

Within the "structuring" data spatialization methodologies, numerous algorithms can be used. Some algorithms allow a geographical representation of the data, some aim at classifying data, and others have the objective to put forward divisions or complementarities. This is the case with the force-based algorithms. This study aims at identifying which activities are common to innovation and export, by studying the similarity between the observable phenomena of each of them. The use of a force-based algorithm seems completely suitable. The principle of these algorithms is the following: every datum is represented by a node (every capability of innovation and export is represented by a node). All the nodes repel each other, respecting the principle of magnets. The more the nodes are dispersed, the less they repel each other. The links can be considered as springs between two nodes (the stronger the weight of the link, the stiffer the spring). At every step of the algorithm, the sum of the forces is applied to every node. These nodes move until they reach a stable state. The force-based algorithms position nodes with regard to the others. Graphs still do not converge on the same final configuration. So it is not possible to read the position of a node as such, and it is necessary to compare its position with the others.

The Gephi software proposes several force-based algorithms, so it was necessary to choose the algorithm most suited to this study. Table 4 proposes a comparison of these various algorithms.

Table 4. Overview of the force-based algorithms available on Gephi software, inspired by Jacomy et al. (2014)

Fruchterman et Rheingold	Yifan Hu	OpenOrd	ForceAtlas / ForceAtlas 2
Algorithm highlighting the complementarities between data	Algorithm highlighting the complementarities between data, rather for processing large data sets	Open source algorithm, highlighting divisions between data.	Algorithm highlighting the complementarities between data

This overview puts forward some differences between the considered algorithms. Yifan Hu is rather intended to handle a significant number of data, which is not the case for this study. This algorithm was thus rejected. On the other hand, OpenOrd puts forward divisions between data. The objective of this study is to highlight similarities. This algorithm was also rejected.

To make a choice between the ForceAtlas and Fruchterman & Rheingold algorithms, it is necessary to go into detail. These two algorithms are based on an energy model integrating an attraction force and a repulsion force. They rely on a certain formula for the attraction force and a certain formula for the repulsion force respectively, depending on the distance d between two nodes. It is possible to define the energy model (a=attraction; r=repulsion) by considering the exponent allocated to the distance d in the attraction and repulsion forces formula (Noack, 2007). If ForceAltas2 (version updated by ForceAtlas) and Fruchterman & Rheingold are compared, their energy models are respectively (1; 1) and (2; 1). Indeed, the attraction and repulsion forces of the algorithm Fruchterman & Rheingold are defined according to Equation 2 (Fruchterman and Reingold, 1991). The attraction and repulsion forces of the ForceAltas2 algorithm are defined according to Equation 3 (Jacomy et al., 2014).

$$\begin{cases} Fa_{F\&R} = \frac{d^2}{k} \\ Fr_{F\&R} = \frac{-k^2}{d} \end{cases} \quad \text{(Equation 2)}$$

$$D_{I,E} = \frac{k}{(p+n)} \quad \text{(Equation 3)}$$

With C and k: constant and d: distance between two nodes

The calculation of a-r according to the energy model (a; r) associated with the algorithm in question makes it possible to obtain an additional indication for the choice of the most appropriate algorithm. According to Noak (2009), a weak a-r favors the visualization of clusters because it means that the attraction force depends less on the distance d between two nodes, while the repulsion force depends more on it. The calculation of a-r for the Fruchterman & Rheingold algorithm is equal to 3 (Equation 4) while that for ForceAtlas2 is equal to 2 (Equation 5).

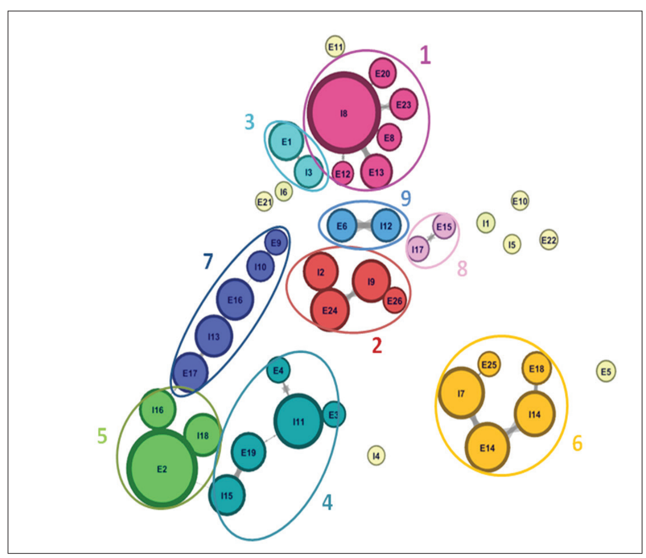
$$a_{FA2} - r_{FA2} = 1 - (-1) = 2 \quad \text{(Equation 4)}$$

$$a_{F\&R} - r_{F\&R} = 2 - (-1) = 3 \quad \text{(Equation 5)}$$

So, the ForceAtlas2 algorithm seems more suited to the visualization of clusters, which seems relevant to this study. This algorithm was therefore retained.

The result of the data spatialization is presented in Figure 9. The Gephi software identified nine groups separated by "modularity class." Modularity is often used in the optimization methods to detect the structure of communities within networks. Gephi uses Leuven's modularity calculation method (Blondel et al., 2008). This includes two phases. First of all, the "little" communities are identified by optimizing the modularity in a local way. Secondly, the nodes of the same community are grouped and a new network is built. Within this new network, nodes become communities. These stages are repeated in an iterative way until a maximum of modularity is reached. This process leads to the hierarchical decomposition of the network. The capacities of the same "modularity class" can be considered as a dimension common to both innovation and export activities.

Figure 9. Data Spatialization: clustering of similar capabilities



Discussion

The objective of this study is to identify the common spaces between the capabilities of innovation and the capabilities of export. The similarity analysis relying on the frame of reference describing separately the innovation and export capabilities highlighted the pairs of practices which can be considered as similar, and the intensity of this similarity.

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Then, a structural data spatialization was realized, through the use of a force-based algorithm. This data visualization methodology has in particular the advantage to show each datum only once, which facilitates the interpretation of the results. It also takes into account the strength of the similarity between the data. Through the use of the Gephi software and the ForceAtlas2 algorithm, the findings show clusters of capabilities which can be considered as similar (Tab. 5). These clusters of capabilities represent nine dimensions which are common to both innovation and export activities.

Table 5. Interpretation of the data spatialization results

Group	Included capabilities (innovation and export)	Description of the common dimension
1	E20 ; E23 ; E12 ; E13 ; E8 ; I8	**Mobilization of external skills**
2	I2 ; I9 ; E26 ; E24	**Consideration of the customer**
3	E1; I3	**Acquisition of information and knowledge**
4	E4 ; E3 ; E19 ; I11 ; I15	**Allocation of human resources and internal skills management**
5	E2 ; I16 ; I18	**Capitalization and sharing of knowledge**
6	I7 ; I14 ; E25 ; E18 ; E14	**Definition of a global strategy and prioritization of projects**
7	E17 ; I13 ; E16 ; I10 ; E9	**Allocation of financial resources and follow-up of the projects**
8	E6 ; I12	**Diffusion of the corporate culture**
9	I17 ; E15	**Management and exploitation of intellectual property**

The common dimensions identified concern the management of internal and external skills (Groups 1 and 4), the acquisition and the capitalization of information (Groups 2 and 5), the management of projects and resources (Group 7), and the strategy (Group 6). Two additional groups appear: the management of intellectual property and the diffusion of the corporate culture (human and cultural aspects). This analysis provides an important degree of precision concerning the characterization of the common space between capacities of innovation and export.

Conclusion

Through this study, the existence of a common space between the innovation and export capabilities was highlighted. First, a reference frame was created so as to represent separately the innovation and export capabilities of SMEs. Then, a similarity analysis between the innovation capabilities and the export capabilities was realized, with the aim of identifying and characterizing a common space. This common space is composed of capacities common to the activities of innovation and the activities of export. These capacities are grouped into nine common dimensions through the use of a data spatialization methodology: (1) network management, (2) consideration of the customer, (3) the acquisition of information, (4) skills management, (5) the capitalization of knowledge, (6) the global strategy, (7) the follow-up of the projects, (8) the intellectual property, and finally (9) the corporate culture.

Therefore, this research work confirms the scientific positioning according to which innovation and export must be considered as two complementary activities, integrating an interface representing the capabilities which an SME has to mobilize primarily to create simultaneously value in terms of innovation and export. The development of these capabilities allows the mobilization of common resources, common skills and common knowledge and makes it possible to minimize the effort associated with the creation of a virtuous circle of innovation / export, supported by a value-creating common interface. The contributions of this study concern first of all the scientific research, by proposing an original paradigm considering the innovation / export link not in terms of the direction of causality, but rather through an integrative and systemic point of view. The study of the intersection between the capabilities of export and innovation represents a contribution to the literature. On the other hand, this study represents a contribution for the support of SMEs, which generally have difficulty mobilizing the necessary resources for the development of innovations, as well as for their success on the international markets. These results allow the identification of high-priority ways of improvement requiring reduced effort in terms of resources and time. However, this research work shows several limits. Indeed, it was chosen for this study to focus on capabilities. But the common space between innovation and export probably does not limit itself to joint capabilities. The joint capacities identified by this study are defined by the abilities to conduct a certain activity common to innovation and export. However, these joint capabilities are dependent on available resources to carry out these activities. These resources to be mobilized can take various forms: knowledge, available skills, tools, etc. It would be interesting to identify these joint resources. One of these resources is the manager profile, which was already approached in this study. Indeed, the manager profile cannot be characterized in the form of observable phenomena. Thus, it cannot be considered as a capability in the sense of our study, but rather as a joint resource. The human aspects play an extremely important role in innovation activities (Rodriguez and Hechanova, 2014) as well as in export activities (Alaoui and Makrini, 2014). This is especially the case in the context of SMEs, because the manager is generally omnipresent and sometimes the only decision-maker (Child and Hsieh, 2014). The ninth dimension, corporate culture, relies on capabilities E6 and I12, and both of these mobilize the manager profile as a joint resource. One of the main perspectives of this work therefore consists of characterizing this joint resource, so as to identify what the ideal profile of an SME manager is through a common innovation / export point of view.

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Impact of Image and Satisfaction on Marketing Innovation

*Alexander Zuñiga-Collazos *[1], Marysol Castillo-Palacio [2]*

Abstract: Colombia is a country that has achieved significant tourism growth in recent years. However, both research and empirical evidence about its tourism development is very limited. Marketing innovation in tourism enterprises is one of the keys to this country maintaining positive tourism development. This empirical study analyzed marketing innovation in 364 of Colombia´s tourism companies. The findings show that "satisfaction" in terms of application of innovative marketing strategies that improve customer satisfaction and "image" in terms of application of innovative marketing strategies that help to improve image of company´s products and services have a significant relationship with marketing innovation of Colombia´s tourist enterprises.

Keywords: Marketing innovation; tourism innovation; image; customer satisfaction; Colombia

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Introduction

In the last two decades there has been growing interest in the topic of innovation in tourism, focusing on different types of innovation in products, processes, marketing, and organizational management. Researchers have also explored potential determinants of innovation in the tourism industry (Hjalager, 2010; Medina-Muñoz et al., 2013). In particular, marketing innovation on tourism industry is a topic of interest to scientific community (Lee et al., 2015; Alizadeh & Isa, 2015; Gössling & Lane, 2015; Zuñiga-Collazos et al., 2015; Carvalho & Sarkar, 2014).

In the case of Colombia, this country has experienced a significant growth on tourism industry over the past decade, According to Ministry of Commerce, Industry, and Tourism of this country the number of visitors has quadrupled in the recent decade (200-2010), with 557.280 visitors to 2.15 million respectively. However, despite the positive development of tourism, Colombian tourism enterprises are facing challenges of competitive tourism and his research and empirical evidence on innovation in tourism enterprises remains very limited (Zuñiga-Collazos, 2015). Consequently, there is a gap in order to understand growth in Colombia's tourism industry and the enterprises that provide the industry's foundation. The purpose of this study is to analyze the relationship between marketing innovation of Colombia´s tourist enterprises (MICTE) in a sample of small and medium tourism enterprises using conceptual variables: marketing innovation as the dependent variable and satisfaction and image as two factors that measure marketing innovation as independent variables.

Marketing Innovation.

According with Organization for Economic Co-operation and Development OECD & Eurostat (2005) there exist four types of innovation: (1) product innovations, referring to significant change in the characteristics of goods and services, meaning new products and improved existing products; (2) process innovations, referring to significant changes in the methods of product and distribution; (3) organizational innovations, referring to the implementation of new methods of organizations; and (4) marketing innovations, referring to all practices of developing new marketing processes, marketing, and selling products or services. Marketing innovation is "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. Marketing innovations are aimed at better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales" (OECD & Eurostat, 2005)

On other hand, organizational strategy and innovation interact for two reasons. The market-driving reason focuses on developing new market needs; in order to obtain a high satisfaction, customers have to be persuaded about new types of products and services. This is where marketing innovation leads to strategy (Menon et al., 1999; Verhoef & Leeflang, 2009). Besides marketing innovation activities can help firms to enter and satisfy new markets (OECD & Eurostat, 2005; Schubert, 2010; Varis & Littunen, 2010). The rationale here is that a firm that have innovation in marketing may better understanding of both customer needs to satisfy, and the ability to have a very good image of products and services offered.

In the literature exists empirical evidence about enterprises of both industrial and services sector as tourism that are based on understanding of innovation in marketing and its relationship with other variables such as performance or other (Huhtala et al., 2014; Ceylan, 2013; Arnett & Wittmann, 2014; Atalay et al., 2013). Nicolau and Santa-María (2013) suggest than the marketing innovation have a higher positive effect on performance hotel, which is explained by potential cost differences among innovations. Finally according by Hjalager (2010), marketing innovation is so important that it has led tourism literature to consider as a separate category to study.

(1) Faculty of Economics Sciences, University of San Buenaventura, Cali, Colombia.
(2) University of Las Palmas de Gran Canaria (ULPGC), Spain.
*Corresponding author: azuniga01@usbcali.edu.co

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Satisfaction and Marketing Innovation.

Kotler (2000) considered customer satisfaction as a mental state which results from customer's comparison of expectations prior to a purchase with performance perceptions after a purchase. In addition, customer satisfaction is the customer's assessment of a service in terms of whether that service has met the customer's needs and expectations (Zeithaml et al., 2006). Therefore, it can consider consumer satisfaction as response based on evaluations and expressed some time during the purchase-consumption process (Lee et al., 2015), where is possible that a good marketing innovation can influence positively. In this sense, Lee et al., (2015) investigated the effects of attitude toward using mobile app services on customer satisfaction. These authors were based on a questionnaire survey of 538 respondents in Taiwan and the path analysis result demonstrated that usage attitude of this marketing innovation is the most significant factor for customer satisfaction.

On the other hand, according by the Innovation Diffusion Theory (IDT), proposed by Rogers (1983). IDT includes five significant innovation characteristics: relative advantage, compatibility, complexity, trialability, and observables. More specifically, compatibility measures a technology's consistency with users' values, past experience, and needs (Rogers, 1995). Agarwal and Prasad (1999) describe a positive relationship between an individual's prior compatible experiences and acceptance of new innovation, and satisfaction. In this sense, Lee et al., (2015) describe as use apps as a marketing innovation improve customer satisfaction.

Finally, from a strategic marketing perspective, innovation and competitive advantage are closely related concepts (Porter, 1991); and all kinds of marketing innovation, if effectively managed, can contribute toward generating advantage (Naidoo, 2010; Desouza et al., 2009).

Image and innovation Marketing

Overall image of an enterprise might have an impact on consumer buying behaviors (Homburg & Giering, 2001; Han & Back, 2008; Hillery et al., 2001). Some authors use the concepts of reputation and image interchangeably (Barnett et al., 2006; Stern et al., 2001). But, in literature about image concept related with innovation marketing are limited. However, Frank et al. (2015) introduces the concept of innate willingness to pay for innovations (IWTPI). Based on a questionnaire, authors collected consumer data from Germany, Indonesia, Bolivia, USA, and Japan; it tests hypotheses about the antecedents to IWTPI, the moderating effects of IWTPI on the formation of customer satisfaction, and their differences between products and services. Results show that IWTPI tends to be positively influenced by importance of status symbols as image. Moreover, these effects are moderated by cultural and economic factors and the effects of IWTPI are positively moderates by public brand image of company. In others words, the innovations realized on companies´s image would have positive impact on possibility to pay for this type of innovations in marketing.

Finally, innovation marketing based on image may impact more stronger in terms of IWTPI when increase the importance of social recognition, which is the a posteriori perception that using certain products and services has led to positive social feedback and thus represents experienced social benefits (Choi et al., 2014; Frank, 2012; Frank et al., 2014). This effect may be even stronger than reported in the literature on consumer innovativeness because willingness to pay for innovations presupposes a greater return on investment, in terms of social recognition, than mere interest in innovations (Frank et al., 2015).

Methodology

According to Cohen and Cohen (1983) and Hair et al. (1995) regression analysis is useful because it can (1) explain the relationship between one variable with others and (2) estimate the behavior of a variable based on what is known of other variables that influence that variable's behavior.

In this study, this technique can explain the relationship between the independent variables and the Marketing Innovation of Colombia´s Tourist Enterprises (MICTE) or for predicative purposes, estimate the behavior of MICTE and determine the influence of independent variables satisfaction and image. The suggested model has the following structure determined by the dependent variable:

$$MICTE = \beta_0 + \beta 1 \bullet \text{Inn-Mark}_1 + \beta 2 \bullet \text{Inn-Mark}_2$$

Where: MICTE = Marketing Innovation of Colombia´s Tourist Enterprises; β_0 = Constant; Inn-Mark$_1$= Satisfaction: application of innovative marketing strategies that improve customer satisfaction (actions taken to improve satisfaction); Inn-Mark$_2$= Image: application of innovative marketing strategies that help to improve image of company´s products and services (actions taken to improve the image).

Sampling

A survey was designed and applied to a representative sample of 364 managers with tourism enterprises in the cities of Medellin, Calarca, Popayan and Santander de Quilichao. Data collected for the study contain a sample of different tourism businesses, including 74 (20.33%) hotels, 203 (54.77%) restaurants, 14 (3.58%) travel agencies, 24 (6.59%) companies providing hosting services, and 49 (13.46%) other types of tourism businesses. The companies surveyed are small and medium enterprises (SMEs). According to the Ministry of Commerce, Industry, and Tourism of Colombia the sample included, by firm size: 0–10 workers, called micro-enterprise (82.7% of the sample), 11–50 workers (15.39%), called small-enterprise, and 51–200 workers (1.61%), called medium enterprise; 15.43% of the companies have been established in the market between 2.1 and 4 years, but it is also important to note that 27% of the companies are start-ups with less than 2 years in the marketplace.

Analysis

According to the results presented in the correlation matrix (see Table 1), it can be determined that the variables Inn-Mark$_1$ and Inn-Mark$_2$ have a significant relationship with respect to the variable MICTE and have also shown that these relationships are positive, as seen by their coefficients. Table 1 shows a positive linear relationship with the dependent variable MICTE with each of the independent variables, so that Mark1 is the variable that contributes the most to the model, due to the fact that this one has the highest correlation coefficient. Regarding the evaluation of the correlation of the residues is highlighted the problem to evaluate the Durbin–Watson indicator, which is close to 0: 1.966. It is also important to note the high significance of the model (F=3985. 304 and p=0.000).

On the other hand, as observed in the coefficient matrix (see Table 1), there are no problems of multi-collinearity; therefore, for each of the variables, their tolerance indicator is not less than 0.10, as suggested by the theory of Menard (1995) (cited by Aldás, 2008). Finally, the detection of outliers is calculated by the Mahalanobis distance and its significance, using the method suggested by Aldás (2008). According to the analysis, none of the analyzed data shows a statistically significant Mahalanobis distance ($p < 0.001$) to infer the existence of an outlier.

Table 1. Correlation Matrix (N=364)

	MICTE	InnMark_1	InnMark_2
MICTE			
Person Correlation	1		
Inn-Mark$_1$			
Person Correlation	0.910	1	
Sig. (Unilaterally)	0.000	0.000	
Inn-Mark$_2$			
Person Correlation	0.877	0.673	1
Sig. (Unilaterally)	0.000	0.000	0.000

*Correlation is significant at the 0.000 level (unilateral)

Outputs for ANOVA analysis shows that the significance level for the *F* test of the regression is 0.000, that is lower than 0.05 as the minimum level of significance expected; therefore, the hypothesis H0 is rejected, and must be at least $\beta \neq 0$, and thus at least some of the independent variables explain the behavior of the dependent variable MICTE. Subsequently, the significance of the parameters is evaluated individually. For this the *t* test is evaluated in the coefficient matrix, taking into account the hypotheses H0: $\beta j = 0$ and H1: $\beta j \neq 0$.

According to Table 2 (matrix of coefficients), Inn-Mark$_1$ and Inn-Mark$_2$ have a significant individual significance within the model, and therefore could be argued that the variables contribute to it. Whit respect to the model, it appears to be a good fit, and we can say that with a corrected R^2 of 0.956, the model is explaining 95.6% of the information with the variables used, namely Inn-Mark$_1$ and Inn-Mark$_2$. The remaining 4.4% of the information can be explained by other variables that have not been taken into account in the model.

Table 2. Matrix of Coefficients

Model	Unstandardized Coefficients		Typified Coefficients	*t*	Sig.	Statistical Collinearity	
	B	Typ. Error	Beta			Tolerance	FIV
(Constant)	0.113	0.037		3.034	0.003		
Inn-Mark$_1$	0.525	0.013	0.585	39.503	0.000	0.547	1.827
Inn-Mark$_2$	0.439	0.013	0.484	32.654	0.000	0.547	1.827

Dependent Variable: MICTE. F = 3985.304; $\rho = 0.000$

Once the validity of the model results is confirmed, the regression line obtained from the coefficient matrix (see Table 2) is:

$$MICTE = 0.113 + 0.585 \bullet \text{Inn-Mark}_1 + 0.484 \bullet \text{Inn-Mark}_2$$

With this equation, we can predict the level of marketing innovations that a particular company will have, if we understand their perceptions. However, to also predict the degree of Colombia´s tourist enterprises marketing innovations, the regression coefficients aditionally allow identifying the relative importance of individual variables to predict. In this case it is clear that the variable Inn-Mark$_1$ is the most important (0.585), followed by Inn-Mark$_2$ (0.484).

The study results are summarized in Table 3.

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Table 3. Regression Results

Model	B	SE	B
(Constant)	0.113	0.037	
Inn-$Mark_1$	0.525	0.013	0.585*
Inn-$Mark_2$	0.439	0.013	0.484*

R^2 = 0.956; *ρ < 0.001

Results

The implementation of marketing innovation activities in Colombian tourist companies is an emerging practice, and according to the results of this study, they spend relatively little effort in achieving this type of innovation. This finding is true for each aspect of innovation. Inn-$Mark_1$, which is satisfaction understood as application of innovative marketing strategies that improve customer satisfaction, had an average rating of 2.72 out of 5.0 by entrepreneurs, thus indicating that the level of changes or improvements in its practices as the way to do actions to improve satisfaction based on innovation marketing as a priority for all companies surveyed. Likewise, when reviewing the data obtained about this innovation type, it appears that there are companies that have made little effort in this direction, and others who have done their best to contribute to this task so that not all have the same level of intent to innovate from the satisfaction. Inn-$Mark_2$ which is image understood as the way to application of innovative marketing strategies that help to improve image of company´s products and services, had an average rating of 2.93 out of 5.0 on the part of employers, indicating that the level of actions in order to improve imagen based on marketing innovation is not being carried out as a priority in all companies surveyed, and compared to the generation of improvements in this type of innovations is not a task given priority. Likewise, reviewing the minimum and maximum rating obtained, it appears that there are companies that have made little effort in this direction, and others have made some effort to do so, so that not all have the same level of intent to improve or obtain new forms of marketing innovation for company. In general this study shows that research and development is given a low priority by Colombian tourism companies.

Conclusions

The results allow a better understanding of the relationship between marketing innovations in the tourism sector. They also provide important empirical evidence supporting the theoretical conceptualization described by Lee et al., 2015; Agarwal and Prasad, 1999; Lee et al., 2015; Homburg and Giering, 2001; Han and Back, 2008; Hillery et al., 2001; Frank et al., 2015, and these results increase this type of evidence for companies located in less developed destinations, where the dynamic and context is different from more established destinations. This could justify the difference in the correlation between Inn-$Mark_1$, Inn-$Mark_2$ with MICTE. These correlations are described below. For less developed countries, marketing innovation should be addressed as a major determining factor in sustained tourism. In connection with how well the model fits, we can say that with a correlated R^2 of 0.956, the model is explaining 95.6% of the information with the variables used, namely Inn-Mark1 and Inn-$mark_2$, while the remaining 4.4% of the data can be explained by other variables that have not been taken into account in the model.

The main conclusion of this study is the observation of a significant relationship regarding the MICTE with the variables Inn-$Mark_1$ (0.585) Inn-$Mark_2$ (0.484), and that these relationships are positive, as shown by their coefficients. In sum, there exists a positive linear relationship between the dependent variable MICTE with the independent variables Inn-$Mark_1$ and Inn-$Mark_2$, and Inn-$Mark_1$ is the variable that contributes the most to the model. In order to predict the degree of Colombia´s tourist enterprises marketing innovations, the regression coefficients allow identifying the relative importance of individual variables to predict the important level of this type of innovation. In this case, it is clear that the variable Inn-$Mark_1$ is the most important (0.585), followed by Inn-$Mark_2$ (0.484).

Finally, this study presents some limitations. In order to expand the sample to a larger number of cities in the country, it is recommended that in future studies the sample can be extended to cities with relatively good tourist development. On the other hand, future research should identify correlations of other innovation variables as process innovation.

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Social Networks as Enablers of Enterprise Creativity: Evidence from Portuguese Firms and Users

Silvia Fernandes [*1], *Ana Belo* [2]

Abstract: The present work analyzes the profiles of social networks' users, individuals and enterprises in Algarve (Portugal), having accomplished online questionnaires. Samples of 230 users and 70 firms were collected. According to data obtained there are different behaviors. Users' results highlight the need of harnessing the potential of recruitment and business projects through social networks, as searching for knowledge, communication and professional relations are expressive. Firms' results reveal two types of social networks' use: 1) knowledge search, interact with customers, launch new products; and 2) potential for marketing. Users' desire of expressing own ideas and being creative had low importance. In social networks they auscultate more about what others are doing than revealing own aspirations. Here firms can act in order to shape users' attitudes and preferences to their creativity. Thus, enterprises can use the first level of social networks (knowledge and product-customer interaction) in order to enhance the second level (marketing and innovation).

Keywords: social networks; users; firms; profiles; behaviors

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Introduction

New communication technologies allow a global interaction like never before imagined. Internet evolution, and especially Web 2.0 (O'Reilly, 2005), opened new opportunities and benefits, given its ease of communication and information dissemination (Brandão & Marques, 2010; Fernandes and Almeida, 2009). One of the greatest opportunities was the opening of new online applications of network environments known as social networks (Tredinnick, 2006; Boyd & Ellison, 2007; Constantinides, *et. al.*, 2008). Today, the internet presents itself as the platform of greater access, in which millions of individuals daily enter at any place or time (Tapscott & Williams, 2007). In this context, new environments appeared (Evans, 2008) such as the social networking sites, including Facebook, YouTube, LinkedIn, Twitter, Hi5, Bebo, and MySpace, among others, in which users either communicate or share content (Pei, *et. al.*, 2011; Boyd & Ellison, 2007). The growth of these cyber-communities is a notable social phenomenon. Empirical studies have described new forms of social and economic behavior that call for deeper analysis.

On those platforms, people create their profiles, communicate, exchange pictures, share movies, or join groups on a particular interest, creating communities. The participation in these communities, and their influence, can add value to any business. The networked individuals can actively participate in innovation, wealth creation and social-economic development in a way never thought of before (Qualman, 2009). According to the study "Internet use in Portugal 2010" (Taborda, 2010), more than 60% of the users of social networks in Portugal consider it important that companies also have a profile there. The continuous entry of firms in these applications can completely change the way of doing business.

Some authors have suggested that, after the knowledge economy and digital economy, a new economy is happening now, naming it "Socialnomics" (Qualman, 2009), "Economy of relations" (Robison & Ritchie, 2010), or "Economy of integrity" (Bernasek, 2010). Thus, the key features of business and innovation, which in past decades were tangible, are now replaced by intangible assets such as connections, knowledge, and integration. Studies on social networking sites have expanded, receiving increased attention from the scientific community (Boyd & Ellison, 2007). These sites are currently a major research focus in several areas. One example is the Facebook application, which has been studied by Dwyer *et. al.* (2007), Acquisti & Gross (2006), Lampe *et. al.* (2007), and Stutzman (2006).

The present work aims at characterizing a group of users involved in social networks as their profiles will be increasingly important for enterprises' business models and strategies. Enterprises need to look deeper and analyze these new environments with multiple perspectives as they allow communication that covers millions of different features and potential customers (Vasconcelos & Campos, 2010; Tapscott & Williams, 2007; Brandão & Marques, 2010; Constantinides, *et. al.*, 2008). The firms' adaptation to this new reality will help them to innovate their strategy and market approach (Magalhães, 2011).

Social networks: main trends

Arima (2010) points out that "social media" is an opportunity for organizations to build brands, demonstrate leadership behaviors, expand resources, reach new audiences and find new sources of ideas. The study of Ingelbrecht *et. al.* (2010), using a sample of 4000 consumers in 10 markets worldwide (including USA, France, Germany, and China), gives to social networks, like Facebook and LinkedIn, the

(1) Centre for Spatial and Organizational Dynamics, University of Algarve, Campus de Gambelas, Faro, Portugal.
(2) Faculty of Economics, University of Algarve, Campus de Gambelas, Faro, Portugal.
*Corresponding author: sfernan@ualg.pt

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role of being the emergent places for retailing and shopping activities. The same study indicates that companies can use mass collaboration as a link between business value and social networking technologies. For example, they can examine a target community of a particular product and interact with it in order to rethink ways of selling or innovating the product.

Social networks help to further intensify networking activities, ideas' exchange and knowledge integration. They can also increase the cooperation among stakeholders (Cross & Thomas, 2010). The most visible issue is the engagement with the community: the company has the possibility to be near its customers and share benefits with them. The benefits of this representation/participation exist if the companies manage to understand the power of collective behavior in the impulse of positive changes in business (Bradley, 2011). For companies, it is important to find their social momentum, which is the social dynamics that, using the internet specificities and interactivity, provides not only an increment to the economic value of the business model but also a return maximization (Hummel & Lechner, 2002).

A review of Falcão (2010) on a study from IGMarketing concluded that social networks are a set of tools that benefits the company as much as it invests in them. Through social networks, it can participate, create content, increment the network, talk to the community, observe, and examine. This results in skills and competencies for the team or individual worker's activity. Currently, social networking sites are being invaded by companies seeking for a presence or with products to promote. Some companies are even breaking down the barriers between the virtual and physical, hiring their professionals online (E.life, 2010). Companies are migrating to social networks, keeping their first web sites on a secondary strategic line.

The large volume of digital information which many companies deal with (Big data), along with social media (social networks, blogs, etc.), will have combined applications. With the mobile wave, these will expand into useful and well-designed applications (apps). Brands will realize the need of strategies to create, distribute and capture consumer attention. The challenge for advertisers is to understand consumer habits in all of those and decide which investment is necessary to capture attention (since they know the financial power of consumers). Several data specialists defend techniques such as basket analysis, clustering, and correlations of social media data to better understand consumer habits, elected brands, and behaviors (Carravilla, 2013).

This study then tries to search for a group of users involved in social networks and discover their socio-demographic characteristics and attitudes in order to discuss potentials and trends from which enterprises or individuals can take advantage.

Data collection

Users' questionnaire and sample

We used a questionnaire oriented to users of social networks (QUTI, table 1), which aims at characterizing the profiles within a group of users of these kinds of platforms. The questionnaire was constructed using a specialized online tool (SurveyMonkey www.surveymonkey.com) which allows the creation of a website where the questionnaire is available. The use of this tool in research is justified because it allows quick access to the questionnaire and facilitates a faster response. It has also the advantage of analyzing the data obtained. Along with a community of other users and companies, it is interesting to get to know this innovative and efficient mean of research and data processing. This tool is already used by a considerable number of researchers. For example, Barry *et. al.* (2008) used it in their research and cite several studies where it was also used. Evans *et. al.* (2009) recommend the use of this service, SurveyMonkey, in future research as it allows users with less knowledge to develop and design efficient psychometric questionnaires.

Data were collected from October to December 2010, with participants having the opportunity to turn back to earlier questions and review their answers. The electronic version of this instrument validates and allows the questionnaire's completion with certain questions requiring a mandatory answer. An email was sent describing the main objective of this study with a link to the questionnaire online (QUTI). Responses were given directly in SurveyMonkey, then exported to Excel, and some issues were analyzed with the SPSS software. The data collected are confidential and private, and they can only be accessed through the use of a login and password (data between server and client are encrypted, encoded). The data are grouped by questions to be treated and compared (Minayo, *et. al.*, 2007).

The types of question fields used in the questionnaire included: multiple choice (one or more answers), array of options (multiple answers) and comment box (open response). The file migrated to SPSS tests the consistency of the collected data by validating answers codes, question by question.

Regarding the purpose of this study, the universe consists of a group of users of social networks. From a group of 1500 regular users of the Facebook platform, we received 230 answers from them in the referred period. Data collection began with the process of releasing online the users' questionnaire. It was relatively easy to answer and required the introduction of the users' e-mail addresses for their post reception of this investigation and its results (table 1).

Research development

After closing the process of online questionnaires, the collected data were then processed. The data treatment began within SurveyMonkey, which was later complemented by a statistical analysis and compared with other studies in the same area.

Users' profiles

Table 1 shows the 16 questions of the QUTI directed to the users, as well as the respective domain (possible values) and types of answer. These types are a multiple choice, with one or multiple responses, and an array of options. A latter attribute (comment box) appears if it is an open answer; in the case of being a closed answer, data entry is not permitted. The questions presented in this survey are based on the comparison of studies and discussion groups on social networks.

Table 1. Characterization of the questions to users - QUTI

Question	Domain	Type of answer
QUTI1: Which social networks do you use?	*Facebook; Hi5; LinkedIn; MySpace; Orkut; Twitter; Youtube*	Multiple choice (several responses), closed
QUTI2: In which social network do you spend more time?	*Facebook; Hi5; LinkedIn; MySpace; Orkut; Twitter; Youtube*	Multiple choice (unique response), closed
QUTI3: How long are you registered in social networks (*Facebook, LinkedIn, Twitter, Youtube, Orkut*, others)?	Less than 1 month; between 1 month and 6 months; more than 6 months and less than 1 year; more than 1 year	Multiple choice (unique response), closed
QUTI4: How long do you use the internet?	Less than 6 months; between 6 months and 1 year; more than 1 year and less than 2 years; more than 2 years and less than 3 years; more than 3 years and less than 5 years; more than 5 years and less than 8 years; more than 8 years	Multiple choice (unique response), closed
QUTI5: Which device do you use to connect the internet?	Phone, Computer, mobile phone	Multiple choice (unique response), closed
QUTI6: Given the following actions, which do you most frequently do?	See and send messages; insert videos; create blogs; develop web pages; share photos; chat; change profiles; download of music and games; search for a job; search for people; search for knowledge (new contents); send news to friends (ex: new products); playing games	Multiple choice (several responses), closed
QUTI7: How much time do you spend in social networks?	Once in a month; 5 hours per week; every day; only at weekends; 1 or 2 hours per day; more than 2 hours per day	Multiple choice (unique response), closed
QUTI8: At what time of day do you use social networks?	It varies during the day; in the morning; in the afternoon; by night	Multiple choice (unique response), closed
QUTI9: Are you more time at home since you start using social networks?	Yes; No	Multiple choice (unique response), closed
QUTI10: Which are the motivation factors for using social networks?	Meet new people; meet old friends; being creative; desire of expressing ideas; knowledge sharing; knowing new products; communication with friends; professional relations; stay informed about events; curiosity about other people; desire of status; dating with people	Array of options (several responses), closed
QUTI11: How old are you?	<10 years old; 10 to 14 years old; 15 to 17 years old; 18 to 24 years old; 25 to 44 years old; 45 to 65 years old; >65 years old	Multiple choice (unique response), closed
QUTI12: Your gender	F; M	Multiple choice (unique response), closed
QUTI13: Which is your education level?	Primary level; Secondary level; Graduated/Bachelor; Master/PhD degree	Multiple choice (unique response), closed
QUTI14: Which is your professional situation?	Employed; entrepreneur; unemployed; housewife; student	Multiple choice (unique response), closed
QUTI15: Civil status	Married; Separated; Single; Single (living with parents); Single (living with other)	Multiple choice (unique response), closed
QUTI16: your email address	Open answer	Text box, open, confidential

It was observed that respondents generally use more than one social network. Table 2 shows the percentage obtained by item (profile).

Table 2. Social networks' users and their profiles

Item	Characteristics/values	Percentage
Social networks used	*Facebook*	100%
	Twitter	5.7%
	Orkut	5.7%
	Youtube	55.1%
	Hi5	26.9%
	LinkedIn	12.8%
	MySpace	6.6%
Social network in which users spend more time	*Facebook*	74.9%
	Twitter	17.2%
	Orkut	0.0%
	Youtube	1.3%
	Hi5	2.6%
	LinkedIn	0.9%
	MySpace	2.6%
Gender	Masculine	42.5%
	Feminine	57.5%
Age	< 10 years old	0.9%
	10 to 14 years old	1.7%
	15 to 17 years old	3.1%
	18 to 24 years old	19.2%
	25 to 44 years old	62.0%
	45 to 65 years old	12.2%
	> 65 years old	0.9%
Education level	Secondary level	46.1%
	Primary level	3.5%
	Graduated/Bachelor	44.3%
	Master/PhD	6.1%
Civil status	Married	30.1%
	Separated	12.8%
	Single	22.1%
	Single living with parents	21.2%
	Single living with other	13.7%
Professional situation	Employed	53.7%
	Entrepreneur	20.3%
	Unemployed	10.1%
	Housewife	2.2%
	Student	13.7%
Time of internet use	Less than 6 months	1.3%
	Between 6 months and 1 year	1.7%
	More than 1 year and less than 2 years	2.6%
	More than 2 years and less than 3 years	5.7%
	More than 3 years and less than 5 years	14.3%
	More than 5 years and less than 8 years	19.6%
	More than 8 yearS	54.8%

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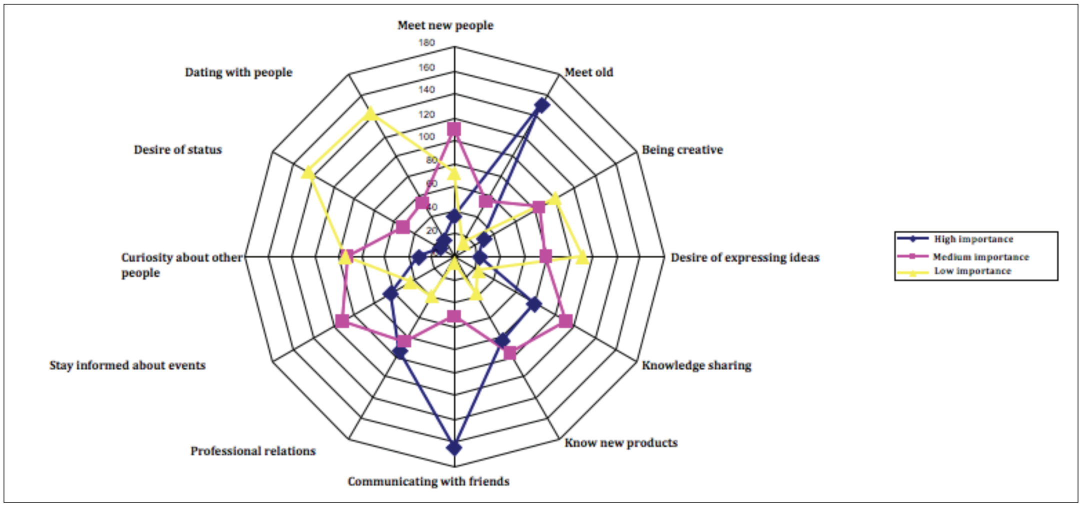
Time of social networks use	Less than 1 month	0.9%
	Between 1 month and 6 months	7.6%
	More than 6 months and less than 1 year	18.2%
	More than 1 year	73.3%
Time spent on social networks	Once in a month	4.4%
	5 hours per week	14.2%
	every day	33.3%
	only at weekends	9.3%
	1 or 2 hours per day	25.3%
	More than 2 hours per day	13.3%
Time of day in social networks	It varies during the day	50.2%
	In the morning	0.9%
	In the afternoon	3.1%
	By night	45.7%
More time at home since social networks' use	Yes	21.3%
	No	78.7%
Mean of connecting the internet	Phone	0.4%
	Computer	57.5%
	Mobile phone/smartphone	42.0%
Actions performed in social networks	See and send messages	85.1%
	Insert videos	22.4%
	Create blogs	5.7%
	Develop web pages	9.2%
	Share photos	45.2%
	Chat	24.6%
	Change profiles	18.4%
	Download of music and games	36.4%
	Search for a job	18.4%
	Search for people	25.9%
	Search for knowledge (new contents)	53.9%
	Send news to friends (ex: new products)	21.1%
	Playing games	23.2%

Resuming these profiles, Facebook is the most used social network, followed by Youtube and Hi5. In terms of time spent in use, Facebook leads again, followed by Twitter. The age groups that mostly use these platforms are from 25 to 44 years old followed by 18 to 24 years old. Considering qualifications, the secondary level leads followed by high graduation (tertiary) level. According to civil status, most users are married, followed by single (not living with parents). Professionally, most users are employed followed by entrepreneurs, with the majority using internet for more than 8 years and social networks for more than one year on a daily basis. However, the time of day in using them varies and time spent at home did not increase since social networks' use. The most preferred mean of connecting the internet is the computer, followed by mobile/smartphone. Finally, the most performed actions in social networks are: see and send messages, search for new contents, followed by sharing photos and downloading music and games.

An important issue to analyze is the motivation behind using social networks. Thus, in this item (which are the motivation factors for using social networks - QUTI10) figure 1 shows that 'Communication with friends' is the main motivation (N=164 individuals), followed by 'Meet old friends' (N=149). These results confirm what other studies defend: the existence of relationships before having a presence in social networks (Boyd & Ellison, 2007). Thus, Facebook tends to be more frequently used to consolidate relationships that already exist offline than to create new relationships. Figure 1 illustrates several other motivations of the respondent users for adhering to social networking sites (the radar main lines have different colors according to a scale of importance: high/medium/low).

Figure 1. Motivation factors of users' presence in social networks and level of importance



The use of such platforms for 'professional relations' is also high (N=94). Classified as medium importance factors are the following: 'knowledge sharing' (N=111) and 'stay informed about events' (N=111). Users are also receptive to knowing new products through social networks (N=96, medium importance). Interestingly, 'dating with people' in social networks is of low importance (N=143), followed by 'desire of expressing ideas' (N=110) and 'being creative' (N=99). These results confirm that social networks' use focus more on benefits to users than on dating with people.

We can relate these motivations with the users' profiles previously obtained (table 2). For instance, the main motivation (consolidating offline relations) is related with civil status, time of day in social networks and actions performed. Other important motivation, establishing professional relations, is more related with time of social networks' use, professional situation and education level (qualifications). Then, medium importance motivations (such as knowledge sharing and knowing new products) are more related with performed actions, education level and time spent on social networks.

An interesting issue emerges from this chart (figure 1). Its discussion refers that motivations such as desire of expressing ideas and being creative had low importance. This aspect, together with the other results, reveal that in social networks users auscultate more what other individuals or enterprises are doing than revealing their own aspirations or ideas. Here firms can act, even in real time (through smartphones or tablets), in order to shape users' attitudes and preferences to their innovation and creativity.

Firms' profiles

We considered 70 Algarve firms as the sample because they completed the questionnaire and answered it on time. Waiting for additional cases would take more time as companies often do not have time to answer free questionnaires. Some institutions helped with contacting firms such as CRIA (regional centre for innovation in Algarve), NERA (business hub of the Algarve region), CIEO (research centre for spatial and organizational dynamics), and the business directory at Sulempresas.com. These institutions interact commonly with firms in the region. After closing the online questionnaire, data were collected for analysis, which began within the SurveyMonkey tool and then complemented with analyses performed with statistical software. Table 3 shows the questions that appeared on the questionnaire (QSME), including their options or attributes. Items were based on observations of social network use and comparisons with other studies. Issues raised by the questions were designed to allow analysis of various corresponding variables and relationships between them.

Table 3. Characterization of the questionnaire to firms in Algarve (QSME)

Question	Options
QSME1: Is your company represented on the Internet with a website?	Yes / No
QSME2: On which social networking sites is your company represented?	Blog; Facebook; Hi5; LinkedIn; MySpace; Orkut; Twitter; Wikis; YouTube
QSME3: Does your company usually use social networks?	Yes / No
QSME4: Has your company implemented an integrated strategy with social networking sites?	Yes / No
QSME5: Do you consider that the representation/participation of your company in social networks favors its business performance?	Yes / No
QSME6: Which activities are more benefited by the representation/participation of your company on social networking sites?	Analyze competition; analyze patterns of behaviour; technical assistance; communicate with customers; trust; knowing trends; cooperation with other companies; being closer to potential clients; loyalty; internationalization; launch new products; marketing; brands; new businesses; opinion search; find new ideas; research; recruitment; promotions

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QSME7: Are you measuring gains from your company's representation/participation in social networks?	Yes / No
QSME8: If you answered "yes" to the previous question, how are they measured?	Open answer
QSME9: In your company, who manages this representation/ participation in social networks?	Person outside the company (freelancer); company's employee; director/manager; subcontractor (outsourcing)
QSME10: Is there a group of people involved with representation in social networks (for content creation, response to customer feedbacks, etc.)?	Yes / No
QSME11: How often do you use social networks for a better performance in your business?	Once a year; monthly; once a week; 3 times a week; 5 times a week; every day; several times a day
QSME12: Do your employees in general access to social networks?	Yes / No
QSME13: Is there control for limiting the use of social networks by your employees?	Yes / No
QSME14: Do you consider a decrease of employee productivity due to social networks access?	Yes / No
QSME15: Do you find your employees more motivated since they use social networks?	Yes / No
QSME16: What is your company's main sector of activity?	Entertainment; manufacturing; traditional commerce; hotels/ restaurants/bars; transportation; communications; services; construction, health/ biotechnology; other
QSME17: What are the qualifications of your company's entrepreneur/director/ manager?	Master; PhD; graduate; post-graduate or technical course; twelfth grade; secondary school; primary school
QSME18: e-mail address of your company:	Open answer
QSME19: name of your company:	Open answer

From QSME and the variables created from this questionnaire, a purpose was to diagnose the most relevant variables regarding firms' participation in social networks. We used categorical principal component analysis (CATPCA) as an exploratory technique of interdependence and dimension reduction (Gifi, 1990; De Leeuw, 1990; Meulman, 1992; Nishisato, 1994) to detect patterns of association among variables. According to Cronbach's alpha coefficient, an indicator of internal consistency, data were highly consistent concerning two dimensions (94%). CATPCA also revealed the weights of the variables.

To capture the most relevant variables, table 4 describes respective loadings (weights) for both dimensions, reflecting the relative importance of the variables. Extant research suggests that the criterion of relevance of a variable occurs when its weight exceeds 0.5 for at least one dimension. The values in bold show the most relevant variables for both dimensions, with 16 relevant variables.

Table 4. Relevant variables and loadings

Variable	Dimension	
	1	2
VERSOR	0,333	**0,51**
VERSWI	0,415	**0,51**
VERSFA	**0,67**	-0,056
VERSTW	**0,59**	0,436
VERSLI	0,452	**0,54**
VERSYO	**0,55**	0,45
VERSRS	**0,65**	-0,123
VEIE	**0,63**	0,098
VEODA	**0,59**	-0,4
VEACTMK	0,3	**-0,58**
VEACTNP	**0,59**	-0,256
VEACTFD	**0,66**	0,128
VEACTCM	**0,59**	-0,354
VEACTCO	**0,6**	0,068
VEGP	**0,67**	0,16
VEQURS	**0,6**	0,21

Another issue in table 4 is that all variables have positive weights for the first dimension, but the second has a strong contrast of both negative and positive weights. This means weak relationships exist between variables of the second dimension. Analysis of the most relevant variables (12 for the first and only 4 for the second) suggests two types or dimensions of social networks (table 5).

Table 5. Dimensions from relevant variables (types of social networks)

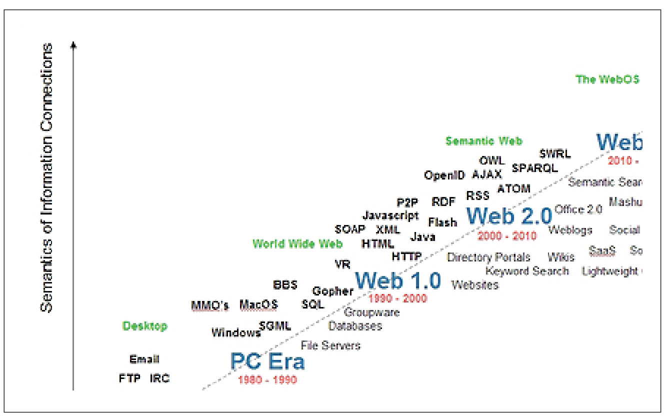
First dimension: social networks for knowledge and for product-customer interaction	Twitter, Youtube - mais orientadas à pesquisa, comunicação e conhecimento (mais profissionais); eTwitter, YouTube - more oriented to (re) search, communication and knowledge (professional-oriented); and Facebook - mais orientada à interacção com clientes, novos produtos a clientes, desempenho (mais sociaiFacebook - more oriented to interaction with customers, new product launches, performance (social-oriented)
Second dimension: DIMENSÃO 2: REDES SOCIAIS DE POTENCIAL PARA MARKETIsocial networks with potential for marketing	Orkut, Wikis, LinkedIn - more oriented to marketing and promotion

The first dimension retains much more information since it captures the largest percentage of explained variance. The second retains less information, capturing residual variance. One purpose was to reduce the dimensionality of the data to the least loss of information (Gifi, 1990; Romesburg, 1984). Extracting dimensions loses some information, but use of all dimensions complicates analysis. The goal was to extract patterns, detected from explained variance while the remaining observations are residual. Thus, the first dimension (i.e., social networks for knowledge and product-customer interaction) was well characterized (table 5) since all of its relevant variables had positive weights. Due to its most relevant variable (VEACTMK) being negative and related to marketing, the second was titled social networks with potential for marketing. Another reason for this classification (especially the word potential) was weak relationships between variables of the second dimension (table 4).

Firms can act in this second dimension (even in real time, through smartphones/tablets) in order to shape users' attitudes and preferences to their innovation and creativity. Thus, enterprises can use the first dimension/type of social networks (for knowledge and product-customer interaction) in order to evolve to a higher level (second dimension). Even through simulations or virtual/serious games, firms can create scenarios of what they consider more interesting, revolutionary and functional from their experience in management and entrepreneurship.

About scenarios, figure 2 shows a trend to semantic web (web level 3) related with, among other factors, semantic databases whose data can be from different social networks. These can perform or shape issues/tasks with clients/users. This is relevant in terms of sustainability, or even resilience, meaning not just persevere but supplant sustainable situation continuously. Shaping users to enterprises' creativity will put them ahead of clients' perceptions and aspirations.

Figure 2. The third generation of web is coming



Social networks are really important to study and explore by enterprises and researchers because this kind of platforms is included in the web level 2 (together with blogs, wikis, video sharing, web services, etc.). This is evolving rapidly to the web level 3 (known as "semantic" or "intelligent" web). Its goal is to create a capability that anticipates user needs, enabling the use of autonomous agents to perform tasks for users (Borrero & Caballero, 2013). And this can capture clients/users from many segments and regions/ countries, potentiating a social networks' CRM (customer relationship management system). Microsoft's (2009) white paper already approached this intersection, a powerful tool for online data and perspectives enclosure to enrich customer interactions.

Conclusion

Social networks are the subject of much discussion, due to massive adoption by both individuals and businesses. This study combines two approaches to investigate how firms and users in Algarve (Portugal) use these networks, and analyze their characteristics and potential. It required two questionnaires adjusted to these goals and firms in the region.

In summary, by analyzing the socio-demographic data from users (such as age, time of day in social networks, level of education, and occupational status), we can think of different profiles. For example, a considerable proportion of respondents are entrepreneurs having a graduation/bachelor. These results highlight the need of enhancing the potential of recruitment strategies through social networks or of starting business partnerships/projects. This is important because the vast majority use these platforms for more than one year, and a significant percentage access them every day. Another aspect is that mobile phone connection is getting significant expression, making it relevant for new business/work applications. Regarding the actions performed in social networks, besides viewing/sending messages, searching for knowledge (new contents) is expressive which can be relevant for innovative initiatives. In the item 'motivation factors' for using social networks, besides communication with friends and meet old ones, the use of these platforms for professional relations has high importance.

The study identified two dimensions or types of most used social networks: product-customer interactions and knowledge, and potential for marketing. For the first type, the most selected social networks are Facebook, to support interactions with customers or new product launches, and Twitter and YouTube, to support research and knowledge generation. For the second type, the most selected social networks are Orkut, LinkedIn and Wikis, with potential to support marketing. However, associations between variables for this type were weak, influencing its strength. Firms can act in this second type/dimension in order to shape users' attitudes and preferences to their innovation and creativity, since motivations such as desire of expressing ideas and being creative had low importance. Results reveal that in social networks users search more for what others are doing than revealing their own aspirations or ideas. Therefore, enterprises can use the experience from the first type/dimension of social networks (knowledge and product-customer interaction) in order to evolve to a higher level (second type/dimension). Firms in Algarve are less likely to use social networks for marketing support, despite having propensity for it. This finding suggests pro-active marketing strategies related to social media. Companies should consider this because niche markets can exist in the virtual world, just like in the real world. Such niches (or even new markets) may emerge attracting public attention through the analysis of their behaviors, shaping their ideas and expectations.

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Adding Entrepreneurship to India's Science, Technology & Innovation Policy

*Ragini Chaurasia *[1], Mitrasen Bhikajee [2]*

Abstract: Science, Technology & Innovation Policy (STIP) is an important policy instrument particularly in the developing countries. India also has recognized the role of science, technology and innovation in development as early as 1958 but still trails behind its peer Brazil, China and the Asian tiger Singapore. Considering strong correlation between research and development investment and growth based on existing studies, this paper brings forth the present situation of India in investment and its influence on the performance of the economy vis-à-vis the three countries. This paper studies the STIP 2013 in detail and reports the contribution of the Department of Science and Technology in India. The main conclusion of this paper is the recommendation for incorporation of "entrepreneurship" in STIP based on global best practices, which can be achieved by government's involvement as a venture capitalist to seed and support innovations, increasing transparency and incorporating entrepreneurial curriculum.

Keywords: entrepreneurial policy and education; growth; India; private sector; government as venture capital; STIP

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1. Introduction

Economic development theories identify scientific innovation, research and development as promising factor of economic growth. Historically economists and policy advisors have undertaken numerous researches to establish the relationship between science and technology (S&T) and economic growth. Works of Romer (1986) and Lucas (1988) are the examples of these researches in the past. They have brought forward the hypothesis that the advancement in S&T will be most important *promoting* factor to achieve economic growth and social development. In the next paragraph, we have done a similar analysis based on data on Singapore.

Table 1 shows the correlation matrix for GDP per capita, and S&T indicators of Singapore between 1996 and 2012. The S&T indicators used are number of researchers, number of journal publications and research and development (R&D) expenditure as percent of GDP. These indicators serve as suitable proxies for measuring S&T (Zhang et al., 2012). Based on Pearson's r correlation rule, we observe that number of researchers and publications of journals is very strongly positively related with R&D expenditure and so is the GDP per capita with number of researchers and publications of journals. We also observe that the GDP per capita is strongly positively related with R&D expenditure.

These positive correlations indicate a possibility that increased R&D investment increases the performance of S&T indicators, which in turn boosts the economy. Similarly, the increased performance of S&T indicators and better economic conditions can again increase R&D as a feedback effect. Thus, S&T promotes economic performance of a country and the economic performance further boosts scientific innovation.

Indeed research by Zhang et al. (2012) proved a long-term equilibrium relationship between scientific innovation and economic growth for Beijing using a Vector Autoregressive Model on indicators for S&T outputs and GDP. He argues that this presence of an interactivity means that scientific innovation promotes economic growth and economic growth boosts the scientific innovation. Similar study in Spain by Sanchez-Sellero et al (2015) show that R&D activities (especially external R&D activities) improve the productivity of Spanish manufacturing firms as empirical evidence towards importance of investment in science technology and innovation (STI).

Table 1. Correlation matrix between GDP per capita, number of researchers, number of journal publications and R&D expenditure as % of GDP

Correlation	GDP per capita	Nos. journal pub.	Nos. researchers	R&D (% of GDP)
GDP per capita	1.0000			
Nos. journal pub.	0.8093	1.0000		
Nos. researchers	0.8041	0.9931	1.0000	
R&D (% of GDP)	0.5110	0.8471	0.8402	1.0000

Source: Analysis on World Bank Data

(1) Sciences Po – Economics Department - Paris, France.
(2) UNESCO New Delhi, India.
*Corresponding author: ragini.chaurasia@sciencespo.fr

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Such understandings have created a wave of STIP across the developed and developing countries. For example, India has declared 2010-20 as a Decade of Innovations during which it targets to raise R&D expenditures to 2.0 percent of GDP (indefinite) by enhancing private sector participation and to position India among the top five global scientific powers while giving priorities to biotechnology, pharmaceuticals, space, nuclear, defence, ICT (software), environment and energy sectors (STIP, 2013).

Similarly Brazil and China has implemented a policy for promotion of science (OECD, 2015). Brazil aims to raise financial resources for innovation, by raising R&D national total expenditure to 1.8 percent of GDP and firms R&D expenditure to 0.9 percent of GDP by 2014. It also aims to increase the number of innovative firms from 41243 in 2008 to 65000 in 2014 and to increase the number of firms that conduct continuous R&D from 3425 in 2008 to 5000 in 2014 by expanding and strengthening infrastructure for S&T research and by increasing the support to human resources capacity building in strategic fields, especially the engineering sciences. China plans to increase R&D investment to 2.5 percent of GDP by 2020; and place China in the world top five positions in patenting and international citations.

While STIPs are implemented differently in each country, it is a big contributor in economic growth and more refinement is required to STIP. This paper is an attempt to study the performance of India economic growth, STI investment and improvements in health in comparison to its peer Brazil and China and one of the Asian tiger Singapore. Among India, China and Brazil, Brazil has specified targeted action plans in its policy documents. All of the three nations focus to place themselves highly in terms of scientific capabilities. China has the highest target for investment in R&D. India has defined broader objectives in its STIP; more specifications are required to meet its objectives.

Similar studies on STIP evaluation exist in the literature. These papers discusses aspects on intention of creation of a national innovation system (NIS) (Dayasindhu et al. 2005); competitive pressure as a source to private sector R&D (Salami et al 2012); NIS as an important determinant of economic performance (Reddy 1997); India's stand as country with high number of science-intensive sectors (Ratchford et al. 2008); India's central position for multinational companies R&D investment (Salami et al 2012) and India's failure in turning its research in profitable venture (Rongping et al. 2008). We draw information on these studies in this paper and bring a recommendation to the policy makers that entrepreneurship should be considered as the main focus in the future policy making both in terms of government's role as a venture capital to seed and promote innovation in some predefined fields and in terms of capabilities enhancement of research staffs. The paper also highlights the fact that India's performance in entrepreneurial space indicates a requirement of government intervention to boost entrepreneurial activities.

The paper also outlines the most important aspect of the STIP in India and tracks the progress made by the Department of Science and Technology through its scheme. This section draws attention of the policy makers towards analysis of what can be a "good" investment to utilize the full capabilities of the economy. This section also discusses the rising issue on how can private sector take the onus of R&D investment. India's STIP 2013 targets to increase the Indian R&D investment from 0.8 percent to 2 percent and specifies an increase in private sector contribution as its main strategy in order to achieve its target. The paper dwells on the fact that there might be a stark contrast in the industry sector between the government and private. An affirmative statement in this regard cannot be made mainly because of lack of sufficient data. In addition the paper also brings forth the necessity of transparency in R&D investment by all the stakeholders to identify the areas with highest need and greatest potential and to allow an effect policy dialogue between government and industry. Last but not the least, the paper brings to the attention of the policy makers that performance on productivity is an indication on untapped potential and as a future opportunity for the policy makers. It is our belief that entrepreneurship as a key aspect in STIP can reinforce consistent efforts in strengthening science, technology and innovation thereby helps to reach to the untapped potential.

2. India: a comparative standing

This section discusses the progress of the four economies – Brazil, China, India and Singapore. While China and Brazil are comparable to India because of the size of it economies and area, Singapore is the Asian pioneer in implementing successfully science and technology as a tool to foster growth and development.

Indeed in all of these economies, a lot of policies have been adopted to fasten the catch up process and among these a great share is attributed to the progress in science and technology. This section, thus, first discusses the trajectories of R&D investment of the four economies and then brings forth a comparative study on GDP growth (GDP per capita) and developments in health (fertility, mortality and life expectancies). Together with this productivity of the economy (total factor productivity and labour factor productivity) is also considered as a by-product of progress in R&D. The paper discusses the concept of productivity improvement in later section of the paper.

a. Expenditure on R&D of India vis. à vis. Brazil, China, and Singapore

We carry out an analysis on the R&D expenditure as a percent of GDP [1] (**Figure 1**) for the four countries over the horizon 1996 and 2013. Analysis shows that the expenditure on R&D is highest for China, followed by Brazil, Singapore and India in the mentioned order. With a yearly-average R&D expenditure per capita of US$ 359.7, Singapore has the highest expenditure per person. This is followed by Brazil with a yearly-average expenditure per person of US$ 69.9, China with a yearly-average expenditure per person of US$ 44.4. India stands last among the four countries with a yearly-average expenditure per person of mere US$ 5.8. As the difference in the yearly-average

(1) Data on R&D expenditure is not available prior to 1996. Also for Brazil data is not available between 1996 and 2000 both years inclusive.

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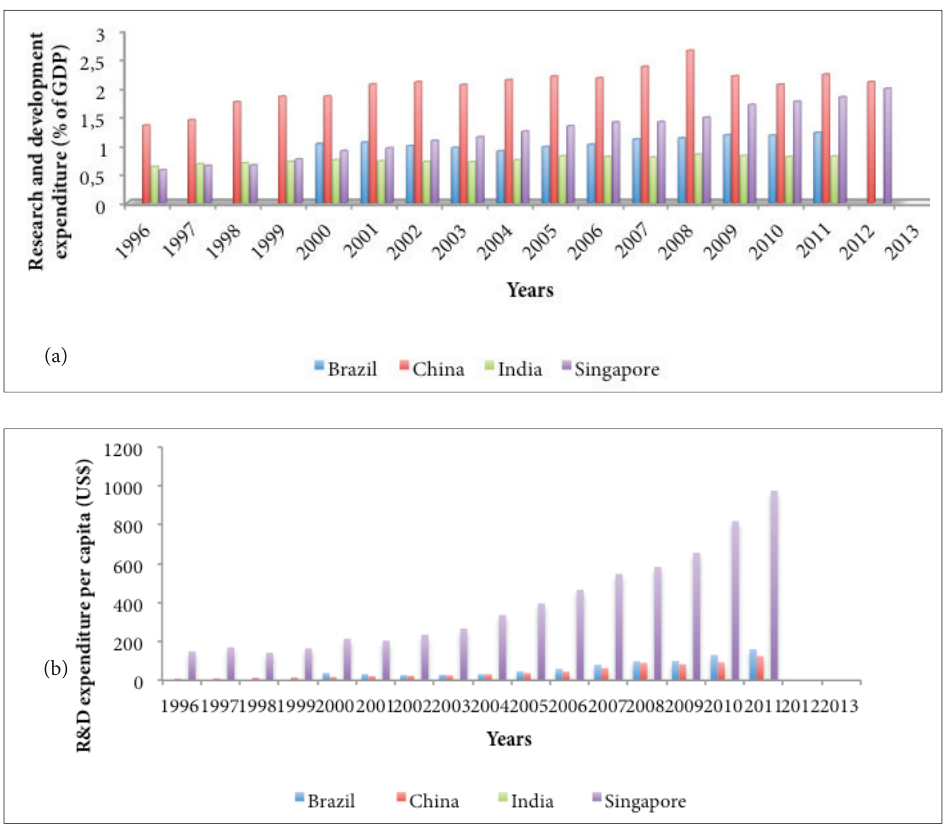
expenditure is very sharp for India and rest of the three countries, we try to change the scale of analysis from R&D expenditure per capita to R&D expenditure per student enrolled in tertiary education.[2]

Considering the gross enrolment ratio in tertiary education (ISCED 5 and 6 [3]) for the year 2011, the population between age group 15 to 64 years and R&D investment in 2011[4] for India, we estimated the number of people potentially enrolled in the tertiary education. We find that India has spent approximately US$ 81, which is still way less than one-fourth of the R&D investment per capita by Singapore. We admit that the estimate of the R&D investment per unit student in tertiary education may be less than actual figures because the calculation relies on the percentage of population between 15 to 64 years age group and not on the percentage of the total population of the five-year age group following on from secondary school leaving as mentioned in World Bank data source; however the main point of this estimate is primarily to provide an interpretation that even if the total R&D investment per capita is adjusted for the actual number of people with potential to enter into research studies[5], India might be able to barely match the actual investment made by Singapore per unit of its total population.

The expenditure as a percent of GDP has increased in the period of observation in cumulative terms, however there is no specific trend in the growth rate pattern. This means that while most years have seen an increase in the percent expenditure there are years where the expenditure has declined for at least a few of these countries under discussion. The cumulative annual growth rate between 2001 and 2011 both years included for Brazil is 1.58 percent, for China is 1.71 percent, India is 0.73 percent and Singapore is 6.67 percent. In comparison when R&D expenditure increased for India by 1 folds, Brazil increased their expenditure in R&D by 2.16 folds, China by 2.33 folds whereas Singapore by 9.12 folds.

Figure 1. Comparison on Research and Development expenditure of India, Brazil, China, and Singapore
(a) Research and development expenditure as a % of GDP
(b) Research and development expenditure per capita (US $)



Source: Analysis on World Bank Data

(2) We do this analysis in order to take in account India's high population. Similar analysis on the rest of the country is not done to prevent loss of focus of the paper.
(3) UNESCO Institute for Statistics defines ISCED 5 as Short-cycle tertiary and ISCED 6 as Bachelor's or equivalent.
(4) Data source: World Bank
(5) A serious concern in India is also the number of students enrolling for education level ISCED 8 (the level defined as Doctoral Studies by UNESCO Institutes for Statistics). Ministry of Human Resource Development has reported that only 84505 students are enrolled in Ph.D. that is less than 0.5 percent of the total student enrolment. At PhD level, maximum number of students is enrolled in Science (22 percent) stream followed by Engineering & Technology (20.5 percent).

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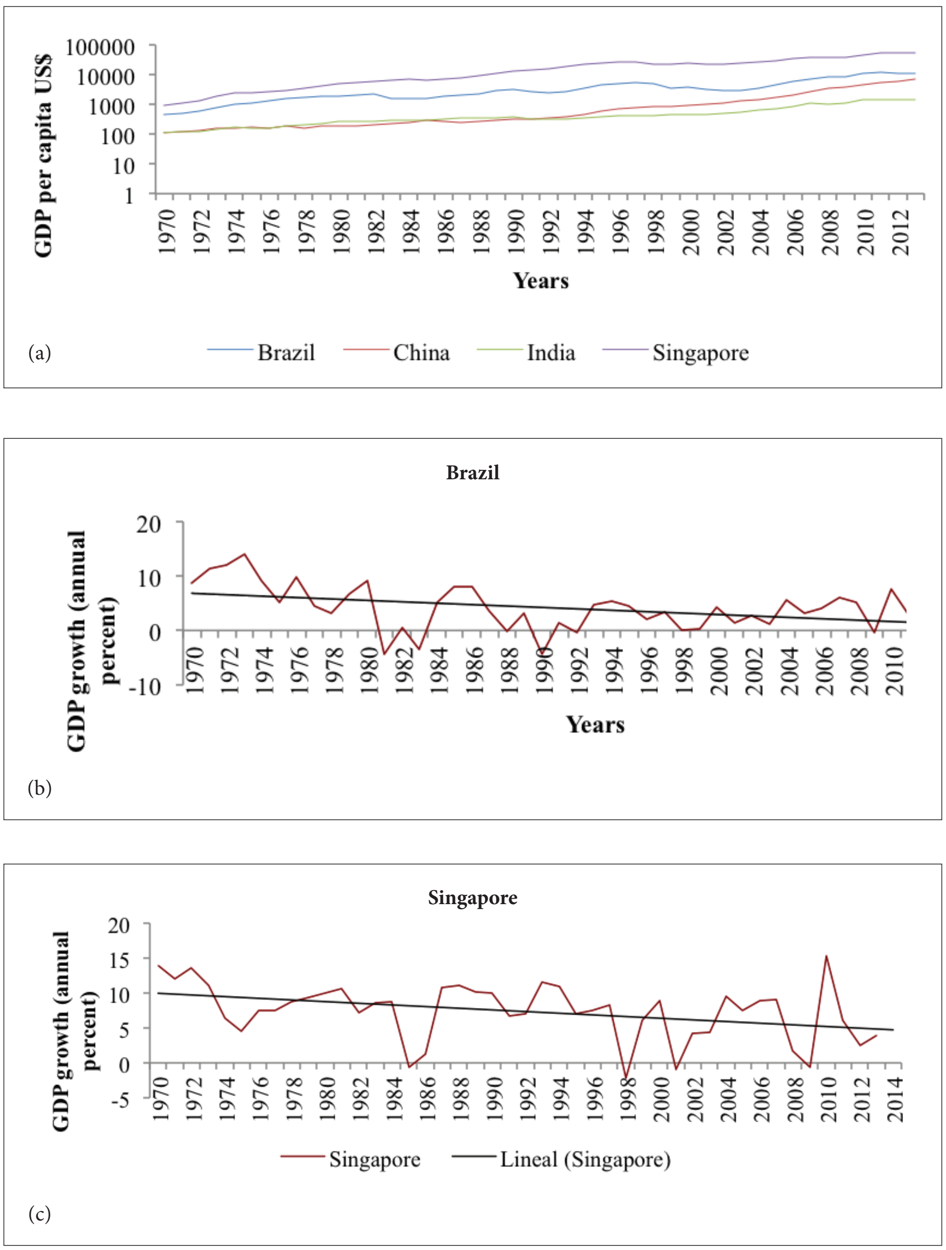
b. Macro-economic data of India vis. à vis. Brazil, China, and Singapore

On studying the GDP per capita of these countries (**Figure 2** a) we find that Singapore is at the top for all the years between 1970 and 2013 (both years inclusive); followed by Brazil. China and India both started very closely, however China gradually picked up and grew far above that of India's GDP. GDP per capita has been on a rise for all these economies. Singapore and Brazil have surpassed India about 5 decades ago, while China surpassed India about 2.5 decades ago.

It is interesting to note that the Singapore and Brazil have surpassed GDP per capita of India despite a decreasing trend in the GDP growth rate for both countries (**Figure 2** b c d e). At the same time, both China and India have shown an increasing trend in the GDP growth rate. Further analysis shows that a low GDP per capita is a characteristic of high population in both India and China, as both India and China have GDP higher than Singapore. **Figure 2**d shows that population of India is increasing steeper than China and is likely to surpass it soon. Given this scenario India needs to adopt strategies that both increases the GDP and decreases the population growth simultaneously.

Figure 2. Macro-economic comparison between India, China, Brazil and Singapore
(a) GDP per capita between 1970 and 2013 (b) GDP growth rate between 1970 and 2013 – Brazil (c) GDP growth rate between 1970 and 2013 – Singapore (d) GDP growth rate between 1970 and 2013 – China (e) GDP growth rate between 1970 and 2013 – India (f) GDP current US$ between 1970 and 2013 (g) Population between 1970 and 2013



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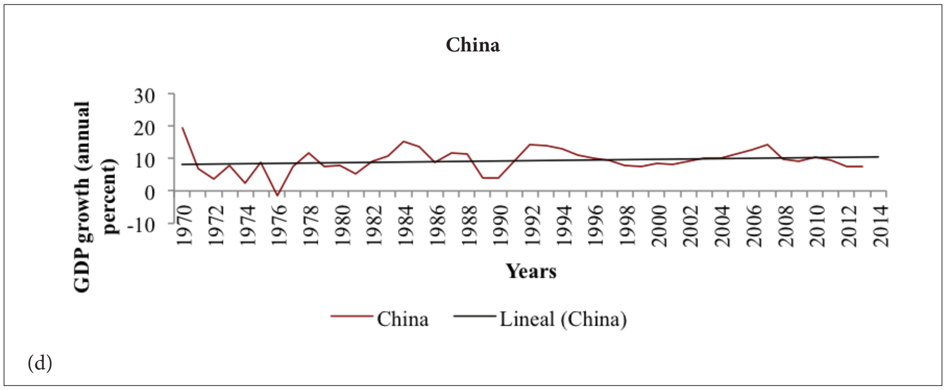
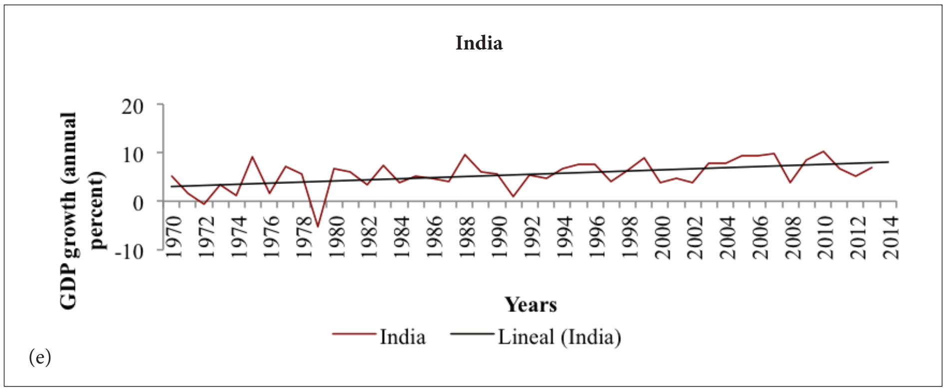
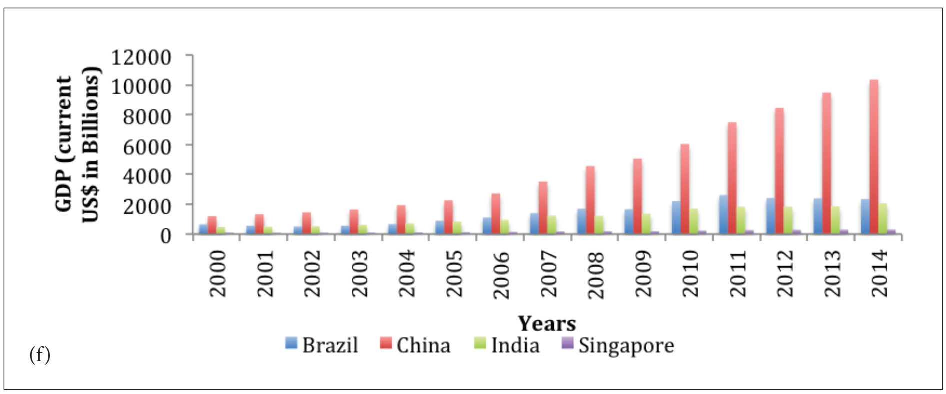
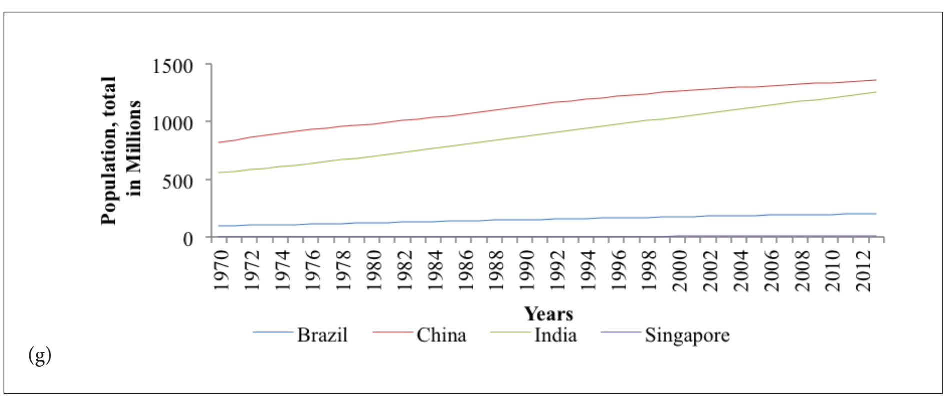






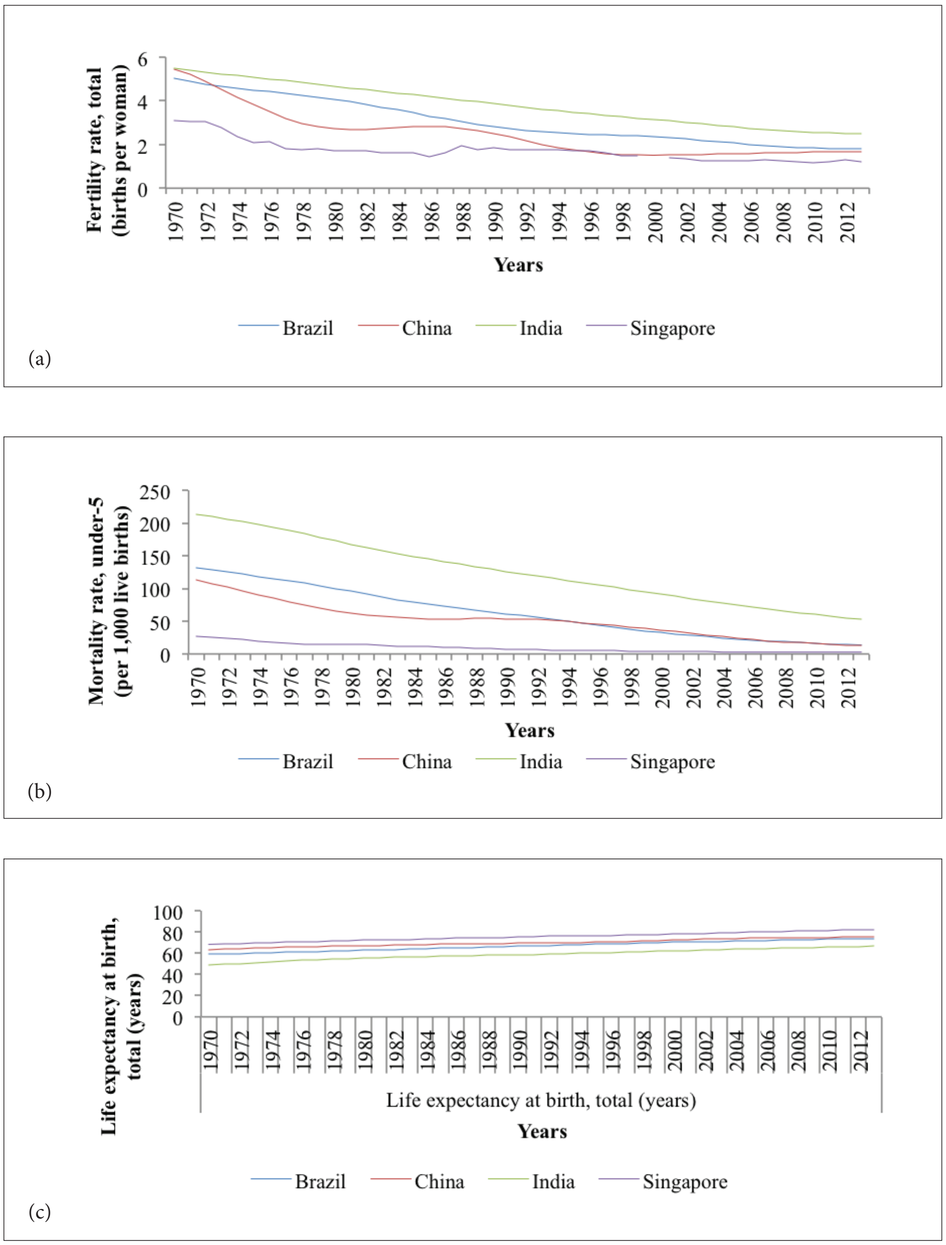


Source: Analysis on World Bank Data

c. Progress in health indicators of India vis. à vis. Brazil, China, and Singapore

The progress in health indicators of India in comparison to Brazil, China and Singapore are presented in the **Figure 3**. It is interesting to note that, all these countries have seen a decline in the fertility rate and mortality rate while experiencing an increase in life expectancies, a positive signal of growth. However, among these countries, India has the highest fertility rate, highest mortality rate and lowest life expectancies at birth in all the years. In 2013, India recorded about 5 births per two women on average i.e. 20 new-borns to eight women. Out of these 20 new-borns, one dies below an age of 5 years and the remaining 19 can live on an average up to 66.45 years.

Figure 3. Health status comparison between India, China, Brazil and Singapore
a) Fertility rate, total births per woman between 1970 and 2013
b) Mortality rate, under-5 per 1000 live births between 1970 to 2013
c) Life expectancies at birth between 1970 and 2013



Source: Analysis on World Bank Data

The fertility rate per women in Brazil is 1.8, China 1.6 and Singapore 1.2. Similarly, the mortality rate per thousand in Brazil is 13.7, China is 12.7 and Singapore 2.8 and the life expectancies at birth for Brazil is 73.8 years, China is 75.3 years and Singapore is 82.3 years, respectively accounting for a life expectancies which is 11%, 13% and 24% higher than that in India respectively. Clearly, a person born in Brazil, China and Singapore is more likely to see better health conditions than one born in India. A high population together with weaker surviving conditions of India compared to its peers brings the need for more innovative solution to improve the life of people and hence should be a focus for promoting R&D in this direction.

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3. Science Policy of India and Schemes to promote R&D

a. Sciences, Technology and Innovation Policy of India

STIP in India has been in existence for five decades; with its first mention in 1958 where the primary focus was on scientific research and it promotion-technology was expected to flow as a by-product of the science activities. This was followed by an adoption of Technology policy in 1983 with objectives to make India self-reliant and technologically capable. This was succeeded by a combined Science and Technology Policy in 2003, which emphasized the need for investment in R&D. The present STIP of India was introduced in 2013 as a necessary framework to integrate Science, Technology and Innovations; it outlines the major activities that have been undertaken in the field of science in India in last few decades.

STIP 2013 identifies science, technology and innovations as a key driver for development and has given central importance to STI enterprises for growth of India. It recognizes that very little has been done in India to give due importance to innovation as an instrument for policy. With an ambition to position India among top five global scientific powers by 2020, the Government of India (GoI) has declared the decade 2010-20 as the "Decade of Innovation" while enforcing the STIP 2013. An important aspect of the STIP 2013 is that, it promotes innovation in the select problems of society and also introduces the key features that will enable innovation to benefit all levels of the society. The detailed list of identified problems and key features of innovation as a policy tool as identified by the STIP 2013 is given

Table 2. Role of innovations as indicated in STIP 2013

Problems to be addressed through science, technology and innovations:

- ✓ Energy and environment
- ✓ Food and nutrition
- ✓ Water and Sanitation
- ✓ Habitat
- ✓ Affordable health care
- ✓ Ski buildings
- ✓ Unemployment

Key feature to make science, technology and innovations a change-agent:

- ✓ Inclusion: innovation should be accessible, available, and affordable by large portion of the population
- ✓ Bridge-gaps: innovation should be able to bridge gaps between the science and technology and socio-economic needs of the country

Source: STIP 2013

STIP specifies some key objectives to improve the adoption of science and technology in India. These objectives are specified in **Figure 4**. To meet these objectives STIP discusses many frontiers of immediate actions, however it does not clearly specify its course of actions. These frontier actions are as follows.

- ✓ To enable school science education reforms by improving teaching methods, science curricula, motivating science teachers and schemes for early attraction of talent to science.
- ✓ To devise new and flexible schemes to address the participation and mobility challenges of employed women scientists and technologists.
- ✓ To create multi-disciplinary (including humanities) inter-university research centres.
- ✓ To create high-cost global infrastructures in some fields through international consortia models.
- ✓ Create transparent centrally implementable Performance Related Incentive Scheme (PRIS) for promotion research funds.

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Figure 4. Objectives specified in STIP 2013

Attracting people towards promoting science	Capacity building	Networking
• Enhancing skill • Making careers in science, research and innovation attractive • Promoting high-risk innovations • Initiation of National Knowledge Network	• World class infrastructure • Private sector participation in R&D • Robust national innovation syste	• Linking STI with inclusive economic growth • R&D outputs into societal and commercial applications

Source: STIP 2013

Target: To position India among top five global scientific powers by 2020

b. Contribution of Department of Sciences and Technology to promote STIP 2013

The GoI has recognized Science, Technology and Innovation as an important factor for fostering GDP growth for more than 4 decades (STIP, 2013). In its attempts, GoI launched Department of Science & Technology in May 1971 with the following objectives:

- ✓ Formulation of policies relating to science and technology to enhance capabilities and sectorial linkages
- ✓ Financial support and promote R&D (including technological surveys and at all levels state, district, and village) for
  - bio-fuel production, processing, standardization and applications
  - utilization of by-products to development value added chemicals.
- ✓ Promotion of ventures involving the commercialization of such technology.
- ✓ Capacity building including setting-up of new institutions and institutional infrastructure.
- ✓ Application of S&T for weaker sections, women and other disadvantaged sections of society.
- ✓ Support S&T entrepreneurship development.
- ✓ Creation of autonomous research institutions.
- ✓ Creating international relations.

In order to meet these objectives a number of scientific programs are launched which are given below **Figure 5**.

Figure 5. Programs launched by Department of Science & Technology

Mission on Nano Science and Technology (Nano Mission)	Focused on Nano technology, an allocation of US$ 167 Millions has been made for 5 years in May 2007
Mega Facilities for Basic Research	This facility extends grants for R&D across institutions. No specific budget or procedure is mentioned in the website.
Fund for Improvement of S&T Infrastructure in Universities & Higher Educational Institutions (FIST)	Same as above. However, they provide the support at three levels, which focuses on infrastructure building, quality of education and research enhancement. The budget limit varies between US$ 170 Thousands to US$ 1.7 Millions depending on their quality.
Sophisticated Analytical Instrument Facilities (SAIFs)	Similar to above. It is an infrastructure investment that has created 13 such centres across India. These centres also provide trainings and workshops to use such instruments.
Human Resource Development and Nurturing Young Talent / Swarnajayanti Fellowships	Under this scheme GoI has provided financial support to doctoral students in science, engineering and medicine in the form of a modest sum of US$ 5000 per person per year to an average 8 researchers per year from 1997 to 2012. This leads to a total of 95 students.
Women Scientists Programs	Women between age group of 30-50 years are provided three types of scholarship – for research in basic/applied science, research in S&T and self-employment. This scheme gives preference to women with a break in career en Scientists Program are as follows. o For research in basic/applied science – An allowance of about US$ 12000 is provided annually per person, which includes fellowship of the applicant and cost of small equipment, contingencies, travel, consumables etc. o Research in S&T – this provides support to women in two modes – internship and project mode. A special one-year internship program has been launched during 12th year plan. The internship aims at developing a proposal for financial support, which is provided under project mode. About US$ 4500 per year per person is provided under internship mode and about US$ 5500 per year per person is provided under project mode.
Kishore Vaigyanik Protsahan Yojana	318 fellowships have been awarded under this scheme and National Science Olympiad Programme has been launched
Innovation in Science Pursuit for Inspired Research (INSPIRE) programme	Launched in 2008, an investment of US$ 32.875 Millions has been made for programs to attract students in early ages towards sciences, scholarships for higher education in science and assured opportunities for research careers
National Science & Technology Management Information System (NSTMIS)	A total of US$ 3 Millions has been allocated in investments have been made for collection, collation, analysis and dissemination of information

Source: STIP 2013 and Department of Science & Technology

The total investment by the Department of Science and Technology in these above-mentioned programs cannot be estimated based on these information. This is mainly because of lack of availability of data for all the individual projects and the total contributions. However, as discussed before the above reported investments have played a great role in helping India pace up its economic growth. World Bank data reports that 10669 patent applications have been filled by residents in India by 2013 and approx. 160 researchers are involved in R&D per million people in India by 2010. These patents and researchers are a by-product of growth of S&T in India. In addition, technological parks have been established which are also successful in contributing their part towards creation of employment and trades across India (Vaidyanathan, 2007). One of the bigger questions still remains that whether these investments are enough to meet the potential of the country. There is a need for policy makers to focus on analysing the requirement of the country.

c. STIP 2013 on private sector investment in R&D

The STIP 2013 has given special attention to the need for an increase in R&D investment from the private sector. This increase is recognized as the main tool to increase the overall R&D investment in India. The major actions proposed in the policy for immediate actions are provided in the **Figure 6**. For this, the policy also calls for identification of around 10 sectors of high impact potential for directed STI intervention and deployment of requisite resources. The policy also aims to target twice the global trade in high technology products (from 8 percent) and the present technological intensity of these sectors (from 6-7 percent).

Figure 6. Main tools to increase private sector investment in India

Strenghthening systems	Public Private Partnership (PPP) mode	Market orientation
• Equal opportunity in both public and private sector for funding • Permitting multi stakeholders participation • Benchmarking of R&D funding mechanisms and patterns globally	• Establishing innovation foundation • Establishing R&D facilities • Co-sharing IPRs generated under PPP • Benefits sharing under for products generated through R&D in PPP	• Nurturing Technology Business Incubators {TBis) and science-led entrepreneurship • Providing incentives for commercialization of innovations

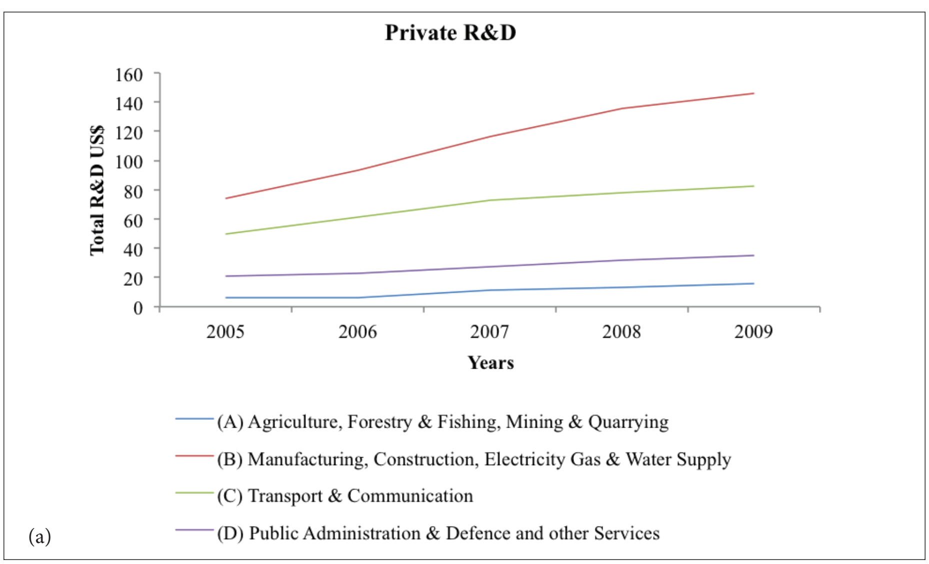
Source: STIP 2013

To further advance this, STIP 2013 also recognizes role of Intellectual Property Rights (IPR). It proposes to put in place a regulatory and legal framework for sharing of IPRs between inventors and investors under which it proposes to modify the regulations for data access and sharing as also for creation and sharing of IPRs.

Very interestingly, STIP has also identified the need for supporting STI driven entrepreneurship with viable and highly scalable business models, which are also the main features of the Singaporean model of development (NRF, 2014). However, a lot of research is to be done to identify the actual scenarios in the entrepreneurial domain in India and to make greater impact of these entrepreneurial space in the catch

Discussion on private sector investment in India vis à vis public interventions between 2005 and 2010

Figure 7. Macro-economic comparison between India, China, Brazil and Singapore
(a) Private R&D between 2005 and 2010 (b) Public R&D between 2005 and 2010 (c) Growth rate Private R&D
(d) Growth rate Public R&D (e) Share of Public Private in R&D in 2009-10



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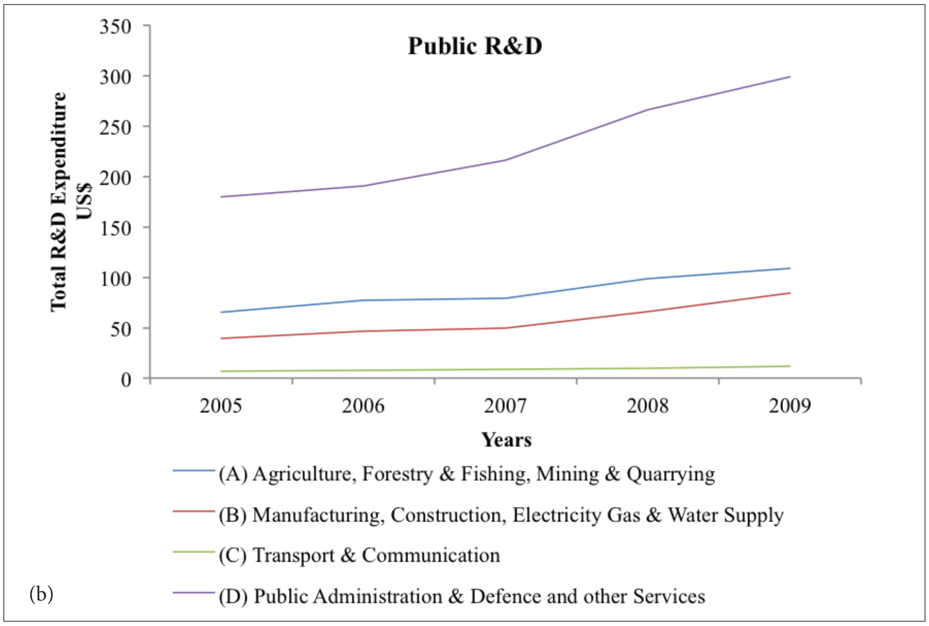
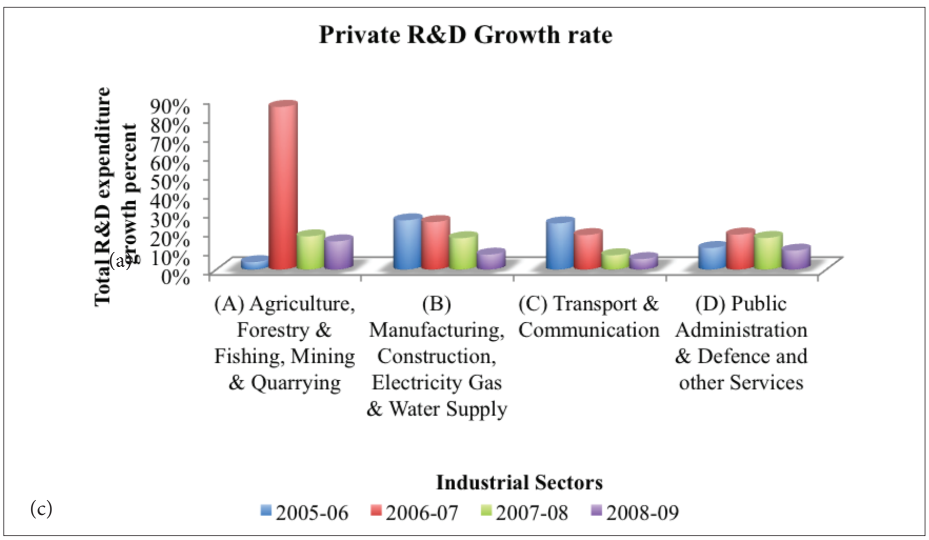
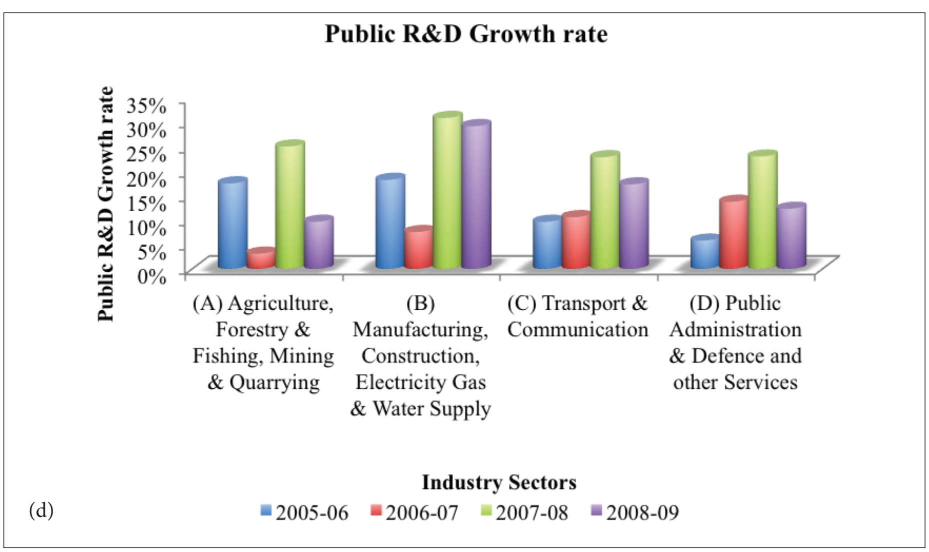
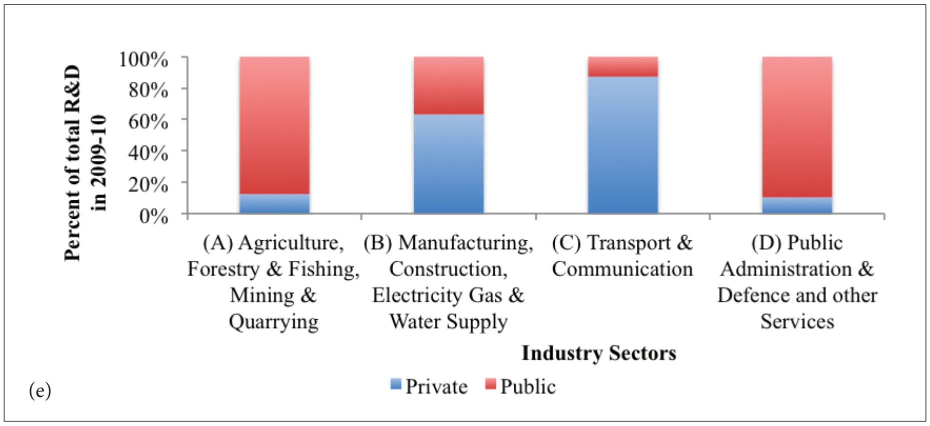

Public R&D
Total R&D Expenditure US$
350
300
250
200
150
100
50
0
2005
2006
2007
2008
2009
Years
(A) Agriculture, Forestry & Fishing, Mining & Quarrying
(B) Manufacturing, Construction, Electricity Gas & Water Supply
(C) Transport & Communication
(D) Public Administration & Defence and other Services
(b)


Private R&D Growth rate
Total R&D expenditure growth percent
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(A) Agriculture, Forestry & Fishing, Mining & Quarrying
(B) Manufacturing, Construction, Electricity Gas & Water Supply
(C) Transport & Communication
(D) Public Administration & Defence and other Services
Industrial Sectors
2005-06
2006-07
2007-08
2008-09
(c)


Public R&D Growth rate
Public R&D Growth rate
35%
30%
25%
20%
15%
10%
5%
0%
(A) Agriculture, Forestry & Fishing, Mining & Quarrying
(B) Manufacturing, Construction, Electricity Gas & Water Supply
(C) Transport & Communication
(D) Public Administration & Defence and other Services
Industry Sectors
2005-06
2006-07
2007-08
2008-09
(d)



Source: Analysis on Data.gov.in

We observe that R&D investment has increased for both public and private sectors (**Figure 7**). However, there is a clear and expected difference in industrial preference for investment by the government and private sector. The public sector spent 60 percent of the total fund in public and defence administration, 22 percent in agricultural allied areas, 15 percent in manufacturing and constructions and the remaining 2 percent in transport and communications. Private sector on the other hand invested 51 percent of the total fund in manufacturing and constructions, next 31 percent in transport and communication, 12 percent in public and defence administration, and the remaining 6 percent in agricultural and allied areas. Similarly we observe that the government is the main stakeholder in the agricultural and defence R&D whereas private sector is mainly concentrated in manufacturing and transport sector. Growth rates are fluctuating for both private and public sector investment across all industries.

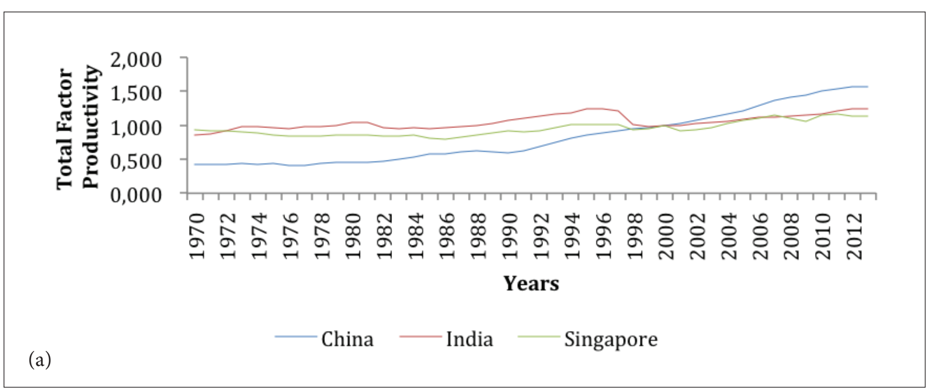
The main take away from these data is that it is imperative that policy makers understand the priorities of private R&D and also the requirement of each company in the industry according to its scale. The paper discusses this issue in the Way Forward in the later sections.

4. Potential in productivity of India vis. à vis. China, and Singapore[6]

Total factor productivity has been increasing for China, Singapore and India between the period 1970 and 2013 (**Figure 8**). While there is a constant observed positive growth for China since 1990, Singapore has gone through negative growth (slow downs) in 5 years since 1990 but the intensity of such negative growth was small. India on the other hand has observed negative growth in three consecutive years from 1997 to 1999 and the decline was as high as 17.1 percent in 1998.

In 2013, China's total factor productivity was highest at 1.566, while India and Singapore were very close to each other in terms of total factor productivity (India was at 1.246 and Singapore at 1.141). Similar trends are observed in data on labour productivity. China surpassed the labour productivity of both Singapore and India about 1.5 decades ago. In 2013, while China's labour productivity was at 3.214, India and Singapore were 1.554 and 1.314 respectively.

Figure 8 Productivity between India, China, and Singapore
(a) Total factor productivity between 1970 and 2013 (b) Labour productivity between 1970 to 2013



(6) Data for factor and labor productivity is not available for Brazil.

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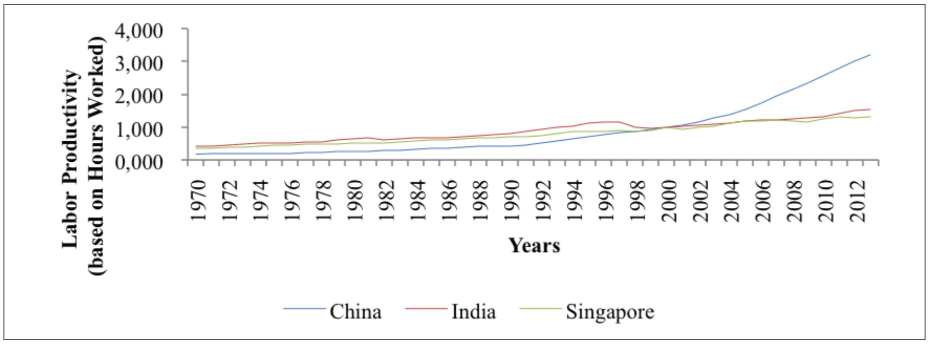

Source: Asian Productivity Organization (APO)

A higher productivity is a positive signal towards boosting the economy. Much can be done by India to match its peer in this regard and these data indicates a lot of good news for India. First, at present India's productivity is more than the Asian Tiger – Singapore, which is known world wide for its success in implementing steep catch-up. Second, the fact that the total factor productivity and labour productivity is high for China; India has a motivation to boost its productivity as one of the major contributors in increasing the rate of catch-up.

5. Entrepreneurial capabilities of India vis. à vis. China, and Singapore[7]

To study the entrepreneurial capabilities of India we analyse the data on total early-stage entrepreneurial activity (TEA) by stages of economic development (percent of population aged 18-64) in 2013 and 2014 (**Table 3**). These stages involve nascent entrepreneurship rate, new business ownership rate, early-stage entrepreneurial activity, established business ownership rate and discontinuation of businesses rate and are provided by the Global Entrepreneurship Monitor (GEM). We find that India's stand is the lowest among all four countries with only a 15.82 percent of population aged 18-64 in TEA whereas Singapore has 22.63 percent, China has 41.3 and leading in the group is Brazil with a total score of 48.1. Stages wise as well India has the minimum percent in all the stages except for nascent entrepreneurship rate where it has second lowest percentage of adult population.

This is a greater concern because India has shown a decline in total entrepreneurial activity by 50 percent between 2013 and 2014 when the other three countries have shown positive growth in total entrepreneurial capabilities (Singapore of 1 percent growth, Brazil of 5 percent growth and China of 13 percent growth). While it is arguable that a high total entrepreneurial activity does not necessarily indicates better economic performance as most of the entrepreneurial activity may come from a lack of job opportunities (a situation classified as "necessity driven" by GEM), however it is still a factor towards increasing the job opportunities in the economy and hence require attention of the policy makers.

Table 3. total early-stage entrepreneurial activity (TEA) by stages of economic development (% of population aged 18-64) in 2014

	Nascent entrepreneurshiprate	New business ownership rate	Early-stage entrepreneurial activity	Established business ownership rate	Discontinuation of businesses	Total[1]
Brazil	3.7	13.8	17.2	17.5	4.1	48.1
China	5.4	10.2	15.5	11.6	1.4	41.3
India	4.12	2.54	6.6	3.73	1.17	15.82
Singapore	6.36	4.82	10.96	2.88	2.39	22.63

Source: GEM Global Entrepreneurship Monitor

6. Way forward: An approach towards achievement of objectives specified by STI in India

a. Government as a venture Capital

Some of success stories of Science Parks in developed countries such as USA and UK have been very actively adopted by other developing countries across the world. The Science Parks of Silicon Valley in California, Route 128 in Massachusetts (Castells et al., 1994), the Research Park Triangle in North Carolina (Link et al., 2003) and Cambridge in the UK (Koh et al., 2005), are a few of those whose models are being incorporated by Kuwait (Sultan, 1998), Brazil (Cabral et al., 1998), Russia (Kihlgren, 2003), Taiwan (Lai et al., 2005) India (Vaidyanathan, 2007), Israel (Rothschild et al., 2005) and China (Watkins-Mathys et al, 2007 and Ratinho et al., 2010). Creation of Science Park is just one of the steps to target growth, as there is lack of clarity in regarding the performance of Science Parks (Phan et al., 2005).

(7) Data for factor and labor productivity is not available for Brazil.
(8) Total is calculated as Nascent Entrepreneurship Rate + New Business Ownership Rate + Early-Stage Entrepreneurial Activity + Established Business Ownership Rate - Discontinuation Of Businesses Rate

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Most economies today place considerable emphasis on entrepreneurship leading to creation of private enterprises as a factor in development and growth of an economy and as a step from simple creation of Science Parks to sustenance of such parks. United Nations University (UNU) has also identified entrepreneurship as a key contributor in growth and employment creation and has highlighted that the impact of entrepreneurial activities will be huge and alike in all the economies - advanced, emerging and least developed economies.

However UNU also brings forth that for realization of such an impact, role of the state is important (Naudé, 2011). This is mainly because creation of enterprises requires appropriate skills and initial financial supports. A growing network of institutions called accelerators takes up appropriate skills trainings in entrepreneurial educations, mentoring and investment rapidly (Bliss et al., 2015). Research has shown that successful accelerators can increase the rates of success in new enterprises by 10 to 15 percent. A dominant form of funding that existed in the market is venture capital funds. Research, as early as in 1990, has also shown that venture capital has about two shares in ever three scenarios where funds are raised from private sector sources by new ventures in technology-intensive business in a data sample of 284 technology-based firms founded in New England between 1975 and 1986 (Freear et al., 1990).

Governments such as those of USA and Singapore have channelled their investments in high entrepreneurial potential projects (Wessner, 2008 and NRF, 2014) as this is directly linked to creation of job and wealth (Ratinho et al., 2010); in other words, these governments have taken positions as venture capitalists to enhance states support to increase the chance of survival of new rising technology-based enterprises.

A Venture Capital fund is a medium between investors who seek private equity shares and new enterprises or small and medium size enterprises with strong potential of growth. These investments are characterized by high-risk-high-return opportunities and require expertise in risk assessment. There are different kinds of VC financing which are presented in the

Table 4. While each VC funding enterprise has its own methodology, each of VC enterprise disburses finance in multiple stages and finance is provided in subsequent stages after an analysis of the projects progress and efficient utilizations. VC work closely with managers of fund seeking firm and also hold decision powers through representation on their board of directors (VC, 2003).

Table 4. Types of Venture Capital (VC) Funds

Types of VC funds	Remarks
Early Stage Financing	This has three sub-divisions seed financing, start up financing and first stage financing It is given to companies for the purpose of finishing the development of products and services.
Expansion Financing	This may be categorized into second-stage financing, bridge financing and third stage financing or mezzanine financing. It is provided to a company to assist the company expands in a major way.
Acquisition or Buyout Financing	This is categorized into acquisition finance and management or leveraged buyout financing. It assists a company to acquire certain parts or an entire company.

Government officials are unlikely to have the expertise or resources to effectively monitor entrepreneurs. However it can always outsource a pool of venture capital investors on an ad-hoc basis and other advisory services to make use of its rich network of growing experts. A directional educational approach to strengthen the work force by incorporating the entrepreneurial aspects in the educational curriculum can be a step in this direction. Similar examples exist in the developed economies of USA and Singapore, GoI can also take initiatives in the same directions. In addition, India's TEA performance also indicates a requirement of government intervention to boost entrepreneurial activities.

Case of USA

With the objective to enhance technological innovation in new enterprise together with finding means to boost the economy, USA Federal government passed an act called Small Business Innovation Development Act and created a program called Small Business Innovation Research (SBIR) in 1982 (Wessner, 2008). This program is funded by 11 federal agencies, which invest 2.5 percent of their extramural R&D budget each. The process of development of a program and its commencement is a multiple step process and is described below in **Table 5** (Wessner, 2008).

Table 5. Process of program development and its commencement

Identification of research development area • Parent funding agencies identify key R&D topics requiring solution • They solicit request for proposal (RFPs) from interested small business enterprise through public announcement
Selection and grants • Proposal are selected on a basis of peer reviews of proposals on a competitive basis by experts of appropriate fields • Best enterprise that meets the requirement and capabilities are awarded contracts or grants

Source: Wessner, 2008

The SBIR program grants the financing in three phases (Wessner, 2008):

- ***Phase I***: In the first phase the program grants as much as US$100,000 to undertake a feasibility study and a limited research study at the end of which the enterprise presents scientific idea for commercialization.

· ***Phase II***: In the second phase the grant value is increased to about US$750,000 to fund more extensive R&D to further develop the scientific and commercial promise of research ideas.

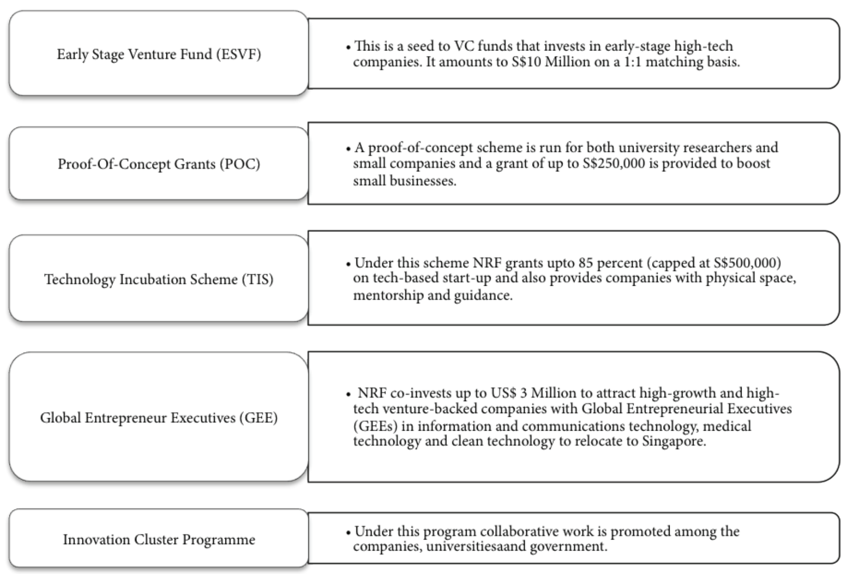
·***Phase III***: When this stage is reached the technology prototype is ready to enter the market space, thus companies do not receive any more SBIR grants and are required to obtain funds from private markets or capital markets. This phase may be difficult for new firms, however agencies have been put in place in support of the new firms.

Empirical analysis on impact of these SBIR programs shows that the mean employment increase and the sales increase were greater for SBIR awardees between 1985 and1995. Quantitatively, it was reported that employment increase by 56 percent and sales increased by 123 percent for the mean SBIR awardee (Lerner, 1996).

Case of Singapore:

Singapore set up The National Research Foundation (NRF), as early as on 1 January 2006. NRF is the body responsible for policies, plans and strategies for R&D, innovation and enterprise (NRF, 2014). NRF launched a National program called National Framework for Research, Innovation and Enterprise (NFIE) to grow innovation and entrepreneurship in Singapore. The main purpose of NFIE is to encourage universities and polytechnics incubate their research into commercial products for the market and assist entrepreneurs to set up technology-based companies. NFIE has rolled out number of grant schemes as support vehicles to achieve its target. These grants schemes are shown in the **Figure 9**. Clearbridge BioMedics and the CardioLeaf® FIT funded under TIS are two of its success stories.

Figure 9. NFIE Schemes



Source: NRF, 2014

Framework for Government as Venture capitalist – key aspects to be focused

As noted earlier government officials might lack skills required for managing a venture fund, however it can always pool in experts in VC firms and other advisory services in the public private mode. Key aspects the government should focus on while entering into such ventures in India are as follows.

· Leveraging local scientific and research base: It is imperative that ventures are made in the direction of technological advancement. For this to happen, GoI has to devise a mechanism for identifying marketable research and evaluating the success potential of these existing and on-going research.

· Focusing on short-term investments with shorter turnaround time: An investment of efforts and money for technologies addressing the immediate problem in a sustainable fashion should be encouraged. Researchers and academics should be given incentives to work in the direction of immediate needs.

· Collaborating national capabilities and international capabilities: Platforms should be prepared for association of national research centres and utilization of all the expertise in the area of incubatory technology. At the same time, networking with global platforms to foster research and global principles of business can give a higher thrust to newly incubated small business on the world platforms (Lerner, 2010).

b. Understanding Indian private R&D level to identify sectors with needs

STIP 2013 has brought forward the requirement of increasing investment in R&D. As per the World Bank data from 2011 India invested only 0.8 percent of GDP in R&D expenditure. STIP 2013 has targeted an increase in R&D expenditure to up to 2 percent of GDP (an increase by 150%) and has also indicated that major increase can be achieved by involvement of private sector involvement (STIP, 2013).

In order to achieve this objective, it is imperative that actual R&D investment scenario of all the private players and the role of government investment in boosting the morale and confidence of these private players be understood completely. Encouraging private-sector innovation, making public research institutions more accountable and channelling more funds into the most promising R&D projects are considered important aspect of improving the status of science and technology in even the most advanced countries (Bremer, 2015).

Further, an understanding of each sector's requirement from government intervention will be useful in designing policy instruments. A policy without this understanding is likely to be ineffective because researches have debated over the capabilities of government investment in particular industries in boosting the R&D investment from the private sector. The most important benefits enjoyed by industries through government investments are as follows (Lee, 2011):

· High (low) technological competence firms enjoy a smaller (greater) tech enhancing effect and greater crowding-out (complementarity) effect of public R&D support
· Firms operating in industries with high tech opportunities or firms facing more intense market competition have more cost-reducing effect less (more) crowding-out (complementarity) effect of public R&D support
· Small firms/ with lower sales growth have greater positive effect

The above hypothesis is supported by data provided by World Bank survey – Institutional and Policy Priorities for Industrial Technology Development, in Canada, Japan, Korea, Taiwan, India and China.

Similar studies have also been carried in different countries across the world. For example – a survey financed by the Spanish Ministry of Industry, the Survey on Firm Strategies (Encuesta Sobre Estrategias Empresariales). The survey contains information on firms' total annual R&D expenditures, which include the sum of internal and external R&D expenses and the imports of technology (payments for licenses and technical assistance). The data also involves information regarding public R&D funding in the form of subsidies that have contributed to the financing of firms' R&D activities (González et al. 2007). It is only based on analysis of data in Spain academicians have been successful in establishing that some firms – mainly small and operating in low technology sectors – might not have engaged in R&D activities in the absence of subsidies in Spain.

Considering above results, it is crucial for the GoI to carry out studies to first identify major industries with potential of increasing R&D investment and to identify which among these industries are likely to show a substitutability (crowding out)[8] effect towards a government subsidy or grant and which are likely to show a complementarity (crowding in). Further in order to identify the potential of government investment, GoI is required to collect more data in the given context.

c. Entrepreneurship as a part of science curriculum

Emphasis is being given to promotion of entrepreneurial space in science in Europe and other developed nations. For example, the Entrepreneurship 2020 Action Plan in Europe, which aims to provide education and training, to better entrepreneurial environment and to develop entrepreneurial role models, is under blueprint stage to enhance the European growth dynamics (Entrepreneurship 2020 Action Plan, 2015). India is also realizing the importance of entrepreneurship and is reviewing the draft entrepreneurial policy.

This draft policy highlights that Entrepreneurship Development Cells (EDCs) have been promoted in the engineering and technological colleges. However, only 80 EDCs has been sponsored so far across India. This new policy once implemented will be able to incorporate entrepreneurship as a central component of education. While this policy is giving due attention to much neglected aspects of entrepreneurship, main challenge still remains the time it takes to implement these policy.

Earlier as well, in 2000, the University Grants Commission (UGC) of India emphasized on a curriculum for undergraduate education in entrepreneurship and distributed it to universities and colleges; however, only small number of colleges could actually implement it. Some of the deadlines as documented in the draft policy are over and some are approaching faster (Draft National Entrepreneurship Policy for review 2015). A quicker reaction on the government's part in promoting entrepreneurship can be one key asset in India's development.

7. Conclusion

Science, technology and innovations have been central in the growth and development of India in the past few decades. However, India has lagged behind some of its peer countries like China and Brazil and the pace of catch-up still falls behind the pace of these countries as reflected by India's low comparative performance as shown in GDP, GDP per capita, population, fertility rate, mortality rate and life expectancy. India is already placing emphasis on strengthening science, technology and innovation. The efforts are indeed reflected in the high productivity data for both total factor productivity and labour productivity in However, India has lagged behind some of its peer countries like China and Brazil and the pace of catch-up still falls behind the pace of these countries as reflected by India's low comparative performance as shown in GDP, GDP per capita, population, fertility rate, mortality rate and life expectancy. comparison to Singapore. At the same time, it is observed that the entrepreneurial activities in India are on the decline, a situation that is likely to slow down India's catch up process. It indicates a requirement of government intervention

8 A substitutability (crowding out) effect towards a government subsidy or grant means increasing government contribution will decrease industry over all contribution whereas a complementarity (crowding in) effect towards a government subsidy or grant means increasing government contribution will increase industry over all contribution.

to boost entrepreneurial activities. We bring forth to the attention of the policy makers key tools for implementation of already existing STIP, based on the experiences from across the world. These tools are:

· Making the government as a venture capitalist to support entrepreneurship,

· Making a robust database for all and major aspects of science and innovations to facilitate policy designs and

· Incorporating entrepreneurial as a part of the science curriculum at a faster pace to integrate science and innovation with profitability.

These three factors together constitute the "E for entrepreneurship" and are likely to prove to be an accelerator to the science, technological and innovation led growth and development.

About authors

Ms. Ragini Chaurasia

Ms. Ragini Chaurasia is a graduate student in Economics (2014-16) at Sciences Po, Paris and a current intern at the Development Centre, OECD Paris. She pursued her internship at UNESCO Cluster Office in India (covering Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka) and worked on the Science, Technology and Innovation Policy of India. Previously, she worked as a Consultant PricewaterhouseCoopers (PwC) Private Limited for two years where she has experience ranging from identification of policy gaps in India vis à vis the world to impact evaluation of social initiatives. She holds a Bachelor of Technology degree from Indian Institute of Technology Delhi (IITD), India.

Dr. Mitrasen Bhikajee

Dr. Mitrasen Bhikajee is a senior program specialist and heads the science sector of the UNESCO Cluster Office in India (covering Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka). Prior to this post, Dr. Bhikajee was the Deputy Executive Secretary of the Intergovernmental Oceanographic Commission of UNESCO in Paris (2011-2014) and the Director of the Mauritius Oceanography Institute (2004-2011). He was Associate Professor at the University of Mauritius and spent fourteen years in marine biology research (1989-2004). He holds a B.Sc. in Zoology, a Master's degree in Fisheries Management and a Ph.D. in Marine Biology.

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Annexure

Annexure 1

Table 6 . Year wise Financial Support in project mode in Research in Science & Technology, Women Scientists Programs

Year	Number of projects	Duration of project (years)	Total budget (US$)
2008	19	2	220522
2007	42	2	527750
2006	43	2	491946
2005	22	2.6	247799

Source: Department of Science and Technology

Annexure 2

Table 7. Year wise expenditure in National Science & Technology Management Information System (NSTMIS)

Year	Number of projects	Average duration (years)	Total budget (US$)
2014	20	1.5	517790
2013	9	1.7	150297
2012	2	2.0	42245
2011	4	0.6	103020
2010	13	1.7	1266321
2009	8	1.4	178867
2008	5	1.9	142304
2007	11	1.5	293033
2006	4	1.4	78067
2005	5	1.8	138794
2004	10	1.9	182671

Source: Department of Science and Technology

Industry 4.0 and Object-Oriented Development: Incremental and Architectural Change

Martin Prause [*1], *Juergen Weigand* [1]

Abstract: Industry 4.0 in manufacturing is about combining cyber-physical systems with industrial automation systems. This integration of systems so different in nature aims to create context-aware factories in which people and machines are in real-time alignment. This paper examines the change processes triggered by Industry 4.0 from a conceptual perspective. We find that the observed patterns of change are not novel but have a lot in common with the paradigmatic shift in software development from structured to object-oriented development. The latter approach features to be incremental in the production phase and architectural in the product and process design phase. We argue that Industry 4.0 will be equally paradigmatic and mind-set changing for architects and engineers as to crafting production processes and creating products for the future.

Keywords: Advanced Manufacturing; Industry 4.0; Object-oriented Development; Technological Change; Technological Innovation

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Introduction

The future of manufacturing is being shaped by megatrends such as changing demographics, globalization, scarcity of resources, climate change, dynamic technologies and innovations, and mass customization (Abele and Reinhart, 2011). Industry 4.0 is Germany's policy answer (BMBF, 2013) to increasing complexities of manufacturing systems and mounting external environmental challenges (Spath et al., 2013). Proclaimed as the fourth industrial revolution, Industry 4.0 is set to be paradigm and strategy – a novel approach to thinking manufacturing and the way of "how-to" transition from traditionally centralized control structures to decentralized ones (BMBF, 2013). In essence, Industry 4.0 is the intelligent real-time, horizontal and vertical integration of humans and machines with objects and information and communication technology systems ("digitalization") to enable a flexible and dynamic management of complex systems (Bauer et al., 2014). More specifically, Industry 4.0 can be defined as the "[…] integration of cyber-physical-systems in production and logistics as well as the application of Internet of Things in industrial processes. This includes the consequences for the value chain, business models, services and work environment." (Kagermann and Wahlster, 2013).

Digitalizing the production chain is not a new trend. During the early 1990s computer integrated manufacturing (CIM) turned into a hype and gained significant momentum. CIM rested on the idea of a fully automated production process from procurement and production to distribution without necessitating human interaction (Bauernhansl et al., 2014). Its successful implementation however was hampered mainly due to missing information and communication technology (ICT) standards (Spath et al., 2013), insufficient understanding, human resistance to change, organizational incompatibilities, and lack of skilled labour to implement and use CIM (McGaughey and Snyder, 1994).

Today the situation is different. On the social dimension, industries are experiencing a shift from an economy centered on organizations to one centered on the individual (Bermann et al., 2013). Based on assistive (ambient) systems and sophisticated human-to-machine interfaces production process flexibility and employees play a key role in Industry 4.0 (Spath et al., 2013). On the technology front, wireless communication and the Internet of Things have reached industrial maturity (Evans and Annunziata, 2012). Politically, the German federal government pushes the importance of standardization (Pichler and Reinhold, 2015; Wahlster, 2014).

The trend of defining and pursuing advanced manufacturing strategies for national economic growth gained momentum in large economies recently. The President's Council of Advisors on Science and Technology in the United States advised the Government to implement an advanced manufacturing strategy (PCAST, 2011), which was accompanied by a national strategy plan one year later (NCST, 2012). Europe's *Horizon 2020* strategy constitutes a roadmap for the factories of the future based on intelligent manufacturing machines (European Commission, 2013). China's State Council has announced its *Made in China 2025* strategy to upgrade its industrial sector across a broad range of industries focusing on intelligent manufacturing product and process innovations, advanced materials, and green manufacturing (State Council, 2015). According to Dezhina et al. (2015), the Russian government has been prioritizing advanced manufacturing since 2013.

However, this momentum will not radically change manufacturing by tomorrow. According to the President of the German National Academy of Science and Engineering, the impact of Industry 4.0 will be revolutionary but its diffusion 4.0 is likely to be evolutionary (Spath et al., 2013).

(1) WHU – Otto Beisheim School of Management Burgplatz 2, Campus Vallendar, Germany
*Corresponding author: martin.prause@whu.edu

A similar paradigmatic revolutionary change with evolutionary transition was experienced by the software industry which transitioned between the early 1970s and the 1990s from structured system development to object oriented system development. In structured system development, the overall process is factored into modules, and each module in the system represents a step in the overall process. The overall process and its decomposition into modules can be represented as a structured top-down chart. In the object-oriented approach, the structure of the system is created around the objects that exist in the model of reality (problem domain). The overall process can be represented as a set of interacting objects (Booch, 1986). Objects represent elements of the problem domain. Different concepts and tools have been developed to support this paradigm in the design phase (object oriented design, OOD) and in the implementation phase (object-oriented programming, OOP).

Similar determined efforts have been made recently in the area of industrial automation systems (IAS). With the specification of a digital factory by the International Electrotechnical Commission (IEC 62832) and the upgrade of the standard specification for programmable controls (IEC 61131 – Version 3), object oriented paradigms were introduced to industrial automation systems in design and implementation phases. Preliminary reference models for Industry 4.0 are directly created using an object oriented structure (Adolphs et al., 2015).

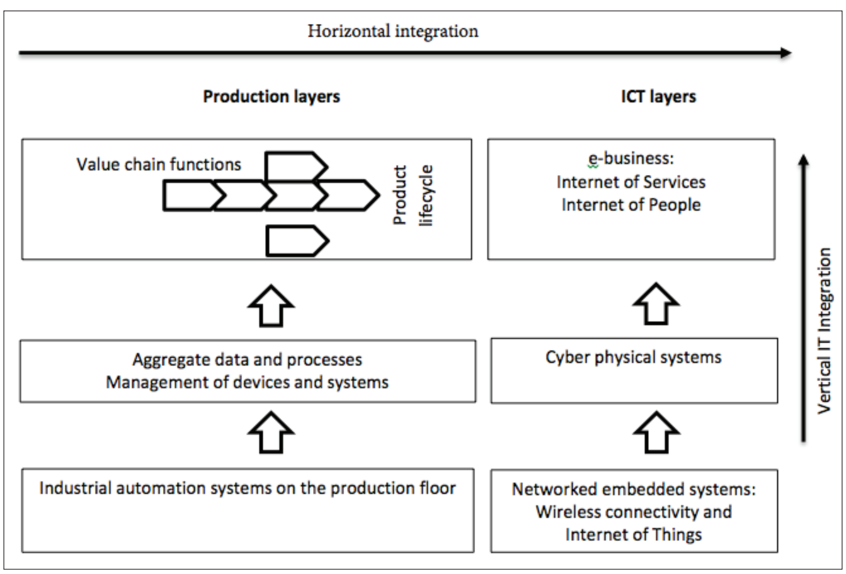
The present paper compares the Industry 4.0 approach and object-oriented development, conceptualizes the resulting system changes, and derives management implications.

Core principles of Industry 4.0

Today's industrial automation systems comprise of a plant to perform the physical process (physical world). Connected and embedded computers in combination with software systems (cyber or virtual world) control and monitor the production process by receiving and analysing inputs from the plant and regulating the site by the computational results (Thramboulidis, 2015). Due to the increase of external complexity originating from megatrends and internal complexity such as increasing product-, customer- and supplier-portfolios, new materials, production processes and IT systems, manufacturing companies have to balance inner and outer complexity to remain competitive (Bauer et al., 2014). The balancing act of increasing product variety and decreasing production batches increases the challenges for a centrally controlled production system. Decentralization facilitates the reduction of complexity (Spath et al., 2013).

The so-called Smart Factory is a specific deployment of the Industry 4.0. The Smart Factory is modularized, self-regulatory (self-adaptive) and digitally integrated with all business functions, within and beyond the organizational boundaries. A Smart factory comprises of intelligent sensor and actor systems (cyber-physical system) to facilitate context sensitive production processes and ICT-based integration of this system across the value chain, value network, and product lifecycle. The Smart Factory is based on transferring the idea of ubiquitous (wireless) computing (Weiser, 1991) to an industrial context (Zuehlke, 2010). A Smart Factory is a "[…] Factory that context aware assists people and machines in execution of their tasks […] by systems working in background, so-called calm systems and context-aware applications" (Lucke et al., 2008). A cyber-physical system (CPS) includes sensors and actors to recognize objects, machines and humans in the production environment to trigger actions based on the environmental context. Successful integration of CPS in the context of Industry 4.0 requires firms to focus on "[…] horizontal integration through value networks, end-to-end digital integration of engineering across the entire value chain and vertical integration and networked manufacturing systems" (Kagermann and Wahlster, 2013) (cf. Figure 1).

Figure 1: The basic concept of Industry 4.0: Connecting machines, products and humans along the horizontal production layers and vertical ICT layers



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Cyber-physical systems vertically integrate the physical world of production plants and embedded devices, based on the Internet of Things, with the virtual world of business processes, the Internet of Services, and social network systems for human-machine communication, the Internet of People. In this concept, objects, machines, and humans have two abilities: (1) an inner state and (2) the capability to communicate the inner state. It implies that products can communicate with their environment (at least passively) as so-called *Smart Products*. A Smart Product is not only uniquely identifiable, but it also has additional attributes to reflect its state and a plan of action for the next production step based on its current context (Vogel-Heuser, 2014; Wahlster, 2014). Depending on its context, which is monitored by sensors and actors, the smart product provides the machine with the logic to process the product. Put differently, the logic of the production process is partly decomposed to the interacting elements. This concept induces the changes from a structured centralized (top-down) control to a decentralized (bottom-up) control, based on the state of and interaction between products, machines, and humans.

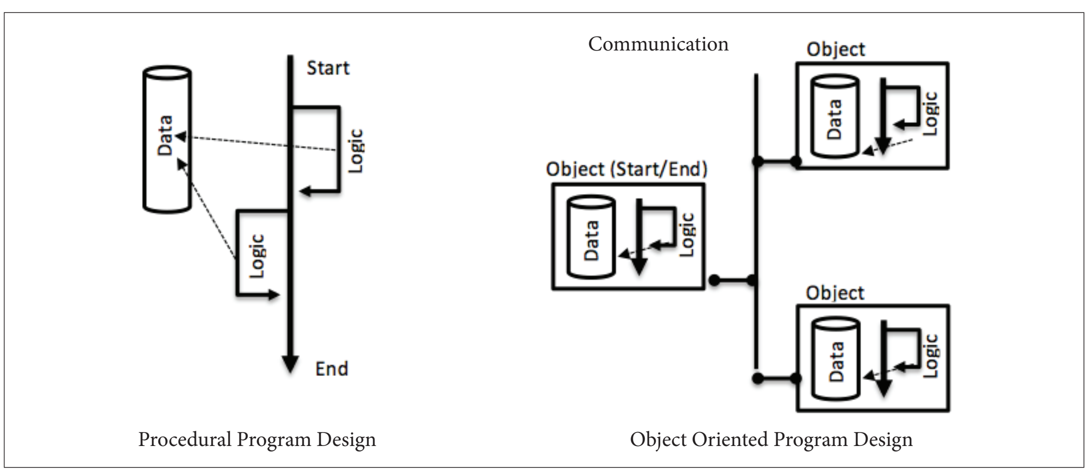
Object-oriented development

Object-oriented programming was first drafted by Ole-Johan Dahl and Kristen Nygaard in 1961 by designing the programming language Simula (Dahl, 1981). The idea evolved and became finally prominent in 1972 with the development of the programming language Smalltalk by Xerox (Capretz, 2003). Since then and for the ensuing 25 years, object-oriented programming took an evolutionary path before peaking in the 1990th (Sircar et al., 2001). Until object-oriented programming became popular, the software was written in a procedural way. Its logic and data was centrally structured. The logic defines how the data must be modified. Data and logic were kept separately. With the exponential increase of computational power two challenges emerged. First, the execution of code became more efficient. Therefore, programs of higher complexity could be created. Consequently, it became increasingly difficult to keep track of and maintain the entire program logic, which led to a software crisis in the early 1990s. The relative cost of maintenance and development had by far exceeded hardware costs (Selvi et al., 2009). Second, to speed up computing parallel execution of code was desired but hard to implement, because the centralized logic and data structure could hardly be split up to be served by different machines.

Object-oriented development proved a solution to these complexity and concurrency challenges. Elements of a problem (model of reality) are represented by objects that mimic elements of the problem domain and just solve sub-problems (Bitter and Rick et al, 2001). An object comprises of internal data to reflect its state and a logic to modify the data to solve the sub-problem. Thus data and logic are highly cohesive. Both data and logic are encapsulated in a *class*. A class is a general definition or template of an element of the problem domain. During the execution of a program, objects are created from a class. These objects are specific instances of a class. For example, assume a class *Dog* with specific attributes e.g. *can bark* and *has four legs*. While the class *Dog* is a general definition of a dog, an instantiated object of the class *Dog* would be a *Terrier*, *Collie* or *Shepard*. All instantiated objects have the specified attributes in common (*can bark* and *has four legs*) and probably more specific attributes. Data and logic are restrictively accessible within the object scope (encapsulation), which leads to low cohesiveness among objects. To communicate with its environment, an object provides a service, so-called *methods*, which can be invoked by other objects to exchange data or trigger some object-specific behavior. A top-level program handles the communication between the loosely cohesive objects and combines the results of the solved sub-problems. As long as the program can handle the class Dog, it can handle any object (*Terrier*, *Collie* or *Shepard*) based on the class dog. The difference between procedural program design and object oriented program design is depicted in Figure 2.

While object-oriented programming has many other features such as inheritance or modularization or polymorphism etc. (Dahl, 1981) to reduce complexity (increase reusability) and enhance concurrency, the key element is based on abstraction and encapsulation.

Figure 2. In the procedural design pattern the logic of the program is structured in procedures (sub-routines) which all access a common data set. In object-oriented design, each object has its own data set. The abstraction is modeled by the boundaries of an object and the communication element. The inner logic of an object, how to solve a problem, is not visible to others.



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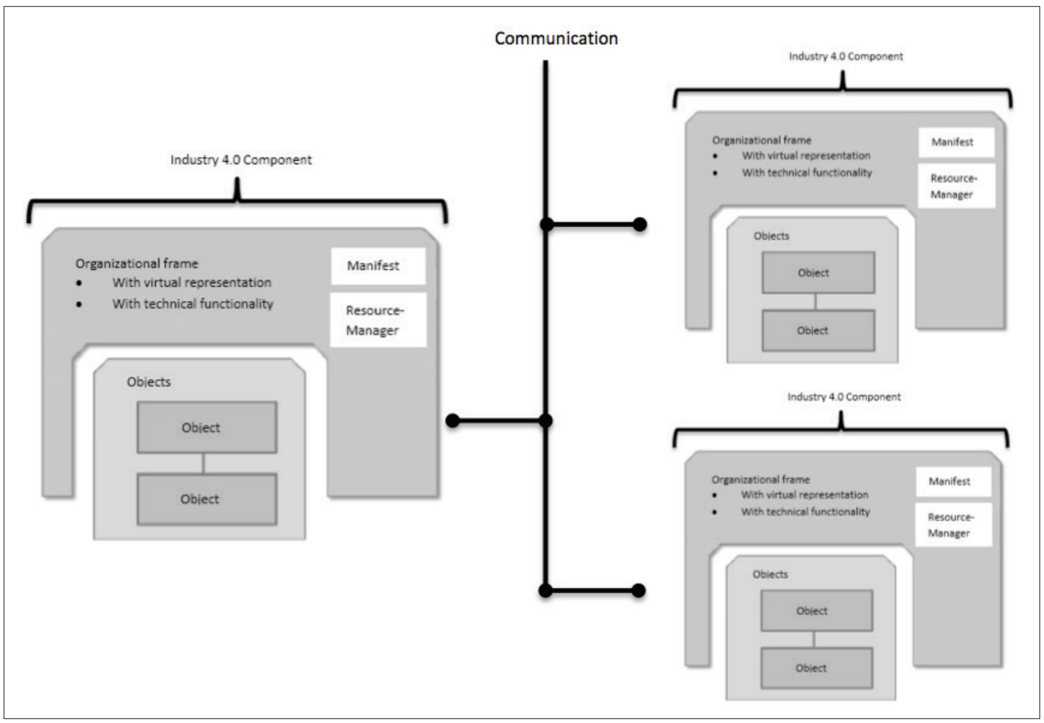
Conceptual similarities between Industry 4.0 and object-oriented development

The change processes in software development and presently in manufacturing have the same root cause. Increasing complexity forces the system to change from centrally-structured control to decentrally-structured control, with a higher degree of autonomy, self-regulation, and self-optimization. This fragmentation of the value chain has been already postulated in the context of fractal factories in 1995 (Warnecke, 1995). Both approaches take a bottom-up approach to implement decentralization and shift the program logic to the decomposed elements.

The model of such a decomposed system in Industry 4.0 is based on a reference architecture with its core element, the Industry 4.0 component (Figure 3). Like an object in object-oriented development may represent any element of the problem domain, the Industry 4.0 component may represent either a production system, a single machine, an assembly line group or a product (Adolphs et al., 2015). It comprises of the physical objects (products or materials) and an organizational frame, which encapsulates the physical objects from their environment and handles the communication. The frame contains a virtual representation of the physical objects, the technical functionalities describing the logic of the production steps, and the overhead data. In analogy with the object-oriented paradigm, data and logic are combined and only restrictively accessible within the scope of the object. Among objects, relationships are loosely cohesive.

Figure 3. Reference architecture of Industry 4.0 based on standardized components and communication. The Industry 4.0 components can contain different objects (products or materials) and communicate using standardized interface. The picture is adopted from (Adolphs et al., 2015).



The standardized organizational frame bridges the physical and virtual word. The control of the process has been partially decentralized and decomposed to the respective components. Abstraction and encapsulation ensure that a particular machine can handle different products without the necessity to pre-program the machine. As long as the machine can handle the type of an Industry 4.0 component it can be processed based on the logic defined by the component itself.

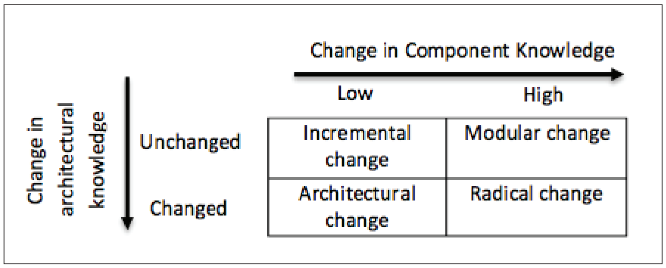
According to Adolphs et al. (2015) the preliminary reference architecture of Industry 4.0 distinguishes between type and instance. A type describes the concept from an idea and development phase to a first prototype of a product. This type serves as a template for the production stage. An instance of a type is a particular produced product (with a serial number). This conceptualization resonates with the class and object paradigm in object oriented development. A class provides a general template. Every logic which can handle this template can also handle any object of this class without knowing its specific instance. The reference model highlights that a similar behavior applies to the type construct, which shares information and data throughout the design and production phases and across different stakeholders, such as suppliers, engineers, and machinists.

Further improvement by implementing self-aware components, which can evolve and even adapt their problem solving behaviour and pass their successful logic on to others, would yield the analogy to inheritance in object oriented development (Lachmayer et al., 2014).

System change of Industry 4.0 and object-oriented development

The change from industrial automation systems to systems conforming with Industry 4.0 follows the categorization of Sircar et al. (2001), who applied the framework of Henderson (1992) to classify the change from structured development to object-oriented development. A system comprises of elements and architecture, reflecting their relationships. A change of a system can be anywhere among those two dimensions (cf. Figure 4).

Figure 4. Classification of the component and architectural change of a system (adopted from Henderson 1992)



Sircar et al. (2001) showed that the change during the analysis and design phase is architectural, because the relationship between elements undergoes a transformation. This is often discussed as a mind shift programmers have to assimilate (Due, 1993). During the implementation phase, the basic programming elements remained the same. Programming languages just supported object-oriented programming by adding more features and constructs. At later stages languages, such as Java, were designed to force programmers to develop in an object-oriented way. However, because the set of elements which constitutes a program did not change, the authors classified it as an incremental change during the implementation phase.

Conceptually, the elements of a production process such as machines and products undergo minor changes compared to the processes. Despite all the challenges to standardize a digital factory and its components (IEC 62832), the change is incremental, because the elements that constitute the whole remain the same. They are encapsulated in Industry 4.0 components, which enrich their functionalities. However, new elements that are elements of the production system are not added. From the architectural perspective, Industry 4.0 facilitates a shift from a centralized to a decentralized production system based on new relationships between those elements. Specifically, process logic is attached to an Industry 4.0 component rather than the machine. The communication among Industry 4.0 components, machines and humans, relies on context-aware systems rather than on centralized control of production. Context-awareness thus facilitates a self-controlled autonomous system.

Programming and manufacturing are inherently two different things. Software solves problems by creating and processing virtual data while manufacturing creates or processes physical products. Nevertheless, the concept of Industry 4.0 and its determinants enables similar change patterns by moving from structured production to object-oriented production in Industry 4.0. The revolutionary character could not only materialize in economic terms, but it could also manifest in a new way of how products are designed and manufactured. This materializes in new development methods and different skills for employees in the design and production phase.

In software development, the development process changes from the top-down waterfall model of structured development to the spiral model of object-oriented development. A similar change has been postulated by Kagermann and Wahlster (2013) for Industry 4.0 with a shift from structured development and production toward a continuous engineering process throughout the whole value chain and network.

Regarding labour skills, Hartmann and Bovenschulte (2013) visualize a skill roadmap for Industry 4.0. They highlight that the existing workforce will be complemented by new IT and technical skills such as Industrial ICT Specialists or Mechatronics Specialists. Based on their education, they already have a head start in object-oriented development, since it is part of any IT related educational curriculum. Thramboulidis (2015) proposes a cyber-physical system for industry automation and emphasizes the challenges for engineers to develop in an object-oriented way. The requirements in Industry 4.0 increasingly focus on cross-functional skills with the effect that the boundaries between blue-collar and white-collar workers will become more blurry (Kagermann and Wahlster, 2013).

As argued by Fichman and Kemerer (1997) complex organizational technologies in general and software process innovation, such as object-oriented programming, in particular create knowledge barriers that inhibit their diffusion. The authors emphasize that organizations with "higher leaning-related scale [scale of activities over which learning costs can be spread], greater related knowledge [existing knowledge related to focal innovation], and greater diversity of knowledge and activities be more prone to innovate, because such organizations can better amortize learning costs, can more easily acquire the knowledge needed to innovate" (Fichman and Kemerer, 1997). As Industry 4.0 carries a similar burden of organizational change, further research on Industry 4.0 assimilation and diffusion should not only focus on determinants and diffusion patterns, but also draw a comparison to object-oriented development diffusion.

Conclusion

Industry 4.0 induces a system change in manufacturing from central to decentral control of production. The change from a top-down to a bottom-up approach shares some similarities with the evolution from structured to object-oriented software development. First, the cause of the change is a system, either software or production, which gets increasingly complex and can only be handled by decentralizing the control. Second, both approaches start from the bottom and decompose the software or production logic to software objects or Industry 4.0 components, which encapsulate data and logic in single entities and are loosely cohesive in communication. Third, the distinction between class and object in software development and type and instance in Industry 4.0 facilitates a change in the development process from a top-down waterfall model to a spiral model in object-oriented development or continuous engineering along the value chain and network. Employing Henderson's framework (Henderson, 1992) the change pattern in Industry 4.0 resembles the change pattern in object-oriented development: incremental in the production phase and architectural in the design phase. In object-oriented development, architectural change induces a mind-set shift in designing software. By the same token, Industry 4.0 induces the development of new cross-functional labour skills. The delineation of blue-collar and white-collar workers will become less relevant.

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Cooperación Académica en Latinoamérica para la Innovación en los Agronegocios

Liliana Scoponi [*1], *Marcelo Fernandes Pacheco Dias* [2], *Gabriela Pesce* [1], *María Alicia Schmidt1, Matías Gzain* [1]

Resumen: Cuando no existe transferencia de conocimiento al sector productivo o en casos donde la capacidad científico-tecnológica de las universidades es débil, como sucede en varias universidades latinoamericanas, las posibilidades de desarrollo económico se reducen. Frente a este problema, el objetivo del presente trabajo es realizar un análisis de las redes sociales de profesores y unidades académicas involucradas en la generación y transferencia de conocimientos sobre agronegocios de una universidad argentina y otra brasilera. El estudio se efectúa sobre la producción de tesis, investigación y extensión durante un período de cuatro años y se utiliza la metodología cuantitativa de Análisis de Redes Sociales. Los resultados muestran redes más fortalecidas y cooperativas en investigación sobre agronegocios de la universidad argentina, mientras que indican mayor desarrollo en redes de extensión y tesis de la universidad brasilera. Se observó en las redes de mayor tamaño condiciones de *Small World* y una actuación interdisciplinar.

Palabras clave: redes; universidad; agronegocios; innovación; Latinoamérica; Small World

Title: Academic Cooperation in Latin America for Innovation in Agribusiness

Abstract: When there is no transfer of knowledge to the productive sector, or in cases where scientific and technological capacity of universities is weak, such as in numerous Latin American universities, chances of economic development are reduced.In the framework of this problem, the objective of this article is to perform a comparative analysis of social networks of teachers and academic departments involved in the generation and transfer of knowledge on agribusiness of an Argentine and a Brazilian university. This analysis is built by the production of theses, research projects and extension activities, during a four-year-period and quantitative methodology of Social Network Analysis is applied. The main results show more strengthened and cooperative networks in research on agribusiness in Argentine university, while indicating further development of extension and thesis networks atthe Brazilian university. Small World conditions and an interdisciplinary performance were observed in larger networks.

Keywords: networks; university; agribusiness; innovation; Latin America; Small World.

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1. Introducción

En las economías de Latinoamérica, los agronegocios constituyen una de las principales fuentes de riqueza y desarrollo. Participan en el Producto Bruto Interno con valores superiores al 30% (Silva &Cantou, 2006), por lo cual su significación trae aparejada la necesidad de ganar o mantener ventajas comparativas y/o competitivas que permitan a las cadenas agroalimentarias captar mayores oportunidades en el mercado internacional.

En este contexto, la innovación juega un rol fundamental (Schumpeter, 1942). Sin embargo, para Metcalfe (2003) pocas empresas tienen condiciones para innovar aisladamente y destaca a tal fin, la cooperación con las universidades en el marco de los sistemas nacionales o regionales de innovación. En consecuencia, en la actual sociedad del conocimiento, las políticas de Investigación y Desarrollo (I+D) orientadas hacia la construcción de competitividad, deben apuntar a fortalecer las capacidades para resolver problemas específicos, planteados por las empresas o por la sociedad en general, que satisfagan las demandas del mercado (Silva &Cantou, 2006).

Los enfoques sobre sistemas de innovación hacen hincapié en la necesidad de compartir e integrar conocimientos distribuidos entre sus componentes a través del aprendizaje mediante la interacción. Innovación y aprendizaje interactivo son dos conceptos centrales de un nuevo paradigma tecno-económico que ha surgido en las últimas décadas del siglo XX, donde las universidades asumen la función de participar activamente en el desarrollo económico y social de sus entornos y adoptan el rol de promotoras de la competitividad de las empresas (Arocena&Sutz, 2001; Dagnino, 2003; Sorondo, 2004).

Según Arocena&Sutz (2001) existe una mayor interpenetración de lógicas que presentaban antes facetas claramente diferenciadas: ciencia y tecnología; academia y sectores productivos e interés privado e interés público. Se advierte una mayor interrelación entre el contexto del descubrimiento y el contexto de la aplicación, donde en la academia se da paso a la investigación transdisciplinaria, realizada mediante equipos reunidos para resolver oportunamente determinados problemas, en lugar de la investigación con énfasis en cada disciplina, en torno a un cierto tema.

(1) Departamento de Ciencias de la Administración, Universidad Nacional del Sur, Bahía Blanca, provincia de Buenos Aires, Argentina.
(2) Facultad de Administración y Turismo – Universidad Federal de Pelotas, Rio Grande do Sul, Brasil.
*Corresponding author: liliana.scoponi@uns.edu.ar

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El modelo tradicional de ciencia durante los últimos cuarenta años se transforma, y evoluciona de un escenario de aislamiento e individualismo hacia otro de cooperación en redes de conocimiento, capaces de conducir esfuerzos colaborativos de investigación para resolver problemas complejos (Sebastián, 2003; Klenk, Hickey&Maclellan, 2010). La colaboración es un proceso en el cual diferentes partes con dominio sobre un problema, percibiendo sus diferentes aspectosinterdisciplinarios, exploran sus diferencias en un proceso interactivo, mediante división de roles, normas y estructuras que posibiliten resolver o decidir cuestiones relacionadas a dicho problema (Olave& Amato, 2001; Arocena&Sutz, 2001).

Sin embargo, la universidad latinoamericana ha asumido tradicionalmente un carácter de enseñanza; en virtud de lo cual,el desarrollo de competencias en los ámbitos de la gestión científica y tecnológica ha sido por mucho tiempo una actividad suplementaria. Esto afecta la oferta de la universidad en su relación con el sector productivo, ya que depende de la capacidad científica y tecnológica que la misma posea (Plonski, 1994; Vega Jurado *et al.*, 2011). Así, Vega Jurado*et al.* (2011) resaltan que para consolidar la relación de la universidad con el sector productivo en Latinoamérica, de forma que sea capaz de promover procesos de innovación empresarial y de desarrollo territorial, es necesario mejorar la investigación universitaria.

Considerando la importancia que reviste la producción de conocimiento y la integración de las universidades para el desarrollo económico y social, en un contexto donde los agronegocios son significativos en las economías latinoamericanas, se plantea la siguiente pregunta de investigación: ¿cómo se desenvuelve la interacción entre docentes investigadores a los fines de la producción y diseminación de conocimientos inherentes a los agronegocios?

Para responder a esta pregunta,se realizó una investigación basada en documentos en dos universidades de Latinoamérica, la Universidad Nacional del Sur (UNS) emplazada en el Sudoeste Bonaerense de Argentina y la Universidad Federal de Pelotas (UFPel) ubicada en el Estado de Rio Grande do Sul de Brasil. Ambas universidades son públicas, similares en tamaño, y se encuentran en regiones donde predomina la actividad agroalimentaria, en particular el agronegocio de la carne bovina que es relevante para su desarrollo económico y social. El objetivo de la investigación persigue analizar en ambas organizaciones los patrones de interacción de docentes investigadores involucrados en la producción y diseminación de conocimientos para los agronegocios. A los efectos deidentificar la estructura de estos vínculos, se utilizó el método de Análisis de Redes Sociales (ARS). Los documentos examinados fueron proyectos de investigación, tesis y disertaciones de posgrado con vistas a caracterizar la producción de conocimiento, y proyectos de extensión para valorar los procesos de diseminación hacia los agronegocios, comprendidos entre los años 2010 y 2013.

El método de ARS ha sido principalmente empleado para identificar los patrones de relación entre profesores en la construcción de conocimiento de las disciplinas científicas (Marteleto, 2001; Rossoni*et al.*, 2008; Martins, 2009)y de diferentes programas de posgrado (Rossoni&Guarido Filho, 2009; Nascimento&Beuren, 2011). No obstante, se reconoce la necesidad de ampliar este tipo de estudios que posibiliten comprender los procesos de generación y transferencia de conocimiento dentro de las universidades (Quintella*et al.*, 2009). De tal modo,los resultados de esta investigación pueden aportar respuestas para conocer la condición de las universidades analizadasen cuanto su contribución en los procesos de innovación en las cadenas agroalimentarias de las regiones bajo estudio.Por otra parte, desde lo metodológico, sevalora la existencia de *Small World*o Mundo Pequeño, de modo de avanzar en la profundización de la validación e interpretación de este fenómeno para comprender los procesos de generación y difusión de conocimientos dentro de la disciplina administrativa (Rossoni*et al.*, 2008; Zancan*et al.*, 2012; Brand &Verschoore, 2014).

El trabajo se estructura de la siguiente manera: en la siguiente sección se efectúa una revisión de la literatura sobre ARS y la aplicación de sus medidas principales para analizar la cooperación académica; en la tercerasección se describe la metodología empleada en el presente estudio; posteriormente en la cuarta sección se presentan los resultados y su discusión. Por último, se concluye sobre la relevancia de los resultados de esta investigación y las futuras líneas de acción en la quintasección.

2. Análisis de Redes Sociales (ARS) en el campo de la cooperación académica

2.1. Indicadores descriptivos de las estructuras de relaciones

La noción de redes sociales y los métodos de análisis de ellas basados en el lenguaje matemático de la teoríade Grafos, de las matrices y del álgebra relacionalhan generado gran interés y curiosidad en las Ciencias Sociales durante las últimas décadas (Wasserman &Faust, 1994; Carrington, Scott & Wasserman, 2005).

Se entiende por red social a una serie de vínculos entre un conjunto definido de actores sociales (individuos, grupos, organizaciones, países, etc.). Las características de estos vínculos como un todo tienen la propiedad de proporcionar interpretaciones de la conducta social de los actores implicados en la red (Requena Santos, 1989). Por lo tanto, desde el punto de vista delAnálisis de Redes Sociales, el ambiente puede ser expresado como patrones en las relaciones entre las unidades de interacción, que se conocen como estructura. En el análisis de redes no se presta tanta atención a los atributos de los actores que conforman la red, sino a los vínculos que los relacionan (Wasserman &Faust, 1994).

El campo científico y académico constituye un sistema social, dado que presenta relaciones reflejadas por actores o colectividades, que son establecidas como prácticas sociales regulares (Giddens, 1989; Machado-da- Silva &Rossoni, 2007). La comunidad académica es propensa a la formación de redes atendiendo sus características propias, puesto que el intercambio de ideas e informaciones genera renovación y creación de nuevos conocimientos (Quintella*et al.*, 2009; de Souza Vanz, 2013). Los científicos inmersos en redes de cooperación comparten perspectivas y condiciones de operacionalización de sus investigaciones, influenciándose mutuamente, lo cual condiciona el establecimiento de contenidos sustantivos(Rossoni & Guarido Filho, 2009). Por lo tanto, la utilización de redes socialesen el análisis de la producción científica permite observar aspectos interdisciplinarios de la colaboración entre investigadores, y asimismo, proporcionar entendimiento sobre la estructuración de un determinado campo de conocimiento (Silva *et al.*, 2006).

En cuanto al tipo de relaciones entre los docentes investigadores de las universidades,éstas se manifiestan de diversas formas, como participación en proyectos de investigación, tesis y disertaciones de posgrado y actividades de extensión, entre otras, las cuales han sido seleccionadas para este estudio en el campo de los agronegocios.Con el propósito dedescribir la estructura de esos vínculos,Wasserman &Faust (1994) proponen un conjunto de métricas o medidas, que buscan cuantificar las variables estructurales de los patrones que caracterizan una red, tales como: tamaño de la red, que refiere al total de nodos que la componen;número de componentes o subgrafos; tamaño de la componente principal o subgrafo de mayor tamaño; distancia geodésica, que mide el largo del camino más corto entre dos nodos; y diámetro, que mide la distancia del camino más largo que conecta un par de nodos.

Otra de las métricas generales del ARS para caracterizar la estructura de una red es la densidad. La densidadexpresa el grado de vinculación entre los actores de una red, demostrando la relación entre el número de lazos efectivamente realizados sobre total factible. Cuando muchas posibilidades de relacionamiento están ausentes se conforman lazos débiles entre los actores, indicando una baja densidad de la red. Por el contrario, la presencia de muchas posibilidades de vinculación indica una consistencia y una proximidad entre los actores, tornándolos densamente conectados y correspondiéndose con lazos fuertes (Granovetter, 1973; Tomaél&Marteleto, 2007; Martins, 2009).Otra medidaque permite caracterizar la estructura de una red es lafragmentación, que indica el aislamiento en la red y cuenta el número de pares de nodos desconectados entre sí (Borgatti*et al.*, 2013).

2.2.El fenómeno de Mundos Pequeños

Finalmente, un tipo de abordaje que es aplicado para el análisis topológico de redes complejas de gran porte es el denominado fenómeno de *Small Worlds* o Mundos Pequeños(Martins, 2009). A partir del experimento de Milgram (1967), se observó que los actores que integran una gran red, aún cuando no estén directamente vinculados entre sí, pueden conectarse a partir de un número pequeño de intermediarios. Watts &Stogatz (1998) establecieron las medidas de *Small Worlds*, concluyendo que este fenómeno ocurre cuando los actores de una gran red de baja densidad, están altamente agrupados localmente, conformando diferentes y bien definidos *clusters,* y al mismo tiempo se encuentran ligados a actores de fuera de sus grupos por medio de un pequeño número de intermediarios. Contrariamente a los que sucede en redes aleatorias donde la distancia aumenta cada vez más con el número de nodos, la distancia media en un Mundo Pequeño presenta poca varianza.

Por lo tanto, la identificación del fenómeno de *Small Worlds,* se da a través de dos variables: el coeficiente de agrupamiento (*clusteringcoefficient*) (CC), que indica el grado de conectividad de los actores con quienes determinado actor se conecta, siendo una medida de densidad local, y la distancia media(PL). Para caracterizar el fenómeno deben presentarse las siguientes características calculadas sobre la componente principal de la red (Watts &Strogatz, 1998; Uzzi&Spiro, 2005; Quintella*et al.*, 2009; Martins, 2009):

a. La tasa PL (distancia media red (PL real)/ distancia media red aleatoria (PL aleatoria)) debe ser cercana a 1.

b. La tasa CC (coeficiente de agrupamiento real (CC real)/ coeficiente de agrupamiento aleatorio (CC aleatorio)) debe ser mayor que 1.

c. El coeficiente *Small Worlds* (Q) calculado como el cociente entre la tasa CC y la tasa PL, debe ser mayor que 1.

En virtud de ello, un grupo social posee cierto grado de apertura, de modo que cualquier vínculo externo a ese grupo representa un aumento exponencial de posibilidades de contactos, y consecuentemente, acceso a informaciones, conocimientos e influencia. En términos estructurales grupos cohesivos no se encuentran aislados, representando este fenómeno “la fuerza de los lazos débiles” (Granovetter, 1973).

Bajo el abordaje de Mundo Pequeño el desarrollo científico no sigue una lógica de fragmentación con grupos de investigación o de trabajo distintos sin relación entre sí. Sino que hay lazos entre ellos, en los cuales la información no es redundante, manteniéndose un nivel de cohesión necesario para que las actividades se tornen familiares entre los miembros de los distintos grupos (Uzzi&Spiro, 2005). De este modo este fenómeno provee estabilidad a las estructuras de relación y a las prácticas y valores científicos, hecho fundamental para entender la mutua relación entre estructuras locales y globales. Posibilita tratar condiciones de permanencia de formas de producción científica, especialmente en momentos de expansión, lo que no significa ausencia de transformación e innovación (Rossoni & Guarido Filho, 2009).

La cooperación entre investigadores fue analizada por varios autores. Moody (2004) lo hizo en el campo de la Sociología y Newman (2001) en el de Física. Ambos encontraron la presencia de Mundos Pequeños en la producción científica, con grupos bien delimitados, permeables, produciendo una conexión entre diferentes especialidades, aún cuando estuvieran distantes. Resultados similares fueron hallados en Brasil en el campo de los estudios organizacionales y de estrategia (Rossoni *et al.*, 2008; Rossoni & Machado-da-Silva, 2008). No obstante, otras investigaciones en Administración no identificaron el fenómeno en forma recurrente (Martins, 2009; Nascimento&Beuren, 2011).

3. Metodología

Para alcanzar el objetivo fijado se utiliza una estrategia de investigación descriptiva basada en documentos.La investigación en documentos es escogida, pues permite responder a cuestiones sobre el pasado y los cambios ocurridos haciendo uso de documentos (Saunders *et al.*, 2011).

El estudio se realiza comparativamente en dos universidades latinoamericanas: la Universidad Nacional del Sur (UNS) de la Argentina y la Universidad Federal de Pelotas (UFPel) de Brasil. Los documentos analizados comprenden la producción de tesis, proyectos de investigación y de extensiónligados a los agronegocios y a la cadena de la carne bovinade las mencionadas instituciones de educación superior,durante un periodo de 4 años (2010 – 2013). Se consideraron vinculados a los agronegocios aquellos proyectos o actividades que actúan en cualquier eslabón de la cadena de producción que involucra un producto animal o vegetal, así como también las actividades de apoyo a estas cadenas. Para relacionarse con la cadena de carne bovina, los proyectos se correspondieron con actuaciones en cualquier eslabón de dicha cadena de producción.

El relevamiento se efectúo a partir de fuentes de información secundarias representadas por registros internos de las universidades, información disponible en las bibliotecas institucionales y datos surgidos de los currículos de los investigadores locales de cada universidad. El período de análisis definido fue el cuatrienio 2010-2013.

Los patrones de interacción social en ambas universidades para la producción y difusión de conocimientos del campo de los agronegocios fueron identificados siguiendo un método cuantitativo apoyado en el Análisis deRedes Sociales(ARS). Para caracterizar el tipo de interrelación existente entre docentesinvestigadores se aplicaron medidas habitualmente empleadas (Wasserman &Faust, 1994): tamaño de la red, número de componentes, tamaño de la componente principal,distancia, diámetro, densidad, fragmentación. Finalmente, a los fines de complementar el examen de las propiedades estructuralesde las redes académicas, se calcularon las variables que caracterizan al fenómeno *Small World* o Mundo Pequeño sobre la componente principal de las redes analizadas(Watts &Strogatz, 1998; Uzzi&Spiro, 1995).

La oferta científico-tecnológica relevada en la primera etapa de análisis se registró en una planilla de cálculo por universidad y se reorganizó en una nueva base de datos para el ARS (Clark, 2006).El procesamiento de datos para la obtención de las medidas estructurales y la elaboración de los grafos incluidos en el trabajo se realizó empleando el *software UCINET*6 (Borgatti, Everett&Freeman, 2002).

4. Resultados y discusión

4.1. Configuración estructural de las redes académicas analizadas

Se presenta en la Tabla 1 un resumen comparativo de los resultados obtenidos en las medidas generales de caracterización estructural de las redes analizadas por institución universitaria.

Tabla 1. Estadísticas descriptivas de las Estructuras de Relaciones de UNS y UFPel.Fuente: Elaboración propia

Medidas estructurales	*Investigación*		*Tesis*		*Extensión*	
	UNS	UFPel	UNS	UFPel	UNS	UFPel
Tamaño	478	357	51	180	35	192
Número de Componentes	11	118	18	42	29	10
Tamaño componente principal	371	190	6	96	3	152
Distancia	4,07	4,75	1,34	6,25	1,11	3,64
Diámetro	9	12	2	16	2	9
Densidad	3%	1%	3%	1%	1%	5%
Fragmentación	0,39	0,72	0,95	0,71	0,98	0,37

Se observa que las redes de proyectos de investigación de ambas universidades presentan similar "tamaño".UFPelmuestra una red menor (357 actores) respecto de UNS (478 actores). Sin embargo, en las redes de tesis y actividades de extensión los resultados obtenidos arrojan un marcado contraste, dondeel "tamaño" de la red es mayor en UFPel respecto de UNS. Así, en materia de tesis, UFPel presenta 180 actores y UNS, 51. Mientras que para actividad de extensión, la diferencia de tamaño es aún superior, dado que comprende 192 actores en UFPel y 35 en UNS, lo cual revela una mayor injerencia de los investigadores de la universidad brasilera en proyectos de vinculación con la sociedad ligados a agronegocios, o bien una mayor atención al registro formal de este tipo de proyectos de vinculación dentro de los sistemas de información académica, en virtud de haber encontrado limitaciones en este aspecto en UNS.

En cuanto alas medidas "número de componentes" y "tamaño de la componente principal", la red de proyectos de investigación en UNS presenta 11 componentes, siendo inferior respecto de UFPel, que muestra 118 componentes. La "componente principal"en UNS aglutina el 77,62% de investigadores, esto es, 371 actores sobre un total de 478 actores. Encambio UFPel integra en su componente principal al 53,22% de los investigadores de la red, es decir, 190 actores sobre un total de 357 actores. Estas diferencias se explican en la modalidad de investigación vigente en UNS, que necesariamente por reglamentación, debe desarrollarse en grupos ("Proyectos PGI") y no individualmente, por lo cual en esta red no se muestran nodos aislados, que sí se presentan en UFPel. Dicha particularidad estaría favoreciendo la cooperación científica y la formación de recursos humanos en investigación.En la red de tesis se observa que UFPel cuenta con 42 componentes y una "componente principal"que aglutina el 53,33% de investigadores, esto es 96 actores sobre un total de 180 actores. En cambio UNS presenta una cantidad de componentes inferior (18) e integra en su componente principal al 11,76% de los investigadores de la red, esto es 6 sobre un total de 51 actores. Se advierte así una mayor heterogeneidad en las componentes de UFPel, incluso con presencia de actores aislados, a diferencia de la red de UNS, en la cual las componentes presentan similar tamaño, no representando ninguna una subred dominante. Respecto de la red de actividades de extensión, en UFPel la cantidad de "componentes" es de 10 mientras que en UNS suman 29. La "componente principal"en UFPelconecta a 152 de los 192 nodos, lo que representa un 79,17% del total de los actores. En cambio la red de extensión en UNS aglutina en su "componente principal" al 10,34% del total de participantes.Puede inferirse que esta situación en UNS restringe las posibilidades de cooperación entre académicos para la difusión y transferencia científico-tecnológica.

Al analizar las medidas de "distancia" y "diámetro", en todas las redes bajo estudio, se advierten valores inferiores en UNS con respecto a UFPel. En tesis y actividades de extensión ello se explica por el tamaño de dichas redes, que es comparativamente inferior en la universidad argentina, por lo cual los actores estarán más cercanos unos de otros. Desde el punto de vista cuantitativo, en la red de tesis, la distancia en UNS es de 1,34 actores y el diámetro de 2. Mientras que en UFPel, la distancia es de 6,25 actores y el diámetro de 16. En el área de extensión, UNS evidencia una distancia de 1,11 actores con un diámetro de 2; y UFPel, presenta una distancia de 3,64 con un diámetro de 9.

Se observa en UFPel, que las redes de investigadores involucrados en tesis y actividades de extensión, son más heterogéneas comparativamente quelas redes de UNS en las medidas analizadas.En el caso de proyectos de investigación, donde la red presenta un "tamaño" mayor en UNS respecto de UFPel, los valores inferiores de "distancia"y "diámetro"pueden justificarse en la modalidad cooperación en grupos de investigación.Mientras la distancia en UNS es de 4,07 actores y el diámetro de 9; enUFPel,la distancia asume4,75 con un diámetro de 12.

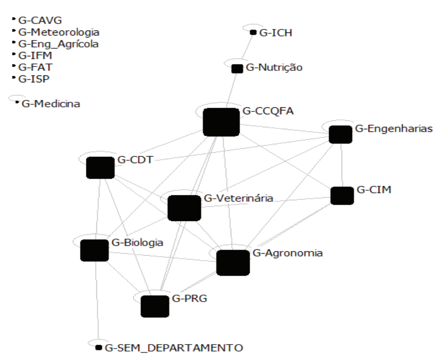
En cuanto a la "densidad" de las redes bajo estudio, UFPel presenta valores menores que UNS en proyectos de investigación y en tesis, esto es 1% y 3% en cada universidad respectivamente, coincidiendoparaambas redes. Lo cual refleja una mayor participación de relaciones efectivas logradas sobre las posibles en UNS respecto de UFPel, considerando que en las redes de esta última, se evidencian nodos aislados y sin vínculo con los restantes actores. Por el contrario, para las actividades de extensión se presenta en UNS un aprovechamiento de las relaciones potenciales del 1%, inferior al 5% que asume la red de UFPel. Esto puede estar afectado por las limitaciones encontradas en oportunidad de efectuar el relevamiento de actividades de extensión en UNS, donde debido a la ausencia de registros formales, sistematizados y homogéneos, sólo pudieron identificarse los responsables de cada proyecto y no los miembros del equipo que formaron parte del mismo.

Finalmente al analizar el indicador de "fragmentación", las redes de proyectos de investigación arrojan un mayor valor en UFPel (0,72) respecto de UNS (0,39).Para la UFPel expresa el grado de aislamiento que se produce en la red dada la cantidad de actores o nodos aislados. Para el caso de la UNS, al existir menor cantidad de componentes, el asilamiento o fragmentación es menor y la conectividad global mayor, con lo cual aún si desaparece un actor específico no provocaría que el resto de los actores quedara aislado uno del otro. Por el contrario, la fragmentación es mayor en las redes de tesis y actividades de extensión de UNS comparativamente respecto de UFPel, siendo en tesis de 0,95 y 0,71, respectivamente; y en proyectos de extensión de 0,98 y 0,37, respectivamente. Dichos valores revelan en UNS el aislamiento de diversos subconjuntos (componentes). Esto significa que las redesde tesis y extensión poseen baja conectividad global y baja transitividad local con respecto a UFPel, en cuyas redes existe mayor conexión entre los actores.

Sobre la base de los resultados obtenidos, se analiza la participación de cada disciplina de acuerdo a la cantidad de actores que se relacionan con ella y su vínculo con otras áreas, con el propósito de valorar la "interdisciplinariedad" de las redes constituidas y la generación y difusión del conocimiento a lo largo de la red.

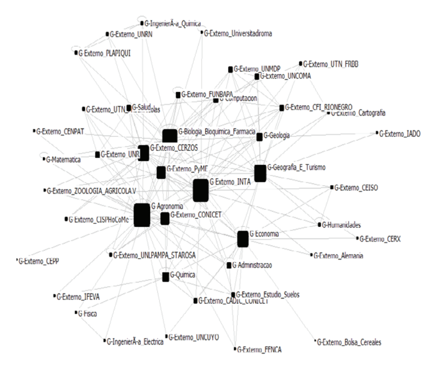
En el campo de los proyectos de investigación (Figuras 1 y 2) se muestra interdisciplinariedad en ambas universidades. Sin embargo, la red UNS no presenta unidades académicas aisladas (no conectadas) como sí se observan en UFPel. En UNS prevalecen las unidades académicas de Agronomía y de Biología, Bioquímica y Farmacia, seguidas por un organismo no perteneciente a UNS, como es el INTA (Instituto Nacional de Tecnología Agropecuaria), dedicado a la investigación y extensión rural dependiente del Ministerio de Agricultura, Ganadería y Pesca de la Nación. De ello se infiere que resulta una red más desarrollada en términos de cooperación, por sus vinculaciones entre áreas de conocimiento y agentes externos. En UFPel los vínculos están concentrados en menor cantidad de áreas del conocimiento, pero con una participación relativa mayor de cada una.

Figura 1. Red de unidades académicas en investigación de UFPel



Fuente: Elaboración a partir de software UCINET.

Figura 2. Red de unidades académicas en investigación de UNS



Fuente: Elaboración a partir de software UCINET.

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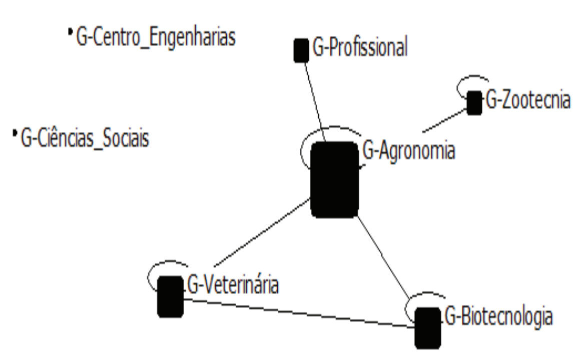
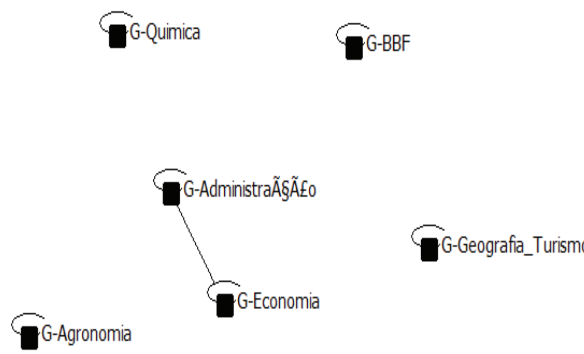
En las redes de tesis, en lo que respecta a la participación de cada disciplina, según pertenencia institucional de los actores (Figuras 3 y 4), se observa en UFPel predominio de las unidades académicas vinculadas a las Ciencias Naturales como Agronomía, Veterinaria y Biotecnología. Por el contrario, en UNS ningún área disciplinar presenta mayor participación relativa en relación a las demás; sólo se observa una vinculación débil entre Economía y Administración.

Figura 3. Red de unidades académicas en tesis de UFPel



Fuente: Elaboración a partir de software UCINET.

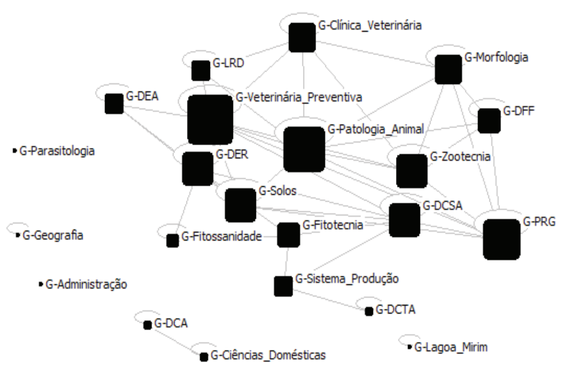
Figura 4. Red de unidades académicas en tesis de UNS.



Fuente: Elaboración a partir de software UCINET.

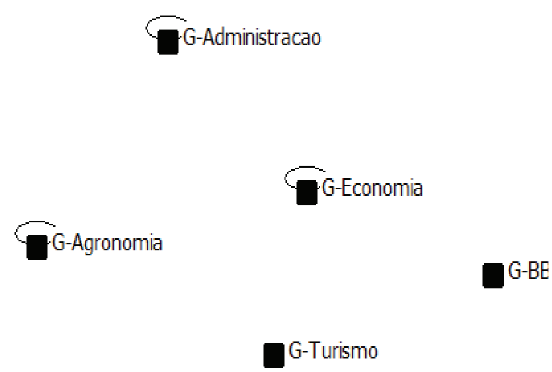
En actividades de extensión (Figuras 5 y 6), UFPel presenta mayor “interdisciplinariedad” entre sus unidades académicas, dominando las Ciencias de la Salud animal como Veterinaria y Patología Animal. En UNS los departamentos realizan las actividades sin vínculos con otras áreas del conocimiento.

Figura 5. Red de unidades académicas en extensión de UFPel



Fuente: Elaboración a partir de software UCINET

Figura 6. Red de unidades académicas en extensión de UNS



Fuente: Elaboración a partir de software UCINET

4.2. El fenómeno de *Mundos Pequeños* en las redes académicas

La presente investigación procura verificar si las redes de docentes investigadores involucrados en la producción y difusión de conocimientos ligados a los Agronegocios sigue una lógica de *Small World* o Mundo Pequeño en las universidades analizadas. A tal efecto, se calculan los parámetros propuestos por Watts &Strogatz (1998) para evidenciar la presencia de este fenómeno sobre la componente principal de cada red. En laTabla 2 se exponen los resultados obtenidos sólo para aquellas redes identificadas en el estudio de su configuración estructural, con gran tamaño y baja densidad: proyectos de investigación en UNS y UFPel, tesis y disertaciones de posgrado en UFPel y proyectos de extensión en UFPel.

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Tabla 2. Estadística de Small Worldpara redes de tesis, investigación y extensión por universidad

MEDIDAS	Nominación /Fórmula	Investigación UNS	Investigación UFPel	Tesis UFPel	Extensión UFPel
		Datos Observados			
Medidas de Cohesión					
Densidad	**Δ**	0,04	0,03	0,03	0,07
Actores	$\mathbf{T_{cp}}$	371	190	96	152
AverageDegree	$\mathbf{C_m}$	13,41	6,02	2,83	10,28
Coeficiente de Agrupamiento - *Clustering*	**CC**	0,591	0,388	0,211	0,497
Distancia media (geodésica)	**Dist geo**	4,11	4,72	6,36	3,66
		Datos Aleatorios (Watts &Strogatz, 1998)			
Coeficiente deAgrupamiento Esperado	**CCesperado=$\mathbf{C_m}$ / $\mathbf{T_{cp}}$**	0,0361	0,0317	0,0295	0,0676
Distancia Media Esperada	**Dist Geo esperada= ln($\mathbf{T_{cp}}$)/ ln($\mathbf{C_m}$)**	2,2790	2,9230	4,3876	2,1560
		Indicadores Small Worlds			
PL=Tasa Distancia Media	**Tasa DM =Dist geo/Dist Geo esperada**	***X***1,8034	***X***1,6148	***X***1,4495	***X***1,6976
CC=Tasa Coeficiente de Agrupamiento	**Tasa CC =CC / CCesperada**	✓ 16,3506	✓ 12,2458	✓ 7,1576	✓ 7,3486
Q=Coeficiente *Small World*	**Q=Tasa CC/ Tasa DM**	✓ 9,0663	✓ 7,5836	✓ 4,9379	✓ 4,3288

Fuente: Elaboración propia

Se advierte que la tasa del coeficiente de agrupamiento (Tasa CC) es notoriamente superior a 1 en todos los casos, dado que el coeficiente de agrupamiento real observado resulta significativamente mayoral coeficiente de agrupamiento esperado en redes aleatorias. Las tasas más significativas surgen en las redes de investigación de ambas universidades latinoamericanas, siendo superior en UNS (16,3506), respecto de UFPel (12,2458). Luego siguen las redes de extensión (7,3486) y de tesis (7,1576) de UFPel.

En cuanto a la distancia media observada, esta es siempre mayor a la distancia media esperada, por lo cual la tasa de distancia media (Tasa DM) resulta superior a 1 en más de un 45% en todos los casos analizados.

No obstante, se estima el coeficiente *Small World* (Q) de Uzzi&Spiro (2005). Se observa así que los valores alcanzados son mayores a 1, siendo más significativo en las redes de investigaciónde UNS (9,0663) y de UFPel (7,5836) por la incidencia del coeficiente de agrupamiento, comparativamente con las redes de tesis y disertaciones de posgrado (4,9379) y de proyectos de extensión (4,3288).

De lo anterior se infiere que, las redes analizadas tendrían fuerza para ser mundos pequeños, si bien los mismos no se verifican actualmente en razón de que las tasas de distancias medias son muy superiores y no cercanas a 1 en todos los casos bajo estudio.

5. Conclusiones

El objetivode la presente investigación ha sido analizar los patrones de interacción de docentes investigadores involucrados en la producción y diseminación de conocimientospara los agronegocios,en dos universidades latinoamericanas de países que son jugadores clave en el mercado internacional de bienes de origen agropecuario: Universidad Nacional del Sur de Argentina y Universidad Federal de Pelotas de Brasil.El estudio se ha efectuado sobre las redes sociales de proyectos de investigación, tesis y disertaciones de posgrado, y actividades de extensión, de modo de efectuar una contribución para comprender la condición de ambas universidades en su capacidad de favorecer los procesos de innovación en las cadenas agroalimentarias de las regiones bajo estudio, frente a la carencia de investigaciones encontradas sobre esta problemática.

En primer lugar, en lo que respecta a la caracterización de la configuración estructural de dichas redes (Tabla 1), se observó en el ámbito de los proyectos de investigación, la existencia de redes de gran tamaño similar en UNS y UFPel, con una componente principal que nuclea en ambas a más del 50% de los investigadores. La red de UNS presenta una menor distancia y fragmentación, producto de la modalidad grupal en que deben ejecutarse los proyectos de pesquisa. En el ámbito de tesis y extensión, se advierten mayores diferencias entre las universidades analizadas, donde la fragmentación es superior en UNS, siendo mayor al 90%, a pesar de tratarse de redes pequeñas comparativamente respecto de UFPel.De lo anterior se infiere que existe mayor conectividad en las actividades de investigación de ambas instituciones universitarias, en relación a extensión e investigación, lo cual estaría favoreciendo un aumento en la calidad del conocimiento generado en la red, para una posterior transferencia y difusión hacia el medio socioeconómico. Por otra parte, la densidad de las redes en UNS y UFPel presenta guarismos bajos, siendo superior en investigación y tesis de UNS, pero inferior en extensión. Esto denota la existencia de un escaso desarrollo de vínculos entre actores a pesar de su cercanía, puesto que operan en pequeños grupos que no se encuentran interrelacionados. En ambas universidades se advierte que existe potencial para el crecimiento de futuras interacciones.

Asimismo, del análisis de las áreas disciplinares participantes (Figuras 1, 2, 3,4,5 y 6)puede advertirse que tanto en UNS como en UFPel, la interpretación de los problemas del medio y su complejidad es abordada desde una perspectiva integral con perfil multidisciplinario. Sin embargo, las relaciones entre las diferentes áreas de conocimiento, se torna débil en las redes de tesis, y aún más en las redes de extensión en UNS respecto de UFPel, agravado por la presencia de subgrupos cerrados con muchos lazos redundantes.Esto evidencia limitaciones al momento de la transferencia efectiva de conocimiento para atender la complejidad de los problemas inherentes a los agronegocios. Por esta razón, resultaría necesario favorecer la generación de vínculos con diferentes unidades académicas.

Finalmente, se verificó si en las redes de mayor tamaño bajo estudio (investigación en UNSy en UFPel, tesis y extensión en UFPel) da el fenómeno *Small World*(Tabla 2).Se advirtió que aún cuando las redes analizadas muestran una baja densidad global, los actores están bien agrupados localmente, dado que los coeficientes de*clustering* encontrados son altos, lo cual indica la posibilidad de formación de capital social vía cohesión (Rossoni & Guarido Filho, 2009). Puede inferirse que este nivel de agrupamiento estaría favoreciendo la estabilidad en la producción y difusión científica, según el tipo de red, ya que la construcción de parámetros de trabajo en cuanto a lo que se acepta o no como conocimiento es definido en primera instancia dentro de los grupos de docentes investigadores.

Sin embargo, los valores hallados en los indicadores de distancia media no están incidiendo favorablemente la posibilidad de desarrollar innovaciones que sean aceptadas como legítimas por los pares, a través de lazos fuera de los grupos, abriendo así un espacio para la agencia. Es decir, que no se evidencia dinamismo en el intercambio de informaciones que permitan compartir significados, conceptos o métodos entre los grupos de actores (Rossoni& Machado-da-Silva, 2008; Rossoni & Guarido Filho, 2009). Los guarismosmás altos del coeficiente *Small World* (Q) en las redes de investigación de UNS y UFP reflejan una mayor factibilidad de que se produzca en ellas intercambio de información no redundante (Quintella*et al*., 2009).

Cabe destacar que en oportunidad del relevamiento de datos, se observó la carencia de bases informatizadas y sistemas de gestión universitaria relativos a los aspectos aquí investigados. Por lo cualsería necesario trabajar en la integración de los sistemas de información inherentes a las misiones de la universidad: docencia, investigación y extensión, incluyendo en ellos los mecanismos de vinculación con el medio socioeconómico.

El presente trabajo ha analizado las redes de UNS y UFPel de manera global para el período 2010-2013, no obstante se considera útil estudiar su evolución a través de diferentes períodos de modo de evaluar su progreso en la diseminación y transferencia de conocimiento.

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La Vinculación Ciencia-Sociedad: Estereotipos y Nuevos Enfoques

Elena Castro-Martínez [1], Julia Olmos-Peñuela [2], Ignacio Fernandez-de-Lucio [1]*

Abstract: La importancia social de la ciencia ha evolucionado notablemente desde mediados del siglo XX, dando lugar a un cambio en el enfoque y desarrollo de la actividad científica. En este contexto, se ha producido un aumento notable de los estudios que analizan en profundidad los procesos de intercambio y transferencia de conocimiento que se producen entre los investigadores y los agentes sociales, en gran medida para su promoción desde las políticas científicas e institucionales. Este artículo describe la evolución de los enfoques sobre las relaciones ciencia-sociedad y analiza los principales elementos de los procesos de intercambio y transferencia de conocimiento mediante un estudio empírico del mayor organismo público de investigación español. Los resultados ponen de manifiesto que la visión dominante sobre las relaciones ciencia-sociedad es muy restringida y requiere ser revisada.

Keywords: vinculación ciencia-sociedad; intercambio y transferencia de conocimiento; organismos públicos de investigación; investigadores; culturas de investigación; áreas científicas.

Title: Science-Society Links: Stereotypes and New Approaches

Abstract: The social relevance of science has evolved significantly since the mid-twentieth century, leading to a change in the approach and development of the scientific activity. In this context, there has been a notable increase of in-depth studies addressing exchange and knowledge transfer processes between researchers and social agents, largely to encourage these processes from the scientific and institutional policies. This paper describes the evolution of the science-society relationships approaches and analyses the main elements of the exchange and knowledge transfer processes though an empirical study of the largest Spanish public research organisation. Results highlight that the dominant view on the relations between science and society is very limited and needs to be revised.

Keywords: science-society links; exchange and knowledge transfer; public research organisations; researchers; research cultures; scientific fields

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1. Introducción

Desde que a finales del pasado siglo los economistas pudieron comprobar que los sectores que experimentaban mayor crecimiento y más altas productividades eran los que dependían de la investigación y la tecnología se acuñó el término "economía del conocimiento" (OCDE, 1996). Con posterioridad, se comprendió que no solo las empresas, sino también otros agentes sociales –públicos y privados- se pueden beneficiar del nuevo conocimiento científico y de las tecnologías de la información y las comunicaciones (TICs), surgiendo un nuevo término "sociedades del conocimiento" (UNESCO, 2005), que se define en plural intencionadamente, por entender que no cabe hablar de un tipo único, ya que "cada sociedad posee sus propios puntos fuertes en materia de conocimiento" (UNESCO, 2005, p.17) y su contexto económico, social y cultural. En estas sociedades, los responsables de las políticas científicas y tecnológicas y de las instituciones acentuaron sus esfuerzos para impulsar el desarrollo tecnológico, especialmente en el campo de las TICs por su carácter horizontal (Valenti, 2002), y, a la vez, para favorecer el intercambio y la transferencia de conocimiento desde los centros de investigación (universidades y organismos públicos de investigación) hacia las empresas, mediante la puesta en marcha de diversos mecanismos, por entenderse que la inversión pública en ciencia y tecnología tenía que proporcionar un retorno social adicional al derivado de sus propios fines científicos y docentes (OCDE, 1999). Para que los procesos de intercambio y transferencia de conocimiento entre los científicos y los agentes sociales sean más eficientes se necesita conocer los propios procesos de producción del conocimiento, las diversas dimensiones de los procesos de intercambio y transferencia de conocimiento y los contextos que les afectan (Bozeman, 2000).

En este trabajo se analiza la evolución de la literatura sobre intercambio y transferencia de conocimiento y, especialmente, la que se ha publicado en los últimos años, porque es cuando han comenzado a surgir estudios que analizan en profundidad ámbitos científicos específicos, así como diversos tipos de usuarios y de mecanismos. Además, mediante los resultados obtenidos en un estudio empírico, se pretende poner en evidencia la diversidad y complejidad de estos procesos, que deberían derivar en políticas adaptadas a los distintos campos científicos, usuarios, mecanismos y contextos.

2. Evolución de los enfoques sobre la relación ciencia-sociedad

2.1 ¿Investigadores en la torre de marfil o creando conocimiento con o para los agentes sociales?

La relación entre la ciencia académica y la sociedad ha evolucionado a lo largo de las últimas décadas, en especial, uno de los aspectos que han sido objeto de debate es la función social de la ciencia y, en consecuencia, la labor de los investigadores (Fernández de Lucio et al., 2011).

(1) INGENIO (CSIC-UPV) Universitat Politècnica de València, Valencia, España.
(2) Departamento de Dirección de Empresas, Facultad de Economía, Universidad de Valencia
*Corresponding author: julia.olmos@uv.es

Los procesos de producción y validación del conocimiento científico han sido estudiados desde diversos campos científicos (filosofía, economía, sociología, ciencia política, etc.) y también las relaciones de esos procesos con la economía y la sociedad. En particular, desde la sociología de la ciencia se ha tratado de analizar de qué forma influye la consideración de la utilidad o aplicabilidad del nuevo conocimiento científico en la organización de las actividades científicas. Así, en 1942 el sociólogo estadounidense Robert King Merton definió el ethos de la ciencia como el conjunto de los siguientes valores: comunismo (difusión accesible y pública de los resultados de la actividad científica), universalismo (la valoración de la ciencia no deben depender de los atributos personales o sociales de los investigadores), desinterés (es el avance de la ciencia y no en los intereses y prejuicios personales lo que debe guiar al científico) y escepticismo organizado (evaluación crítica de unos científicos a otros no basada en la autoridad jerárquica) (Merton, 1942). Posteriormente otros autores han defendido la necesidad de producir conocimiento que sea relevante para la sociedad y en cuya producción ésta tenga un papel activo (Hessels & Van Lente, 2008). Entre estos enfoques se puede destacar la ciencia post-académica (Ziman, 2000), el Modo 2 de producción de conocimiento (Gibbons et al., 1994) o la triple Hélice (Leydesdorff & Meyer, 2006). En síntesis, estos enfoques propugnan un nuevo contrato social entre los científicos y la sociedad que demanda una reorientación de las actividades de investigación hacia la satisfacción de sus necesidades (Guston, 2000; Hessels & Van Lente, 2008; Martin, 2003), sobre todo en el caso de la investigación financiada por el Estado.

La literatura sobre las relaciones de la ciencia con la sociedad ha tratado de comprender mejor los factores, externos e internos, que afectan a las citadas relaciones, habiéndose estudiado diversos aspectos como las características de los investigadores y las empresas y las condiciones del contexto (Polt *et al.*, 2001), las barreras (Bruneel *et al.*, 2010; Tartari *et al.*, 2012) o los factores individuales relativos a los profesores e investigadores, donde se han analizado los que pueden influir en su predisposición a involucrarse más o menos activamente en procesos de intercambio y transferencia de conocimiento con la sociedad – edad, sexo, nivel académico, experiencia previa, motivaciones, área del conocimiento, calidad científica, forma de trabajo, etc. (Closs *et al.*, 2013; D'Este & Perkmann, 2011; Perkmann *et al.*, 2013).

También se han analizado los factores organizativos presentes en la entidad en la que desempeñan su actividad, pues si la entidad no comparte, ni valora, ni facilita, ni canaliza esta predisposición a intercambiar conocimiento con los agentes sociales, será muy difícil que se concrete. A este respecto, se han identificado cinco dimensiones de las organizaciones que pueden ser importantes para favorecer (o dificultar) el compromiso de los investigadores con la transferencia de conocimiento: a) presencia en las prioridades políticas; b) consideración en los sistemas de selección y de promoción de los investigadores; c) dedicación de recursos; d) dotación de estructuras; y e) documentación de este tipo de actividades, que permita su estandarización y proporcione indicadores para evaluar su desempeño (Jacobson *et al.*, 2004). Finalmente, se ha estudiado en qué medida afectan las políticas científicas y de innovación a las actividades de intercambio y transferencia de conocimiento entre investigadores y agentes sociales (Abreu *et al.*, 2009; Castro-Martínez *et al.*, 2008; Molas-Gallart, 2012).

2.2 Los usuarios del conocimiento: más allá de las empresas

Los procesos de utilización del conocimiento, especialmente en los procesos de innovación, se estudiaron a partir de los años 80 del pasado siglo para tratar de diseñar políticas de fomento de la innovación más adecuadas (Kline & Rosenberg, 1986; Rejean Landry *et al.*, 2001; OCDE, 1996), lo que ha llevado a identificar distintos tipos de bases de conocimiento en los diversos sectores empresariales (analítico, sintético y simbólico) que afectan al tipo de fuentes de conocimiento que precisan las correspondientes empresas (Asheim *et al.*, 2007). Respecto a los usuarios del conocimiento científico, los estudios se han orientado casi exclusivamente a las empresas -especialmente las manufactureras-, como si éstas fueran las únicas que, para llevar a cabo sus actividades, necesitaran nuevos conocimientos. Sin embargo, son muchos los agentes sociales que pueden beneficiarse de este esfuerzo y, gracias a ello, desempeñar mejor sus propios fines (Castro-Martínez & Olmos-Peñuela, 2014): profesionales como médicos, abogados, informáticos, psicólogos o jueces, por poner algunos ejemplos; entidades sociales, como asociaciones de empresarios, sindicatos, ONG's, entidades culturales, hospitales, partidos políticos, organizaciones internacionales, etc., pero especialmente las administraciones públicas a todos los niveles (nacional, regional, local) y en todas sus áreas de intervención, para identificar la pertinencia de sus políticas, diseñarlas o evaluar sus logros; por su importancia, esto ha sido objeto de estudio específico (Weiss, 1979). Finalmente, los ciudadanos también precisan un mejor conocimiento de los avances científicos, porque si no, no podrían interpretar las implicaciones económicas y sociales de la ciencia y la tecnología, ni tener criterio para decidir sobre los interrogantes que plantean los nuevos hallazgos científicos, ni saber valorar el alcance y los efectos de muchos de los nuevos productos y servicios que ofrece el mercado (López Cerezo, 2005; Miller, 2012).

2.3 Los mecanismos de vinculación: ¿sólo cuentan las patentes y las spin-off como indicadores de las relaciones ciencia-sociedad (empresa)?

Otro aspecto a tener en cuenta en las relaciones ciencia-sociedad es que los mecanismos de intercambio y transferencia de conocimiento entre los investigadores y la sociedad pueden ser muy diferentes en función del tipo de conocimiento y de las condiciones que rigen cada proceso. Una parte de la literatura se ha centrado en el estudio de las estructuras de gestión que actúan como interfaz entre el sector científico y productivo tales como las "Oficinas de Transferencia de Tecnología" (Siegel *et al.*, 2003; Tseng & Raudensky, 2014) o las "Oficinas de Vinculación Tecnológica y Transferencia" (Malizia *et al.*, 2013). Estas estructuran han permitido impulsar, gestionar y canalizar las interacción entre universidades y empresas mediante diversos tipos de canales o mecanismos de intercambio y transferencia de conocimiento, que han sido, a su vez, objeto de estudio en la literatura (Abreu *et al.*, 2009; D'Este & Perkmann, 2011; Dutrénit, 2010; Hughes & Kitson, 2012; R. Landry *et al.*, 2010; Malizia *et al.*, 2013; Perkmann *et al.*, 2013), aunque también se ha podido observar que no todos ellos son susceptibles de ser canalizados o formalizados por estas estructuras, pues, en ocasiones, se producen mediante procesos de interacción informal (Meyer-Krahmer & Schmoch, 1998).

Un conocimiento patentable se transfiere mediante una licencia, pero la solución a un problema específico de un usuario se puede llevar a cabo en el marco de un contrato de consultoría o mediante una consulta puntual, dependiendo del trabajo adicional y de los recursos necesarios para ello. Así mismo, determinados conocimientos se canalizan mejor mediante la elaboración y difusión de guías, protocolos o procedimientos, ayudando a sus potenciales usuarios a incorporarlos en sus respectivas prácticas. En ocasiones, los investigadores no tienen la solución al problema planteado y es preciso llevar a cabo un proyecto de I+D junto con la entidad que demanda el conocimiento para desarrollarlo conjuntamente. También es frecuente que la forma más adecuada de transferir a un potencial usuario un compendio de saber hacer acumulado sea un curso de formación *ad hoc* o la participación en un comité de expertos, como sucede en el caso de la gestión de pandemias o catástrofes ambientales (Carayol, 2003; Molas-Gallart *et al.*, 2002). Finalmente, cuando el objetivo es el aumento de la cultura científica y tecnológica de los ciudadanos, los medios de comunicación y las actividades institucionales de divulgación son los mecanismos más utilizados (Torres-Albero *et al.*, 2011).

La mayoría de los estudios examinan las actividades de interacción formalizadas institucionalmente, tales como, la licencia de patentes o la creación de nuevas empresas de base tecnológica, los contratos de investigación y consultoría, entre otras, por ser fáciles de identificar, registrar y cuantificar en términos económicos, dado que en todos los casos se dispone de un instrumento legal (contrato o acuerdo) mediante el cual la relación se formaliza. Sin embargo, estudios recientes han demostrado que este tipo de actividades representan tan solo una parte de las relaciones y que la informalidad es una característica prevalente en las interacciones ciencia-sociedad (Abreu *et al.*, 2009; Link *et al.*, 2007; Olmos-Peñuela, Molas-Gallart*, et al.*, 2014). En un contexto en el que los gobiernos piden que los investigadores demuestren los retornos sociales de la ciencia financiada públicamente, y en el que las universidades y centros públicos de investigación evalúan a los investigadores en base a las actividades que realizan susceptibles de ser registradas en las bases de datos corporativas, por tanto, formalizadas, aquellas actividades que no se adapten a los *estándares* de medición corren el riesgo de verse sistemáticamente perjudicadas, tanto por la falta de financiación pública para sus investigaciones como en la promoción de sus investigadores dentro de sus instituciones. Así mismo, la literatura también muestra que algunos mecanismos, como la licencia de patentes, son de escasa aplicación en países no desarrollados (Sutz, 2000). En este contexto, en la actualidad se está debatiendo en el ámbito iberoamericano un manual para identificar indicadores de vinculación universidad-sociedad que permitan a las instituciones de educación superior e investigación capturar información más amplia y diversa a este respecto (http://www.octs-oei.org/manual-vinculacion/index.php).

2.4 ¿Cómo utilizan los agentes sociales el conocimiento científico?

Las necesidades de nuevo conocimiento por parte de los usuarios son diversas (incluso en el caso de las empresas) en función del sector al que pertenecen, de su tamaño, su cultura y su propia capacidad. Por su parte, no cabe hablar de una única aplicación potencial de los nuevos conocimientos. Beyer (1997) describe tres tipos de usos del conocimiento científico: el uso directo o instrumental, que corresponde a la solución de problemas específicos, y los usos indirectos, derivados de la promoción de la reflexión, la crítica y la conceptualización (el llamado uso conceptual), o el apoyo y legitimación de una idea o posición (uso simbólico).

En principio, las políticas de fomento de las relaciones ciencia-sociedad se diseñan con objeto de favorecer las interacciones de los investigadores con las industrias en sus procesos innovadores, por lo que implícitamente están considerando sólo el uso instrumental del conocimiento científico, pero cuando se amplía el tipo de sectores para dar cabida a los servicios –incluyendo a las administraciones públicas y otros agentes sociales– se observa que los usos conceptual y simbólico pueden presentar mayor relevancia que el instrumental. Esto afecta especial pero no exclusivamente a los conocimientos procedentes de las humanidades y las ciencia sociales, que proporcionan a las industrias culturales y otros agentes sociales contenidos para sus productos, servicios y procesos, pero también elementos para conceptualizar sus productos/servicios en contextos culturales diferentes (Asheim & Coenen, 2005) y para fundamentar sus estrategias de negocio y mejorar su gestión de la innovación (DEA, 2007; Jaaniste, 2009). En el caso de las administraciones públicas es frecuente el uso del conocimiento proporcionado por los científicos para articular y legitimar sus iniciativas políticas.

3. Contexto y metodología del trabajo empírico

La parte empírica de este trabajo se ha realizado en el CSIC, que es el mayor organismo público de investigación español. En el año 2011, el CSIC, cuya sede central se encuentra en Madrid, contaba con 126 institutos distribuidos por todo el territorio español. Ese mismo año, el CSIC contaba con 14.050 empleados, de los cuáles 5.375 eran personal científico y 3.122 eran investigadores de plantilla (CSIC, 2012). Los investigadores del CSIC (que representan alrededor del 6% de los que hay en España) publican el 20% de los artículos científicos de origen español recogidos en bases de datos internacionales. Este organismo abarca prácticamente todas las disciplinas científicas, organizadas en ocho áreas del conocimiento (Biología y biomedicina, Ciencia y tecnología de alimentos, Ciencia y tecnología de materiales, Ciencia y tecnologías físicas, Ciencia y tecnologías químicas, Ciencias agrarias, Recursos naturales, Humanidades y ciencias sociales). La unidad organizativa principal es el instituto de investigación, en el que trabajan los investigadores en torno a grupos o proyectos de investigación.

En el periodo 2010-2011, el CSIC financió un proyecto de investigación titulado "El impacto socio-económico de las actividades del CSIC: Una estrategia de aproximación. Proyecto IMPACTO", cuyo objetivo era desarrollar un enfoque coherente de aproximación a la evaluación de los impactos del CSIC sobre las empresas y las entidades sociales (administraciones públicas, entidades sin ánimo de lucro, organismos internacionales) con las que ha colaborado. Para llevarlo a cabo, se realizó una encuesta dirigida a los Investigadores del Consejo Superior de Investigaciones Científicas con título de doctor y capacidad para figurar como investigadores principales en convenios o contratos con otras entidades. El tipo de muestro fue aleatorio estratificado por áreas científicas del CSIC y categoría profesional de los investigadores. La encuesta fue realizada *on line* con refuerzo telefónico y se obtuvo una muestra final de 1583 investigadores con un error muestral de ±1,9% para un nivel de confianza del 95%. En la tabla 1 se muestra la distribución de la población y de la muestra analizada de investigadores del CSIC según las áreas científicas.

Tabla 1. Población y muestra de los investigadores del CSIC: distribución por área científica.

Áreas científicas	**Población**	**Población**	**Muestra**	**Muestra**
	(N)	**(%)**	**(N)**	**(%)**
Biología y biomedicina	771	18,2%	244	15,4%
Ciencia y tecnología de alimentos	285	6,7%	128	8,1%
Ciencia y tecnología de materiales	562	13,3%	201	12,7%
Ciencia y tecnologías físicas	569	13,4%	204	12,9%
Ciencia y tecnologías químicas	480	11,3%	209	13,2%
Ciencias agrarias	412	9,7%	203	12,8%
Recursos naturales	759	17,9%	277	17,5%
Humanidades y ciencias sociales	402	9,5%	117	7,4%
TOTAL	**4.240**		**1.583**	

Fuente: elaboración propia a partir de la base de datos del proyecto IMPACTO.

El instrumento de recogida de información utilizado fue un cuestionario diseñado teniendo en cuenta las dimensiones identificadas por (Bozeman, 2000), pero haciendo más hincapié en los mecanismos de transferencia y en el impacto social de la investigación sobre la base de una revisión de la literatura (Bonaccorsi & Piccaluga, 1994; D'Este & Patel, 2007; Schartinger *et al.*, 2002). El cuestionario estaba estructurado en 6 secciones: características de la actividad investigadora, que incluía una pregunta sobre los fines de la investigación; relaciones con otras entidades del entorno socioeconómico; obstáculos y aspectos facilitadores de las relaciones; relaciones con la sociedad en general (divulgación social de la ciencia); resultados de las relaciones con el entorno socioeconómico; y perfil del Investigador.

4. Resultados y discusión del trabajo empírico

Uno de los factores que puede determinar la implicación de los investigadores en actividades de intercambio y transferencia de conocimiento es la orientación de su actividad científica, es decir, sus objetivos a la hora de abordar sus investigaciones. El científico americano Donald E. Stokes (1997), considerando que la distinción entre investigación básica y aplicada propuesta en el informe de Vannevar Bush "*Science The Endless Frontier*" (1945) no expresaba adecuadamente las dos "finalidades" básicas que guían el quehacer científico (el avance del conocimiento y la aplicación del nuevo conocimiento), propuso una matriz de dos por dos para entender las relaciones entre la creación del conocimiento y su aplicación; esta propuesta permite situar en cada uno de los cuatro cuadrantes resultantes a los investigadores en función de la mayor o menor prevalencia de ambos objetivos en el enfoque de sus investigaciones. En la Tabla 2 se han recogido las respuestas de los investigadores del CSIC a la pregunta del cuestionario sobre los fines de su investigación. Concretamente, los investigadores respondieron a las dos siguientes cuestiones: "¿En qué medida su actividad investigadora está inspirada por realizar contribuciones científicas a la comprensión de fenómenos?" y ¿En qué medida su actividad investigadora está inspirada por el uso práctico y/o la aplicación de los conocimientos fuera del ámbito científico o académico hechos? Para estas dos preguntas, los investigadores respondieron en base a una escala Likert con 4 anclajes de respuesta siendo "1 = nada" y "4 = mucho". Cada una de las variables categóricas resultantes (comprensión de los fenómenos y consideración de la aplicación) fueron transformadas en variables binarias con valor "1 = alta" si el investigador había respondido "mucho", y con valor "0 = baja" en el resto de los casos. Puesto que los comportamientos ante una escala de actitud siempre deben ser tomados con precaución debido a que las respuestas arrastran cierto grado de "deseabilidad" y no reflejan necesariamente las actividades que en realidad llevan a cabo las personas, se ha optado por realizar esta división para evitar este sesgo de deseabilidad (Olmos-Peñuela, Castro-Martínez*, et al.*, 2014). Así, este ejercicio permite obtener un mapa de los valores que guían el trabajo de los investigadores y establecer cuáles son los grupos predominantes mediante el cruce de estas dos variables binarias, obteniendo así los cuatro cuadrantes identificados por Stokes (1997). En la tabla 2 puede apreciarse que son mayoría los investigadores del CSIC entrevistados que se encuadran en el llamado "cuadrante de Bohr", es decir, orientan su investigación preferentemente hacia el aumento del conocimiento; esta orientación de la actividad investigadora es el perfil más extendido en el CSIC y es transversal a todas las disciplinas científicas, aunque las áreas de biología y biomedicina y de recursos naturales destacan con una mayor proporción de investigadores con esta orientación. Son menos (el 22%) los que se podrían encuadrar en el llamado "cuadrante de Pasteur", por tener en cuenta en la misma medida la comprensión de los fenómenos y hechos y la aplicación de los conocimientos; este perfil también se extiende casi en la misma proporción entre las distintas áreas científicas, si bien cabe destacar una mayor presencia de estos investigadores en las áreas de ciencias y tecnologías químicas y de humanidades y ciencias sociales. Los investigadores del llamado "cuadrante de Edison" –cuyo principal objetivo es la aplicación de conocimientos a la resolución de problemas– no llegan al 10%, cifra equivalente a los del cuarto cuadrante, cuya motivación es otra, como por ejemplo, adquirir formación científica o conocer mejor la naturaleza de un contexto local determinado, al que el autor no asignó nombre de referencia alguno. En el cuadrante de Edison se sitúan sobre todo investigadores de ciencias y tecnologías físicas y de materiales. El hecho de que la mayoría de los investigadores del CSIC se declaren más motivados por la comprensión de los fenómenos o hechos que por la aplicación práctica de sus conocimientos no significa que los investigadores del CSIC no asuman su dimensión social: más del 80% de los investigadores encuestados afirman haber establecido algún tipo de contacto o colaboración con algún agente social en los últimos tres años.

Tabla 2. Distribución de los investigadores según la orientación de su actividad investigadora.

Baja		**Consideración de la aplicación o uso de los conocimientos**		
		Alta	**Total**	
Comprensión de los fenómenos y hechos observables	**Alta**	**Bohr** (58,1%)	**Pasteur** (22,2%)	80,3%
	Baja	- (9,9%)	**Edison** (9,8%)	19,7%
Total		**68%**	**32%**	

Fuente: elaboración propia a partir de la base de datos del proyecto IMPACTO.

El otro protagonista de los procesos de intercambio y transferencia de conocimiento es el agente social con el que interactúan los investigadores. A este respecto, la Tabla 3 recoge la distribución de los tipos de agentes con los que han colaborado los investigadores del CSIC, en respuesta a la pregunta del cuestionario que especificaba: "Indique el número de veces que ha tenido contactos con los siguientes tipos de entidades (especificadas en la pregunta) durante los últimos tres años", ofreciendo 4 posibles valores: 0, de 1 a 3, de 4 a 6 y 7 ó más, además de las opciones no sabe y no contesta. Lo primero que destaca en la tabla es que, después de las empresas, que suman cerca del 46%, el siguiente agente social con el que han mantenido más colaboraciones los investigadores es la administración pública y algo menos los otros dos tipos de entidades especificados, pero, en conjunto, los agentes no empresariales superan a las empresas en la proporción de entidades con las cuales han colaborado los investigadores del CSIC. Con estas respuestas, al menos en el CSIC puede decirse que si el análisis de las actividades de vinculación con la sociedad se centra exclusivamente en las relaciones con las empresas, se está ocultando una parte importante de la dimensión social de los investigadores.

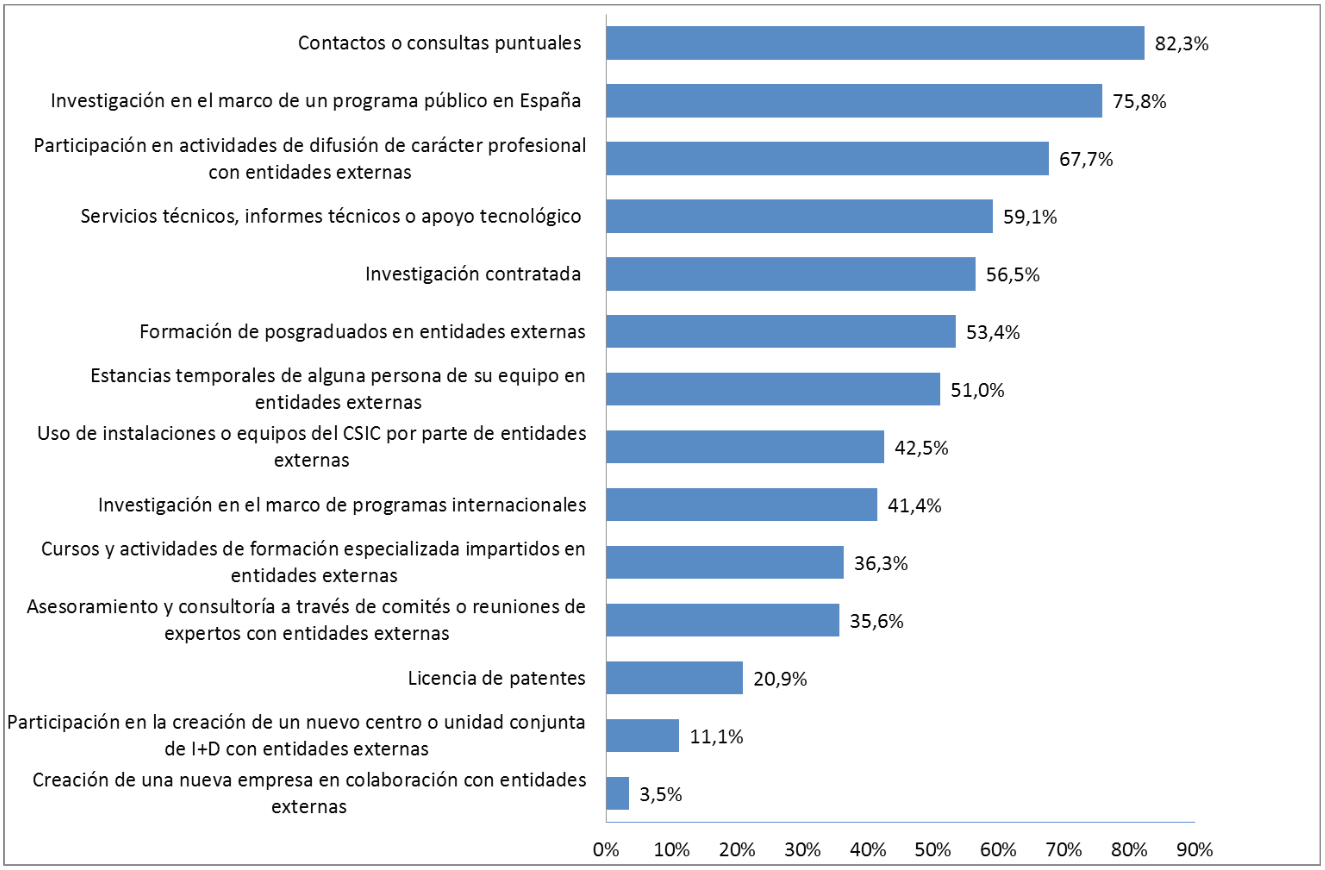
Tabla 3. Distribución de los diferentes tipos agentes sociales con los cuales los investigadores del CSIC han colaborado al menos una vez.

Tipo de agente social	**%**
Empresas ubicadas en España	33,8
Empresas ubicadas en otros países	12,1
Organismos de la Administración Pública	36,2
Organismos internacionales (UNESCO, FAO, Banco Mundial, Comisión Europea, etc.)	12,6
Entidades sin ánimo de lucro (ONG´S, cámaras de comercio, asociaciones, fundaciones, centros tecnológicos, etc.)	12,9
Ninguna colaboración con ninguno de los agentes sociales en los últimos 3 años	4,4%

Nota: los % no suman 100 porque los investigadores pueden haber mantenido relaciones simultáneamente con los diversos tipos de agentes.
Fuente: elaboración propia a partir de la base de datos del proyecto IMPACTO.

Por lo que se refiere a los mecanismos de interacción, el cuestionario formulaba la pregunta de la siguiente manera: "Señale si ha desarrollado las siguientes actividades con empresas, administraciones públicas, organismos internacionales o entidades sin ánimo de lucro durante los últimos tres años", ofreciendo un amplio rango de mecanismos posibles, desde los más puntuales a los de mayor implicación y duración. La figura 1 muestra que más del 82% de los investigadores declaró haber mantenido contactos o consultas puntuales, tipo de mecanismos de difícil captura y, por ello, de escasa utilidad para evaluar el impacto social de la investigación. El segundo mecanismo más utilizado es la investigación en el marco de ayudas públicas españolas, lo que significa que las políticas que fomentan la interacción logran sus objetivos, pero en tercer lugar aparece la participación en actividades de difusión profesional, que es un tipo de mecanismo que no se suele tener en cuenta en los sistemas de evaluación de este tipo de interacciones. Uno de los dos mecanismos más empleados en los sistemas de evaluación de la interacción (las *spin off*) apenas tienen presencia en el CSIC. Por consiguiente, el hecho de que en los sistemas de evaluación de la relación ciencia-entorno socioeconómico se consideren casi exclusivamente las licencias de patentes y las spin off y, en el mejor de los casos, los proyectos de I+D conjuntos y los contratos de servicios de I+D, nuevamente tiene como consecuencia que dejan de tenerse en cuenta muchas actividades de interacción, algunas de ellas de gran importancia para las entidades sociales, como las actividades profesionales, la formación, la movilidad o el asesoramiento experto.

Figura 1. Distribución de los mecanismos de intercambio y transferencia de conocimiento utilizados por los investigadores para colaborar con los agentes sociales los durante los últimos 3 años.



Fuente: elaboración propia a partir de la base de datos del proyecto IMPACTO.

Con la pretensión de capturar el uso que, en opinión de los investigadores, hacían las entidades con las que ellos habían interactuado con los conocimientos generados o intercambiados en el marco de sus colaboraciones, en el cuestionario se introdujo una pregunta relativa al beneficio logrado como consecuencia de la interacción, combinando diversos usos de tipo instrumental (solución de problemas específicos) con el simbólico (legitimación de ideas o posiciones). Como quiera que el uso conceptual (promoción de la reflexión, la crítica y la conceptualización) tiene difícil encaje en el ámbito empresarial, las preguntas se orientaron preferiblemente hacia los usos instrumentales y simbólicos. La tabla muestra que, contra todo pronóstico, el uso simbólico (ideas para la toma de decisiones) tiene una gran importancia para todos los agentes con los que se ha colaborado, incluidas las empresas, lo cual coincide con los resultados de la encuesta realizada a las empresas que han contratado con el CSIC en este mismo proyecto, donde éstas declaran valorar mejor los usos estratégicos que los tácticos o instrumentales (Valmaseda Andía *et al.*, 2015).

Tabla 4. Distribución de los tipos de beneficios obtenidos por los agentes sociales como consecuencia de sus colaboraciones con los investigadores.

	Empresas	Organismos de la Administración Pública	Organismos internacionales	Entidades sin ánimo de lucro
Herramientas para resolver problemas	73,8%	60,5%	55,5%	56,3%
Diseño/desarrollo de nuevos productos o servicios	54,0%	32,6%	28,8%	40,9%
Beneficios económicos o ahorro de costes para la entidad	53,1%	22,9%	18,3%	24,5%
Aumento de la formación de los trabajadores	61,8%	64,8%	56,3%	55,6%
Ideas para orientar la toma de decisiones	76,7%	68,6%	60,7%	62,4%

Fuente: elaboración propia a partir de la base de datos del proyecto IMPACTO.

5. Conclusiones

Los procesos de intercambio y transferencia de conocimiento entre los investigadores y los agentes sociales son complejos y diversos y dependen de muchos factores, unos ligados a los participantes –investigadores y agentes sociales- y otros debidos al contexto en el que se desenvuelven. Este trabajo ha puesto de manifiesto que el esfuerzo por conocer en profundidad los procesos de intercambio y transferencia de conocimiento redunda en una mejor comprensión del impacto social de la actividad científica, no sólo en lo referente al tipo de agentes que pueden beneficiarse de las actividades y capacidades científicas de los organismos públicos de investigación, sino también respecto a la variedad de mecanismos posibles, que puede permitir una mejor adecuación entre las necesidades sociales y la oferta de capacidades.

Los instrumentos y políticas de fomento que ofrecen los gobiernos suelen estar muy focalizados hacia las empresas y hacia el uso instrumental del conocimiento, cuando hay otros agentes sociales demandantes de nuevos conocimientos, pero además, incluso las empresas también hacen un uso simbólico de los conocimientos. Por ello, se considera que, si las políticas quieren favorecer los procesos de intercambio y transferencia de conocimientos entre los investigadores y los diversos agentes sociales, deberían huir de concepciones simplistas y excluyentes, que empobrecen el análisis y restringen las posibilidades de interacción y tratar de ofrecer cauces diversos y más adaptados a los diversos tipos de usuarios y usos del conocimiento científico.

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Impacto de los Intermediarios en los Sistemas de Innovación

*Walter Lugo Ruiz Castañeda *[1], Santiago Quintero Ramírez [2], Jorge Robledo Velásquez [3]*

Resumen: La perspectiva sistémica ha sido aplicada extensamente al estudio de la innovación, dada la existencia de múltiples agentes heterogéneos cuya interacción permite la generación, difusión y uso del conocimiento. Sin embargo, tal interacción presenta dificultades por las brechas existentes entre los agentes, siendo los intermediarios los responsables de construir puentes y facilitar la vinculación. No obstante, analizar el impacto de los intermediarios no es fácil, principalmente por el problema de atribución, que reduce muchas aproximaciones a fotografías carentes de análisis dinámico y longitudinal. Este trabajo propone superar tales limitaciones mediante simulación basada en agentes, la cual ayuda a ampliar el entendimiento del fenómeno de la intermediación en los sistemas de innovación y su impacto en el desempeño.

Palabras claves: Intermediarios de innovación; sistemas de innovación; modelación basada en agentes; capacidades de innovación; costos de transacción

Title: Impact of Intermediaries in Innovation Systems

Abstract: The systemic approach has been widely applied to the study of innovation, given the existence of multiple heterogeneous agents whose interaction allows the generation, diffusion and use of knowledge. However, such interaction presents difficulties because there are gaps between agents, being the intermediaries responsible for building bridges and facilitating linkage. Nevertheless, analyzing the impact of intermediaries is not easy, mainly because the problem of attribution, where different approaches are nothing more than a photography that lacks a dynamic and longitudinal analysis. This work aims to overcome such limitations by agent-based simulation, which helps broaden understanding of the phenomenon of intermediation in innovation systems and their impact on performance.

Keywords: innovation intermediaries, innovation systems, agent-based modeling, innovation capabilities, transaction cost

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1. Introducción

El relacionamiento de agentes heterogéneos que conforman los sistemas de innovación no es sencillo, debido a la existencia de brechas de diferentes dimensiones entre ellos (Parjanen, Melkas, & Outila, 2011), ocasionando unos altos costos de transacción (CT) (Batterink, Wubben, Klerkx, & Omta, 2010). Son los intermediarios quienes encaran esta dificultad mediante la construcción de puentes entre agentes distantes y la generación de confianza, favoreciendo el relacionamiento que permite el establecimiento de un sistema de innovación. Como expresan Ruiz y Robledo (2013), las diferentes perspectivas que han abordado el fenómeno de la intermediación, reconocieron la necesidad de precisar el impacto de los intermediarios en el sistema en el que están inmersos; del mismo modo, plantearon que tal evaluación es un problema complejo, dadas las dificultades que hay en la atribución de su aporte al sistema de innovación. Se encuentra entonces que, para una correcta valoración de tal aporte se requiere un análisis dinámico y longitudinal que describa el desempeño y co-evolución de los diferentes agentes que conforman el sistema de innovación, siendo esto fundamental para poseer elementos que evidencien la contribución de los intermediarios y se puedan tomar decisiones con respecto a estos agentes (Ruiz & Robledo, 2013).

Desde la postguerra se han desarrollado modelos orientados a ayudar al entendimiento del proceso de innovación, desde visiones reduccionistas como los enfoques lineales de primera generación hasta los modelos sistémicos de quinta generación (Rothwell, 1994). Estos últimos entienden el proceso de innovación como sistémico y resaltan la importancia del aprendizaje. Sin embargo, los mecanismos responsables de la conformación de los sistemas de innovación no son fáciles de comprender, principalmente por la complejidad de los procesos dinámicos y por la heterogeneidad de los actores que intervienen (Gilbert, Pyka, & Ahrweiler, 2001). Por lo anterior, los sistemas de innovación se pueden considerar como Sistemas Complejos Adaptables (SCA). Estos últimos se conciben como un arreglo de agentes interactuantes descritos por reglas, las cuales cambian al acumular experiencia (Holland, 2004). Estos SCA son representarlos recurrentemente a través de la Modelación Basada en Agentes (MBA), por ser una herramienta potente para obtener información de la dinámica de sistemas que son conformados por agentes heterogéneos y el relacionamiento entre ellos tiene sus características propias (Rahmandad & Sterman, 2008). Justificando la adopción de esta aproximación para afrontar el problema de análisis del impacto de los intermediarios en los sistemas de innovación.

(1) Centro de Desarrollo Empresarial, Universidad Pontificia Bolivariana, Medellín, Colombia,
(2) Ingeniería Industrial, Universidad Pontificia Bolivariana, Medellín, Colombia.
(3) Dpto. de Ingeniería de la Organización, Universidad Nacional de Colombia, Sede Medellín, Colombia.
*Corresponding author: walterlugo.ruiz@upb.edu.co

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A continuación se plantean unos supuestos principales, con los cuales se elabora el modelo conceptual y la lógica de la simulación. Luego se aplica el modelo de simulación mediante la parametrización del modelo y la simulación de escenarios que permitan hacer experimentos con los intermediarios, con el fin de analizar su impacto en el desempeño del sistema de innovación. Para finalizar, se presentan las conclusiones y unas recomendaciones de trabajo futuro.

2. Formulación del modelo

Supuestos fundamentales

Para analizar el impacto de los intermediarios en los sistemas de innovación a través de un modelo de simulación, se debe tener en cuenta que estos sistemas emergen de la interacción entre agentes heterogéneos (Edquist, 1997). Dicho modelo debe de permitir realizar experimentos con los agentes intermediarios para poder analizar su impacto en el desempeño del sistema.

Las capacidades que requiere el sistema de innovación para realizar sus funciones de generar, difundir y usar conocimiento y tecnología están distribuidas entre los diferentes agentes que lo conforman. Estas capacidades han sido clasificadas por varios autores y se les ha dado la connotación de capacidades tecnológicas, de innovación y/o de innovación tecnológica (Kim, 1997; Ernst, Mytelka, & Ganiatsos, 1998; Guan & Ma, 2003; Wang, Lu, & Chen, 2009). En la Tabla 1 se pueden ver cómo cada capacidad de innovación es asignadas a una función de los sistemas de innovación:

Tabla 1. Asignación de capacidades de innovación a las funciones de los sistemas de innovación

Función	Capacidad	Aplicación
Generación de conocimiento y tecnología	Investigación	Generar y adaptar conocimiento y tecnologías.
	Desarrollo	Desarrollar experimentalmente productos, procesos, métodos de mercadeo y formas de organización
Difusión de conocimiento y tecnología	Difusión	Capturar resultados de I+D y tecnologías y aprovechar sus beneficios.
	Vinculación	Realizar transferencia de tecnología interna, entre agentes y la infraestructura local de ciencia y tecnología
Uso de conocimiento y tecnología	Producción	Operar y mantener su infraestructura productiva de forma eficiente, así como adaptar y mejorar la tecnología de producción existente.
	Mercadeo de la innovación	Identificar necesidades presentes y futuras del mercado, desarrollar nuevos productos, establecer canales de distribución, prestar servicios al cliente y publicitar la innovación.

Las capacidades de innovación con que cuentan los agentes los caracteriza de la siguiente forma: los explotadores poseen capacidades de producción y/o mercadeo de la innovación, los intermediarios tienen capacidades de difusión y/o vinculación, y los exploradores ostentan capacidades de investigación y/o desarrollo. Estos agentes se pueden considerar como especializados en una función de los sistemas de innovación. Sin embargo, en el modelo propuesto se permite que los agentes puedan ejercer varias funciones, los cuales se clasifican como: introductores o porteros, que tienen capacidades para explotar e intermediar; representantes o gestores, que pueden explorar e intermediar; integrados, que consiguen explorar, intermediar y explotar; ambidiestros, que exploran y explotan, y los de desarrollo incipiente, que no se distinguen por una alta capacidad en ninguna función de los sistemas de innovación.

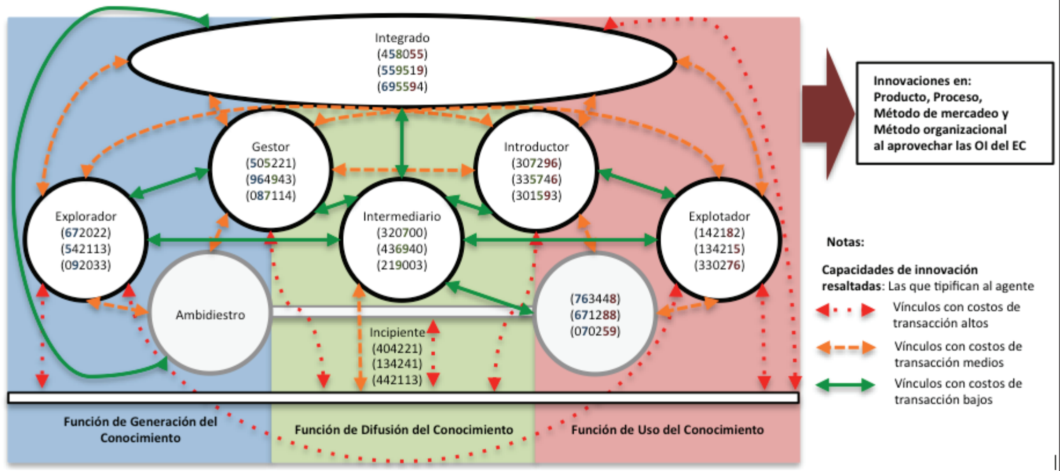
Para que los agentes se puedan considerar como competentes, sus capacidades deben de ser validadas por un entorno competitivo. En el modelo propuesto, este entorno es representado por necesidades que requieren ser satisfechas por los agentes, quienes mediante sus capacidades mínimas deben de suplir los atributos de cada necesidad, dándole al modelo un comportamiento *market pull*. Estos atributos se manifiestan en vectores que representan innovaciones, los cuales se denominan oportunidades de innovación (OI). Los valores en cada posición del vector de atributos determinan las necesidades de cada oportunidad de innovación.

Para finalizar, una consideración significativa es la de reconocer la dificultad en la interacción entre agentes producto de la brecha que se genera por su heterogeneidad, especialmente entre exploradores y explotadores, causando altos CT que influyen en el desempeño de los agentes y el sistema. Estos CT dependen de la tipología de los agentes que están interactuando, sustentándose esta afirmación en el planteamiento de Williamson (1985), quien sostiene que siempre que los activos son específicos en un grado no trivial, en el caso del modelo las capacidades de innovación que hacen que los agentes competidores sean heterogéneos, hay un incremento en la incertidumbre, la cual ocasiona que las brechas contractuales sean mayores. En esta dirección, los agentes intermediarios que poseen altas capacidades de difusión y vinculación, generan confianza y, por ende, disminuyen los CT en las interacciones en las que están involucrados. De forma similar, los agentes introductores o porteros, representantes o gestores e integrados, que también cuentan con capacidades de difusión y vinculación, pueden generar CT bajos o medios dependiendo de los agentes con que estén interactuando. Por último, los agentes que no poseen capacidades de difusión o de vinculación como los exploradores, explotadores y agentes de desarrollo incipiente, generan unos CT altos en sus interacciones.

Modelo conceptual

Los supuestos que rigen el modelo se presentan en la Figura 1, donde se observan los diferentes tipos de agentes según sus capacidades, ejemplos de vectores de capacidades de cada tipo de agente, la función que cumplen en el sistema de innovación según sus capacidades, los diferentes vínculos que se pueden generar, el CT que se asigna a cada vínculo, y cómo esta relación contingente entre agentes puede aprovechar OI que están presentes en el entorno competitivo mediante la innovación en producto, proceso, método de mercadeo u organizacional.

Figura 1. Modelo Conceptual

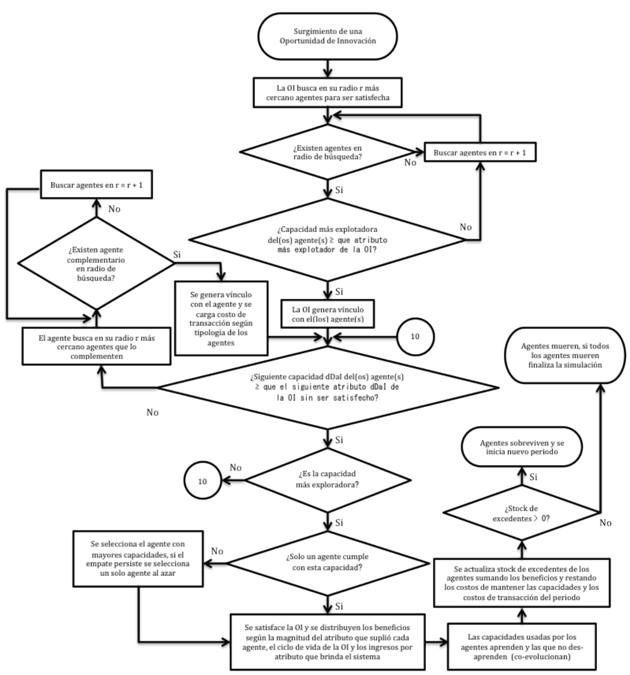


Fuente: elaboración propia

Lógica del modelo de simulación

Las reglas de decisión del modelo de simulación se pueden apreciar en el diagrama de flujo presentado en la Figura 2, donde la localización juega un papel fundamental al ser la primera regla de búsqueda de agentes. Luego, la complementariedad en las capacidades es la regla que define si se realiza el vínculo o no. Esta búsqueda se rige por ir de la explotación a la exploración o de derecha a izquierda en el vector de atributos de las OI (dDaI). Cada vínculo entre agentes según su tipo, determina el CT. Cuando una oportunidad de innovación es aprovechada, esta reparte sus beneficios entre los agentes o agente que suplen sus atributos con sus capacidades, de acuerdo a la magnitud de cada atributo y el ciclo de vida de la oportunidad de innovación. Estos beneficios se suman al stock de excedentes de cada agente por período, al cual se le restan los costos de mantener sus capacidades y los CT de cada uno de sus vínculos. Los agentes que disminuyan su stock de excedentes hasta cero desaparecerán del sistema. Los agentes que suplan OI aprenden acumulando las capacidades que utilizaron y des-acumulan las que no mediante el des-aprendizaje.

Figura 2. Diagrama de flujo de la lógica del modelo



Fuente: elaboración propia

3. Aplicación del modelo de simulación

Los valores iniciales de los parámetros del modelo y la lógica para definirlos se pueden apreciar en la Tabla 2. Ahora, para la elección de los escenarios se tiene en cuenta el planteamiento de Holland (2004, p. 55), sobre que "todos los SCA tienen puntos de apalancamiento, en donde pequeñas adiciones producen grandes cambios dirigidos"; por ello, se analiza al intermediario como posible punto de apalancamiento que genere un desempeño diferenciado del sistema de innovación.

Las simulaciones se realizan en el programa NetLogo 5.1.0. Cabe anotar que estas simulaciones son consideradas como exploraciones de micromundos, o mundos simplificados y manipulables (Resnick, 2001), por lo que se puede hablar más de exploración de micromundos que de simulaciones de la realidad (Resnick, 2001).

Tabla 2. Valores de los parámetros del modelo

Parámetro	Valor	Observación
Número inicial de OI	100	Valor que se asigna igual al número de agentes iniciales para analizar que tanto influye en su supervivencia y cómo se comporta esta cantidad en el tiempo.
Número inicial de agentes	100	Igual al número de OI para observar que tan eficientes son para aprovecharlas y que porcentaje es capaz de sobrevivir en el tiempo.
Tasa de nacimiento de las OI	18%	Valor umbral hallado después de varias corridas, entendiéndose como el porcentaje mínimo de renovación de las OI para tener un sistema sostenible en el tiempo, entendiendo que se requiere reemplazar a las OI que desaparecen por no ser aprovechadas dada su volatilidad y las que cumplen con su ciclo de vida.
Tasa de nacimiento de los agentes	4%	Este valor equivale al emprendimiento que existe en el sistema, el valor de 4% se calcula de acuerdo al valor de la densidad de nuevas empresas mostrado por el grupo del Banco Mundial para algunos países de Latinoamérica.
Factor de aprendizaje	0,3	Valor acorde con los resultados empíricos de los estudios del comportamiento de las capacidades tecnológicas realizados en Asia por Hobday (1997) y Kim (1997). El valor del factor que se acomoda a estos datos empíricos es el de 0,3 el cual significa que se puede llegar de una capacidad básica a una avanzada en 37 años.
Factor de des-aprendizaje	0,3	Se le dio un valor igual al del aprendizaje para equilibrarlos en el sistema, pues no habría un argumento plausible para que fueran distintos.
Stock de excedentes máximo	270	Se calculó el valor a partir del siguiente razonamiento: como las capacidades son asignadas aleatoriamente a todos los agentes en todas las posiciones con valores de cero (0) a nueve (9), las capacidades van a tener en promedio para los agentes el valor de 4,5, por lo que una magnitud de 4,5 en las 6 capacidades de longitud del vector de capacidades da un valor de 27; este valor significa que si cada magnitud de capacidad tiene un costo de mantenimiento de uno (1), entonces 27 sería el costo de mantener las capacidades en un período para un agente promedio. Sin embargo, para el sistema estándar se considera el costo de mantenimiento de las capacidades de dos (2), por lo que el costo promedio de mantenimiento de un agente por período sería de 2 x 27 = 54. Además de esto se le asigna aleatoriamente un stock de excedentes a cada agente, por lo que se debe de elegir el valor máximo de dicho stock, el cual se considera que debería de ser el valor de mantenimiento de un agente por cinco (5) años, ósea 54 x 5 = 270.
Tiempo máximo de ciclo de vida de las innovaciones	10	Este valor se asigna a las OI de forma aleatoria, el valor máximo de 10 años limita la posibilidad de que algunos productos puedan tener una duración mayor en el mercado, sin embargo es poco probable dado el nivel de competencia de los sistemas económicos actuales.
Volatilidad máxima de las OI	5	Este valor también se adjudica de manera aleatoria y se selecciona un valor máximo de 5 años, este valor parece excesivo, sin embargo las necesidades latentes pueden durar mucho tiempo hasta que aparece una innovación que logre suplirla,
Ingreso por atributo	10	Es importante que el valor del ingreso supere varias veces lo que cuesta mantener la capacidad, esto es indispensable para motivar a los agentes a competir por estos ingresos. El ingreso es 5 veces mayor al costo, sin embargo, se debe de tener en cuenta que muchas veces los agentes aprovechan OI con capacidades superiores a los atributos, es por esto que se requiere, para que el sistema sea sostenible, una diferencia de este estilo.
Costo por capacidad	2	El valor se asigna mayor a 1 para poder a futuro hacer experimentos de política que conlleve a subsidios. Es de anotar que el valor tanto en los ingresos como en los costos se da igual en todas las posiciones.
Costo de transacción: Bajos, Medios y Altos	1, 5 y 10	Los valores se asignan calificando de uno (1) a diez (10) el costo de transacción que se genera en cada vínculo, dependiendo de la tipología de los agentes que lo forman, donde 1 es bajo, 5 es medio y 10 es alto.

Considerando lo anterior, se plantean los siguientes escenarios:

Escenario problema (A)

Como ya se mencionó, las capacidades con las que deben contar los agentes para realizar la función de intermediación en los sistemas de innovación son las de difusión y vinculación. Por ello, un escenario problemático para que exista realmente un sistema de innovación, es que ningún agente posea capacidades de difusión y de vinculación.

En este escenario no existe intermediario, ni tampoco se les da la opción a los otros agentes para que asuman la función del intermediario. Esto se logra asignando un nivel de cero a las capacidades de difusión y de vinculación de todos los agentes del micromundo.

Escenario problema con un intermediario (B)

Siguiendo la recomendación de Holland (2004) de buscar identificar puntos de apalancamiento, se parte del escenario problema y se le adiciona un único agente intermediario con unas capacidades medias (valor de cinco) de difusión y vinculación, con el fin de analizar qué impacto genera este agente en el desempeño del micromundo.

Es de notar que para todos los escenarios, las magnitudes de las posiciones de los vectores de las OI del entorno competitivo se asignan de forma aleatoria de cero (0) a nueve (9).

Escenario sin intermediarios pero con capacidades de difusión y vinculación distribuidas en todo el micromundo (C)

En este escenario se asigna a todos los agentes del micromundo capacidades de difusión y vinculación de forma aleatoria: pudiendo carecer de ellas (valor de cero), o tener niveles incipientes (de uno a tres), o niveles medios (de cuatro a seis), o niveles avanzados (de siete a nueve), en cualquiera de las dos capacidades encargadas de las funciones de difusión. Sin embargo, se elimina la opción de que existan agentes intermediarios, o sea, aquellos que por sus capacidades se especializan solo en la función de difusión de conocimiento y tecnologías.

A diferencia de los escenarios anteriores, en este interactúan en el micromundo agentes del tipo introductores o porteros, representantes o gestores, e integrados.

Escenario con intermediarios y con capacidades de difusión y vinculación en todo el micromundo (D)

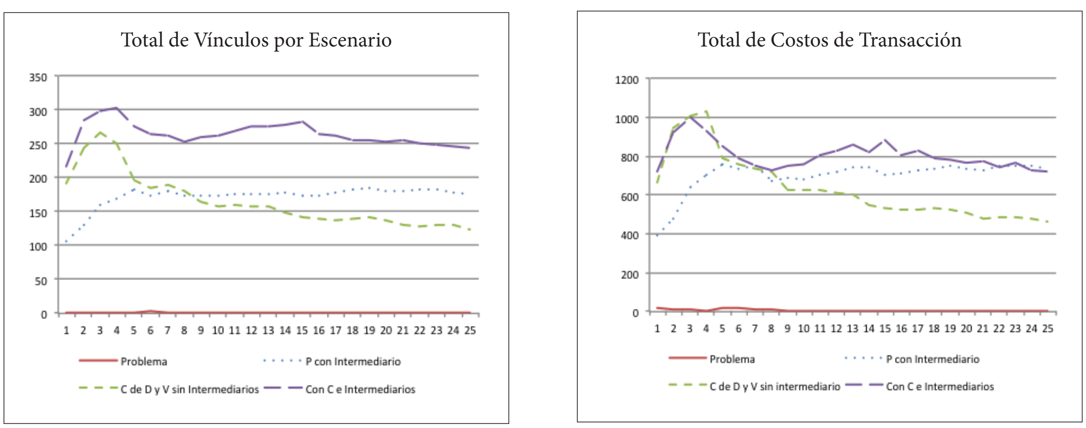
Se considera que este es el escenario 'ideal' o 'normal', donde puede existir todo tipo de agentes y las capacidades se asignan de forma aleatoria para todos ellos. En este micromundo todos los agentes tienen la posibilidad de generar, difundir y usar conocimiento y tecnología para aprovechar las OI del entorno competitivo.

La diferencia de este escenario con el anterior es el permitir que existan agentes que por su tipología se consideran intermediarios, lo cual se hace con el mismo fin del escenario dos de identificar puntos de apalancamiento en el desempeño del micromundo.

Resultados y análisis de los escenarios

A continuación se comparan los resultados de las simulaciones de los cuatro escenarios, donde se puede ver la evolución de las principales variables del modelo (ver Figura 3). El tiempo de simulación es de 25 años, lapso suficiente para identificar las tendencias en el comportamiento de cada uno de los escenarios. A los datos obtenidos de las simulaciones se les realizó un análisis estadístico, donde primero se analizó si había diferencia significativa entre los cuatros escenarios, para luego aplicar la prueba de Tukey para identificar esas diferencias entre los comportamientos de cada escenario.

Figura 3. Evolución de las principales variables del modelo para los cuatro escenarios de simulación



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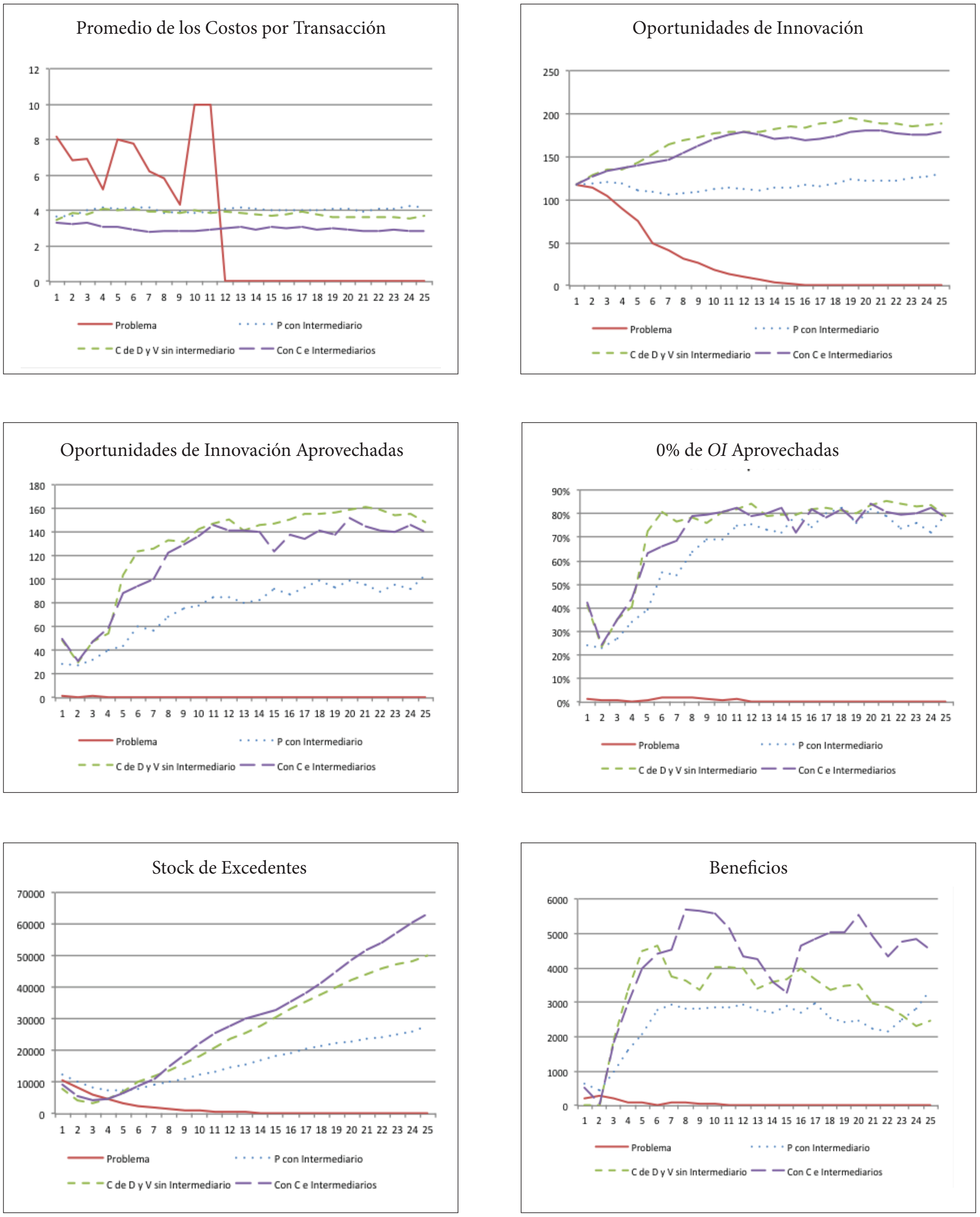

Fuente: Elaboración propia basado en los resultados de las simulaciones en NetLogo 5.1.0

El total de vínculos o transacciones se puede interpretar como si evidentemente existe o no un sistema. Esto se puede afirmar puesto que, como manifiesta Bertalanffy (1968) en su Teoría General de Sistemas, para que haya un sistema las unidades deben de estar en interacción.

La gran diferencia en el comportamiento de los escenarios A y B se tenía prevista, teniendo en cuenta lo manifestado por Klerkx y Leeuwis (2008; 2009) y Batterink et al. (2010) donde los intermediarios se consideran como formadores y orquestadores del sistema de innovación.

La diferencia en los dos comportamientos es significativa, aunque el único cambio realizado es la introducción de un agente intermediario con unas capacidades medias de difusión y vinculación, permitiendo esto identificar un punto de apalancamiento. Ahora, al comparar los escenarios C y D, NO se encuentra diferencia significativa. Teniendo en cuenta esto último, NO se puede hablar de un punto de apalancamiento cuando se introducen intermediarios en un micromundo donde ya existen capacidades de difusión y vinculación; muy diferente a lo observado entre el escenario A y B.

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El actuar del intermediario en el caso del escenario B y las capacidades de difusión y vinculación del escenario C y la combinación de estos elementos en el escenario D, mantiene unos CT promedio por vínculo similares; demostrando c**ó**mo las capacidades de difusión y vinculación, ya sea aportadas por intermediarios o por otro tipo de agentes, son importantes para reducir los CT presentes en los sistemas de innovación.

El comportamiento observado en la Figuras 3, respecto al número de OI del entorno competitivo y al número de OI aprovechadas por los agentes competidores, tiene mucha relación, pues mientras más OI sean aprovechadas, puede aparecer una mayor cantidad de ellas en el micromundo, mostrando cómo los ambientes más innovadores generan una mayor dinámica. El número y porcentaje de OI aprovechadas por los agentes competidores depende mucho de las capacidades que tengan los agentes del micromundo para generar, difundir y usar conocimiento y tecnología, así: en el caso del escenario A, donde los agentes no cuentan ni con capacidades de difusión y vinculación, se distingue cómo los agentes no logran aprovechar las OI y poco a poco estas van desapareciendo debido a su volatilidad. Mientras que al agregarle un intermediario en el escenario B, el número de OI se logra mantener estable en el mundo, pues los agentes logran aprovecharlas a través de la interacción y el aprendizaje de las capacidades que están utilizando. Los escenarios C y D presentan unos comportamientos muy similares; esto se puede considerar un comportamiento contra-intuitivo, ya que se esperaba que el escenario D, por el actuar de los intermediarios, tuviera mejores resultados que el escenario C. En síntesis, como en el caso de vínculos, en las OI también se puede notar el efecto de apalancamiento que tiene el instalar un intermediario en un micromundo que no posee capacidades de difusión y vinculación.

El análisis del desempeño económico de los escenarios se hace a partir del comportamiento del stock de excedentes y beneficios (Figura 3). Estos comportamientos van de la mano de la cantidad de OI aprovechadas, pues son estas las que otorgan los beneficios a los agentes del micromundo. El escenario A obtiene unos beneficios muy pobres en comparación con los otros escenarios; estos beneficios aportan poco al stock de excedentes, que se va viendo menguado por los costos de mantenimiento. Ahora, al agregarle un intermediario a ese escenario problema (escenario B), se aprecia un comportamiento diferente, donde los beneficios y el stock de excedentes van aumentando, se estabilizan y mantienen en el tiempo, puesto que los agentes van especializándose por la acumulación de capacidades que propicia el aprendizaje; sin embargo, los resultados no alcanzan a ser tan buenos como cuando existen más capacidades de difusión y vinculación en el micromundo (escenarios C y D), pero sí son mucho mejores que en el escenario A.

Los escenarios C y D, con capacidades de difusión y vinculación distribuidas entre los agentes del micromundo, presentan mejores resultados en los beneficios y stock de excedentes, lo cual se puede explicar por su éxito en el aprovechamiento de OI, comportamiento provocado por la cantidad de vínculos entre agentes, por la acumulación de capacidades y por la co-especialización de los agentes. Esta conducta genera unos mejores resultados a la hora de aprovechar las OI, permitiendo que los agentes logren aumentar su stock de excedentes gracias a su desempeño innovador. Sin embargo, estos escenarios no presentan diferencias significativas en el stock de excedentes, por lo que el impacto del intermediario en este indicador del desempeño económico es poco significativo.

En las simulaciones de los escenarios se pudo apreciar la generación de un contexto dinámico caracterizado por la co-evolución y la auto-organización; esto se puede ver en la Figura 3, especialmente al inicio de las simulaciones de los micromundos, donde los agentes inician sus relaciones y empiezan a co-evolucionar y co-especializarse gracias al aprendizaje que se da vía interacción con otros agentes complementarios y al uso de sus capacidades, que les permiten acumularlas y des-acumularlas. Ese comportamiento *caótico* al inicio de las simulaciones puede no corresponder a un sistema real, pues aunque se ha tratado de ajustar los parámetros del micromundo, ningún sistema real empieza en t=0 de una manera puramente aleatoria. Posteriormente, la propensión en los comportamientos se va volviendo más persistente, reflejando la auto-organización que se da en los SCA, que los lleva a mostrar el orden oculto del que habla Holland (2004).

El escenario B observado en la Figura 3 es bastante revelador, pues en este el intermediario juega un papel donde aporta sus capacidades para que se dé el puente entre los agentes extremos facilitando la difusión. También se tiene en cuenta en todos los escenarios que el intermediario no pretende reemplazar las relaciones que ya se han creado entre los agentes del micromundo; sin embargo, no todos los agentes tienen las mismas capacidades de difusión y vinculación; por lo tanto, el intermediario actúa como facilitador, especialmente entre los agentes que presentan más debilidades en estos sentidos, tal cual como lo manifiesta Göktepe (2006).

Una contribución importante del intermediario que se puede observar, especialmente en el escenario B, reconocida por Klerkx y Leeuwis (2008), es su construcción de capacidades en los demandantes y proveedores de conocimiento para cooperar en el proceso de innovación; dicha labor también es realizada en los escenarios C y D por los agentes que poseen capacidades de difusión y vinculación. De igual forma, se identifica en los escenarios B, C y D que los intermediarios contribuyen reduciendo los CT promedio de los vínculos involucrados en el intercambio de conocimientos, aporte reconocido por Dyer y Singh (1998) para los intermediarios, el cual se visualiza especialmente en el escenario B. En el caso del escenario B, que transforma fundamentalmente al escenario A al agregar un intermediario, se podría usar la conclusión de Boon, Moors, Nahuis y Vandeberg (2008), quienes plantean que la interacción entre usuarios y productores de conocimiento organizados a través de intermediarios, parece ser la herramienta más importante para la articulación de la demanda de conocimiento y el aprendizaje interactivo.

En cuanto a la diferencia entre ingresar un intermediario a un micromundo donde no existen capacidades de difusión y vinculación y uno en el que sí, como en los casos de los escenarios B y D, la diferencia en los resultados confirma lo expresado por Konttinen, Nieminen y Suvinen (2010), cuando dicen que se justifica la intervención de políticas para apoyar la conformación de intermediarios, siempre y cuando la relación Universidad-Empresa-Estado no esté funcionando bien; por ello, en el caso del escenario D, son escasas las contribuciones que los intermediarios aportan al comportamiento al compararlo con el escenario C; siendo muy diferente e impactante el agregar un intermediario en el escenario A. Sin embargo, como se asignaron capacidades de todo tipo en los escenarios C y D, así como en las capacidades que hacen parte de las funciones de generación y uso de conocimiento en los escenarios A y B, no se puede perder de vista lo expresado por Van Lente, Hekkert, Smits y Van Waveren (2003), cuando reconocen que aunque es útil e incluso necesario el rol del intermediario, no es suficiente para el buen desempeño del sistema, el cual sigue dependiendo de la composición del mismo o, en otras palabras, de los actores empresariales y científicos que lo componen.

Con las variables de salida de los escenarios se pretende analizar el impacto de los intermediarios en el desempeño del Sistema de Innovación, como se hizo en este apartado. Sin embargo, hay unos comportamientos emergentes que vale la pena resaltar. En primer lugar, no solo el intermediario impacta en el desempeño del sistema de innovación, sino que permite la conformación y orquestación del mismo como se pudo apreciar en el escenario B, mostrando el gran impacto que tiene el intermediario en lugares donde no se ha logrado establecer un sistema de innovación por las escasas capacidades de difusión y vinculación que existe en los agentes, lo que ha conformado unas brechas que son superadas gracias al intermediario. En segundo lugar, el impacto que genera el intermediario en el sistema de innovación, también depende de las capacidades de los agentes que conforman el sistema; por ejemplo, como se pudo observar al agregar intermediarios en sistemas que ya cuentan con capacidades de difusión y vinculación y que no poseen unas brechas tan grandes entre los agentes, siendo su impacto no tan notorio como cuando se instala en lugares donde los agentes no cuentan con estas características.

Conclusiones y trabajo futuro

El modelo permite zanjar el problema de atribución del intermediario manifestado en la literatura sobre intermediarios de innovación, mediante un análisis comparativo, dinámico y longitudinal, que admite analizar el impacto de los intermediarios en el desempeño y conformación del sistema de innovación. Al comparar el comportamiento de los cuatro escenarios en el tiempo se puede observar que los intermediarios tienen un impacto diferente en el desempeño del sistema de innovación de acuerdo a las capacidades con que cuenten los agentes con los que va a interactuar. En el caso de un lugar donde no se ha formado un sistema de innovación, donde existen brechas entre los agentes que generan y usan conocimiento, y donde las capacidades de difusión y vinculación con las que cuentan los agentes del sistema son insuficientes, el intermediario actúa como un punto de apalancamiento que permite la formación del sistema de innovación e impacta en el desempeño innovador y económico del mismo. Mientras que, en el caso de un lugar donde los agentes que van a conformar el sistema poseen capacidades de difusión y vinculación y, por ende, menos brechas entre algunos agentes, el adicionar agentes intermediarios, aunque en algunos casos puede mejorar el desempeño del sistema de innovación, no genera unos impactos tan marcados en su desempeño.

Por otra parte, se resaltan las características novedosas del modelo: i) ofrece un enfoque *market-pull*; ii) permite la co-evolución y co-especialización de los agentes; iii) considera un entorno competitivo dinámico que genera múltiples OI en cada período representando diferentes necesidades o atributos; iv) premia a los agentes que suplen las OI, asignando un ciclo de vida a la innovación y una volatilidad a las OI; v) rige la búsqueda de agentes por una lógica de cercanía; vi) se considera a los agentes con una racionalidad limitada; vii) no se limita a los agentes en la búsqueda de colaboradores complementarios distantes; y viii) permite a los agentes tener todo tipo de capacidades, así como su posible acumulación y des-acumulación.

Como trabajo futuro se requiere avanzar en la validación del modelo, tanto desde el punto de vista conceptual, como operacional. De forma similar, solo se analizaron cuatro escenarios que se requerían para dar respuesta al objetivo del trabajo; sin embargo, el modelo posibilita dos tipos de aplicaciones: por un lado, para el desarrollo teórico, en el sentido de Davis, Eisenhardt y Bingham (2007); por otro lado, para la formulación de políticas sobre intermediación y aprendizaje, según se desprenda de la comprensión que genere el modelo sobre el papel de los intermediarios a partir de las simulaciones. Con respecto al modelo, se pueden adicionar nuevas variables y/o relaciones que permitan realizar otros análisis del papel de los intermediarios; estas adiciones pueden estar enfocadas, por ejemplo, a la creación de *spin-offs* que hereden capacidades que los agentes de origen no están usando, como alternativa al des-aprendizaje; así como a permitir la imitación, donde los agentes puedan competir por medio de esta estrategia por las OI que ya están siendo suplidas, especialmente incorporando el modelo Bass; de forma similar, se puede diferenciar entre enlaces débiles y fuertes que influyan en la topología de red, así como permitir a los agentes priorizar sus vínculos con agentes con quienes ya tuvieron una relación anterior, entre otras posibilidades.

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Discussing the Concepts of Cluster and Industrial District

Francisco Javier Ortega-Colomer [*1], *Francesc Xavier Molina-Morales* [2], *Ignacio Fernández de Lucio* [1]

Abstract: The significance and popularity of the cluster and industrial district concepts claim for a deeper reflection. The analysis of one of the European Commission's (EC) policy documents shows inconsistencies that do not impede the formulation of normative statements. That way we answer the question of why and how cluster ideas have substituted industrial district principles and the consequences derived from that phenomenon.

Keywords: Industrial districts; clusters; conceptual analysis; rhetorics; European Commission

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Introduction and Objectives

Despite the ongoing globalization process, the regional dimension is attracting a lot of interest in terms of the shifts in science, technology and society. For instance, it is well-known that in many countries there has been a process of decentralization of the power authorities (UK, Germany, Austria and Spain are examples). At the same time, regional analysts have been investigating why industries agglomerate and specialize in specific locations, and how firms can profit from this activity –so called, external economies. In fact, regional development can be analysed by identifying the economic, social and institutional dynamics involved, and by redefining the changing role played by different actors and by taking 'the region as a scale of economic organization and political intervention' (MacKinnon et al., 2002, p.293).

Economists and geographers working in these areas have proposed a great range of neologisms "to capture and represent the spatial form and nature of local business concentrations" (Martin and Sunley 2003, p.8). Industrial districts (Becattini 1990), new industrial spaces (Scott 1988), territorial production complexes (Lonsdale 1965), neo- Marshallian nodes (Amin and Thrift 1992), regional innovation milieu (Aydalot 1986), network regions (Martin and Sunley 2003: 8), and learning regions (Florida 1995) are some of the terms that have been suggested (Martin and Sunley 2003 suggested these examples: Scott 1988; Amin and Thrift 1992; Harrison 1992; Harrison et al., 1996; Scott 1998; Markusen 1996; Asheim 2000). However, the most popular of them are industrial district (Becattini 1990) and cluster (Porter 1990), notions that are the focus of this paper.

We should first confirm the extensive use and popularity of these concepts among academics (from disciplines such as geography, economics, management, history and sociology), policy makers (from some European countries, mostly from Italy and Spain), institutions (for instance, the European Commission) and practitioners (consultancy firms, such as Tecnalia). The success of these concepts has resulted in some rather confusing and sometimes chaotic usages, which, at the same time, justify our examination of their conceptual development.

Since 1990, the concepts of industrial district and cluster have been used to refer to the same phenomenon in many regional research writings (Markusen 2003; Lazzeretti 2006). In Spain, both types of policies (industrial districts and clusters) have been employed in various regional programmes. For instance, while cluster policies have been implemented in the Basque Country and Catalonia, the Valencia region has used the industrial district model. In our view, the indiscriminate use of concepts in scientific writing is sometimes due to arbitrary considerations such as the preferences of the journal editors.

Markusen (2003, p.701) described this as terms that 'lack substantive clarity' or as 'fuzzy concepts'. Because these terms arose out of the interaction between the research community and policy-makers they have been coined also as 'transdiscursive terms' (Miettinen 2002, p.133). Others refer to them simply as 'fashion labels' (Martin and Sunley 2003, p.23) because of their temporal nature while the philosopher W. B. Gallie termed them 'essentially contested concepts' for combining general agreement on the abstract notion that they represent with endless disagreement about they might mean in practice (Gallie 1956). However, many authors have made efforts to differentiate these concepts and have warned about the consequences of the confusion or lack of clarity in their use (Markusen 2003; Lastres and Cassiolato 2005; Lazzeretti 2006). Others have strived for a deconstruction of the cluster concept (Martin and Sunley 2003), concluding that in transcending their epistemological boundaries the regional scientist can provoke a misuse of the original concept and ignore the contributions of colleagues.

Our first reaction is that the logic of these concepts (industrial district and cluster) is far from clear and an analysis of their underlying rhetoric is required. To this end, we analysed a European Commission policy document titled The Concept of Cluster and Cluster Policies and their Role for Competitiveness and Innovation: Main statistical results and lessons learned (European Commission 2008). Although, in our opinion, there are some inconsistencies in this document, surprisingly they do not impede the formulation of normative statements.

(1) INGENIO (CSIC-UPV), Universitat Politècnica de València, Valencia, Spain.

(2) Department of Business Administration and Marketing, Universitat Jaume I de Castelló, Spain.
*Corresponding author: fraorco@ingenio.upv.es

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For instance, industrial clusters are argued to act as vehicles to foster prosperity at the European level in terms of more employment and higher wages. We perform a critical analysis of this and similar statements.

The paper is structured as follows. The first section discusses the origins and definitions of the concepts. The next section compares their rationales, methodologies and rhetoric. The final section discusses the pitfalls in use of the cluster concept for policy making.

Origins and Definitions of the Concepts of Industrial District and Cluster

Industrial District

First, the intellectual detonator for the emergence and development of the industrial district concept was an analysis about the modes of organizing the production process in the early stages of capitalism (Marshall 1890; Marshall 1919). At that time (the end of the 19th century) the hegemonic mode of production was the so-called factory system, where all productive operations were concentrated in the same location (Becattini 2002). Marshall's writings were the source of inspiration for several authors (Brusco 1990; Pyke et al., 1992; Porter 1998; Becattini 2002) who attempted to explain external economies[1] from an operational point of view. According to Krugman (1991), the agglomeration of firms provides a troika of external economies to the firms located in the same area: economies of specialization, economies of labour pooling and economies of knowledge spillovers, which are on the base of the advantages of these firms. In addition the Marshallian notion of 'industrial atmosphere' captures the flows of intangible resources and knowledge circulating within a district.

This approach re-emerged in the 1970s when some researchers argued that the innovative capacity of some small and medium enterprises in Italy could overcome the decline of the Fordist production model (Becattini 2002). A vast number of case studies on Italy (Becattini 1962; Becattini 1973; Becattini 1979; Gazzero 1973; Fuà 1983; De Angelini (1986); Becattini (1986); De Angelini 1986; Della Vecchia 1987; Ciborra and Longhi 1989; Del Fabbro 1992; among others) became the starting point for a new paradigm. The argument is that while large enterprise suffered from the consequences of both rapid changes in the demand for products and services, and the rise in oil prices, some small enterprises collaborated in order to adapt to this new reality. These firms exchanged knowledge and expertise with other firms in the same sector and firms in their immediate surroundings, thereby enabling several complementarities. The firms involved were mainly engaged in fashion, e.g. shoes and textiles. Becattini (1990, p.38) defines an industrial district as: 'A socio-territorial entity which is characterized by the active presence of both a community of people and a population of firms in one naturally and historically bounded area. In the district, unlike in other environments, such as manufacturing towns, community and firms tend to merge'.

This definition reflects Becattini's attempt to find a unit of analysis beyond the product or technology criteria; such as the Standard Industrial Classification (SIC) codes. Becattini proposed sense of belonging as a sociological criterion to classify firms belonging to a district (Becattini 1990). However, he needed to find a geographically and cognitively delimited unit of analysis which meant including an entity that was alive and thus shifting continuously. This reality was widely debated among different perspectives such as History, Sociology, Economics (among others) in order to integrate the community of people, population of firms (final product industries plus related and auxiliary industries plus machinery and tools firms) and the institutions or supporting organizations (academic, social institutions or trade associations and others) within the same analytical framework. Becattini was aware of his limitations: he could focus only on a specific natural environment and a specific history of a location where a particular case of possible and likely social evolutions took place simultaneously. He believed that his proposal should include more analytical elements both exogenous (e.g. the evolution of a technological sector) and also the evolution of the set of actors evolved that took account of the stages of birth, growth and decline. He included the sense of belonging to a specific location, territory, culture, tradition and history in the analysis to delimit the industrial district as a stable variable. This enables a better understanding of how some locations have created well-known brand images and why the lines between low-, medium- and high-tech are sometimes blurred.

The Cluster Concept

The cluster approach traces its roots in a series of case studies in several industrialized countries (Porter 1990). This seminal work provided the basic conceptual framework of clusters and the legitimization for using it in the policy arena, mainly in strictly economic issues. Although the concept of cluster was primarily posed in Porter (1990), it was later defined by him as 'a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster can be a single city or state or a country or even a network of neighbouring countries' (Porter 1998, p.199).

Porter (1998) extended his original analysis to account for the firm's local environment, including the geographical dimension, to identify, define and scope clusters. His and his group of researchers' main objective was to identify the nature of firm competitiveness which resulted in development of the cluster framework. Porter (1980) proposed the industry attractiveness framework comprised of five competitive forces (threat of substitute products, threat of entry of new competitors, intensity of competition/rivalry, bargaining power of customers, and bargaining power of suppliers). He developed the value chain model to identify sources of competitive advantage at firm-level (Porter 1980) and then proposed the well-known diamond model (Porter 1990) which was followed in Porter (1998) by the cluster framework.

The cluster concept was designed to respond to questions such as why are certain companies located in certain countries able to achieve sustainable competitive advantage. The cluster concept attempts a global

(1) The term 'external economies' was coined by Marshall in a study of the assumed advantages of the factory system as hegemonic model of production: he proposed an alternative model based on a network of small cooperating firms (Marshall, 1919).

or universal development and applicability, and focuses on searching sources of competitive advantage especially 'knowledge, relationships and motivation' (Porter 1998, p.78). These advantages are difficult for distantly located competitors to integrate in their processes because of the nature of the business environment (Bathelt et al., 2004, Bathelt and Glückler 2014). Only co-located firms are able to benefit and their close location is an entry barrier to 'outsiders'. The cluster concept emerged and has been developed in an era of globalization and is more recent than the concept of industrial district (Lazzeretti 2006). Its widespread use has been encouraged by the marketing efforts of the consultancy firm, Monitor[2], led by Michael Porter, which has had links to the Institute for Strategy and Competitiveness during its activity. In spite of its increasing popularity in academia and politics (Ketels 2003), the cluster concept has encountered serious criticism that is chaotic, vague and problematic[3] (Gordon and McCann 2000; Martin and Sunley 2003). The literature review reveals that in trying to differentiate among clusters, more variables were included in the analysis which has resulted in the cluster concept being adapted to enable application to any kind of sector and region.

A Concise Comparison of the Concepts of Industrial District and Cluster

In this section, we briefly compare the concepts from a critical perspective.

Their Emergence

From a dynamic perspective, these concepts are continuously evolving. Although Porter and Ketels (2009) defend their common roots, we would argue that their starting points significantly differ. In short, while it is the community of people that matters for Becattini, Porter's point of departure is analysis of the firm's value chain. After that, they converge in giving territory a prominent role.

As already noted, Becattini's original proposal was designed to overcome the limitations of the conventional classifications of firms (e.g. SIC). Sense of belonging was used instead of product or technology similarities as a criterion to group firms. Thus, industrial district is used as a heuristic tool to analyse the economic reality. The district is the unit of analysis, whose frontiers are the most relevant relationships explaining local development. Porter was searching for key issues in the competitive advantage of individual firms. If a firm's activities can be viewed as a number of value chain activities, then its main strategic decisions consist of placing each activity within the most adequate local environment. Thus, the cluster framework is more a theory of the firm, to explain why firm performance varies, that is, why some firms are more successful than others. So, although both concepts use territory or place as the centre of the analysis, the aims, development and final proposals are significantly different.

Their raison d'etre

If we compare analytical proposals, district and cluster show similarities in terms of justifying the advantages for firm collaboration. First, district externalities can be translated to related and auxiliary activities and factor conditions in the Porterian diamond. Competitive and cooperative duality of district internal relationships is mirrored in part by the local rivalry factor in the Porterian diamond. However, the roles of the institutional settings of district and cluster differ. The institutional setting of an industrial district is described as active in supporting the whole system and offering real services; in the cluster, institutions and government act indirectly or as subsidiary improvements on the diamond. Moreover differences emerge when we consider social aspects. Industrial district refers explicitly to the community of people and the context in which knowledge flows and numerous diverse categories of relationships occur**.** Porter barely refers to the social aspects of clustering since it is the individual firm that is the focus of the analysis. Social issues are seen to be the result of the economic success of private firms, while the success of economic issues for Becattini is the result of the social cohesion within a community of people.

Their Methodology

Different methodologies are associated with these concepts, mainly based on case studies. For industrial districts, case studies are used to describe both success stories and cases showing decline. They allow specific and idiosyncratic details to be captured that cannot be observed using other methodological approaches. However, case bias prevents generalization of conclusions. Other strands of research, i.e. the so-called district effect and studies focusing on identifying or mapping districts, attempt to demonstrate district advantages and superiority using comparison analysis. Firms belonging and outside districts are compared in terms of financial performance, innovation capacity, efficiency and other outcomes. These firms are usually in the same industry and the same country. However, the existence of a district effect has been questioned for several reasons, and often as a consequence of the globalization process which is challenging the rather static advantages of district formation.

Research on district identification is related to identifying whether or not a particular area/group can be considered to be an industrial district, i.e. whether the firms in an area are an agglomeration or a conventional district. This analysis uses mainly quantitative methods. It is assumed that not all agglomerations of firms can be identified as industrial districts which require a number of conditions to be fulfilled. These relate in particular to the industrial specialization of the local labour systems. In Porter's works, the cluster effect is rarely applied in a strict way probably because of an implicit assumption by which any group of agglomerated firms can be considered as a cluster, varying only on

(2) http://www.monitorgroup.com.cn/en/idea/leaders/leaders10.asp [accessed January 2009]. In 2012 Monitor group announced its bankruptcy state: http://www.forbes.com/sites/stevedenning/2012/11/20/what-killed-michael-porters-monitor-group-the-one-force-that-really-matters/
(3) Some authors responded to Martin & Sunley's article (Benneworth & Henry 2004).

the strength of their conditions (Tokunaga et al., 2014). The diamond model acts as a reference for comparison with real cases. The most common type of case study consists of evaluating particular areas at local, regional and/or country level using the diamond as the benchmark.

Their Rhetoric

The rhetoric accompanying the concepts of district and cluster differs according to the potential audience and actual aims. Becattini uses a rich vocabulary and quite dense texts that are full of metaphors. Aesthetics and the beauty of the writing are important to communicate ideas. Metaphors and other literary devices include the Virtuous circle to refer to the effect of the competition and cooperation in districts, or the caterpillar and the butterfly to explain the process of transformation in the Prato district. Becattini theorizes about familiar realities: Prato is used as an example in much of Becattini's work. It is close to where Becattini lives and works. He can be described as having high levels of very specific knowledge about the reality he studies. Rather than seeing this closeness as a limitation, Becattini considers it as necessary to understand global issues from a local viewpoint.

Porter is much more pragmatic view. His language is aligned to private business consultancy and literary rhetoric is out of place. He discusses what he sees as important (apparent) direct and clear solutions, at expense of loss of some rigour. He uses such terms as competitive, profits and superior, and ranking, optimizing, efficient, economic-based prosperity, etc.

Another kind of fuzziness has been identified by different audiences. The 'industrial district' concept has been criticized by policy-makers because of its fuzziness in terms of its use of metaphors. A nice example is the notion of sense of belonging. Becattini proposed it as a criterion to identify members of a district. The author recognizes the difficulties involved in identifying and using this sociological element. Policy-makers require clear delimitation with regard to the different ambits of the actions of administrative and politically recognized frontiers.

Porter's approach is perhaps clearer, although it has been criticized by regional analysts, mainly geographers, whose work is overlooked in the hypothetical contributions of Porter. The cluster approach does not define the geographical scale with clarity. Also Porter seems opposed to such precision: 'the geographic scope of a cluster can be a single city or state or a country or even a network of neighbouring countries' (Porter 1998, p.199).

The pragmatic and flexible use of these notions has generated confusion among authors trying to build theory and understand how proximity generates advantages for firms (Crawley 2012). According to (Boschma 2005, p.71), proximity implies not only a geographical distance measured, for instance, in kilometres, but also includes 'cognitive, organizational, social, and institutional' dimensions.

Ultimately, both approaches are aimed at different goals. Becattini tries to understand how some Italian areas have reached high levels of developments since the 1970s, elaborating a model to explain how a community of people can be integrated through a population of firms. People are at the centre of the analysis, and economic activities are the mean. Becattini tries to generalize his conclusions to other countries. Porter on the other hand is more interested in the corporate side. He considers that countries will enjoy higher levels of welfare if its firms are more competitive, achievable through optimal localization in the value chain. Becattini is a renowned academic, while Porter is heavily involved in his consultancy enterprise and the production of strategies for firms.

Use of the Cluster Concept for Policy Making. An example from the European Commission

For several decades, economists and geographers have strived to integrate into their studies the context and the localization of firms in order to explain differences in performance at different levels (from firm to national or regional ones). In 2008 an EC document (European Commission 2008)4 explicitly addressed the role of clusters in the modern economy. This report apparently answers some of the concerns in the literature about definitions, initiatives and policies. It provides some statistical results and lessons within the cluster framework, to develop this tool to increase prosperity. In the next section, we aim to analyse this document through the light of the above conceptual descriptions.

In fact, this document provides some answers to the questions posed above, although from a slightly different perspective. In our opinion, these answers are problematic because they do not take any other approaches (and consequently other dimensions such as the social) into consideration (e.g. industrial district). Our reading of this report gives support to some previous conceptual revisions. The fact that this policy document deals only with clusters is an indication that the concept of industrial district is considered out-of-date and old-fashioned. For example, the report dedicates only one paragraph to Becattini. This conceptual outshine is part of a broad strategy. This would suggest that the report is economic and narrow in scope.

The aim of the report was 'to present and further analyse the concept of clusters and to inform about main policy approaches in support of clusters' (European Commission 2008, p.7) and complement the broader EU innovation strategy related to the creation of world-class clusters able to compete with clusters in leading countries such as the USA and Japan. Note that the report attempts to provide 'evidence' (European Commission 2008, p.7) of a specific phenomenon: the benefits of localized agglomeration of industries. This debate has been widely discussed in academic circles and their use and application in different contexts and for different purposes is analysed in the literature on cluster typologies and concepts (Porter 1998; Porter 2001; Boari et al., 2003; Tallman et al., 2004; Tripathi 2013). We would

(4) *'The Concept of Clusters and Cluster Policies and their Role for Competitiveness and Innovation. Main Statistical Results and Lessons Learned'.*

contest such a narrow view which sees clusters only as an economic phenomenon whose analysis can be understood, measured and analysed only from an economic dimension. Such a view underestimates the contributions of geographers, sociologists and also economists. Critical views are not reflected (or discussed) in the literature review at all (Gordon and McCann 2000; Martin and Sunley 2003; Cooke 2006). On the other hand some contributions are referred to as success stories. However there is little focus on the benefits that such a heuristic tool provides for understanding the economic success in the Third Italy. Specific and tailored actions to promote and support clusters are required: indiscriminate growth, for instance, in housing and banking clusters has become a social problem as illustrated by some Spanish examples (Torres-López J. 2010; García-Montalvo 2013; Herrero et al., 2013; Sabaté 2014).[5] If we assume higher economic activity in clusters, we need to differentiate among types of economic activity and clusters that should be supported by policy.

We think that the approach taken in the EC document (2008) cannot be considered to be an 'evidence-based approach' that is directly related to 'prosperity' (European Commission 2008, p.29). The document states that data provide clear evidence in support of clusters. However, in our opinion, the data are far from being clear, well defined, reliable and unlimited (see (European Commission 2008, pp.17-18, 24): 'While many factors other than clustering can have an impact on prosperity, the data provides clear evidence that clusters are significantly related to prosperity (European Commission 2008, pp.28-29).

Due to data limitations a relationship between clusters and prosperity is difficult to prove. The regional agglomeration effects cited are based on employment data only, which requires to be complemented by other indicators e.g. value-added, for them to be meaningful. In addition, the approach adopted is 'deliberately based on the measurement of the revealed effects of clusters' (European Commission 2008, p.18) and assumes that 'the interactions (in and between clusters) are meaningful' (European Commission 2008, p.18) despite differences in type and intensity. Although some of these limitations are acknowledged in the report, they make the promised evidence-based approach impossible. Perhaps the approach should have been described as tentative or exploratory.

The cluster concept in the EC report is linked directly to concepts such as open innovation and the triple helix, which, according to the report, are 'nowadays broadly accepted' (European Commission 2008, p.21). However, also these concepts have been criticized due to their use 'as vehicles to conceptually understand developments that have taken place in particular countries or fields of research' (Tuunainen 2004; Vega-Jurado et al., 2007).

Likewise, it is stated that 'cluster firms interact more frequently with research institutions which are located in proximity than other firms and have an easier access to international networks and capital' (European Commission 2008, p.22). This is refuted in surveys conducted in peripheral and low absorptive capacity regions, such as Valencia (Azagra-Caro, 2007a; Azagra, 2007b; Gutiérrez-Gracia et al., 2008), especially for the science-based clusters, such as biotechnology. The role played by local institutions, including research institutions, has been questioned. The effects of local institutions and public bodies are controversial and have been criticized as being irrelevant and even disruptive to cluster development (see Entrepreneurship and Regional Development, 2006, Special Issue on industrial districts). Finally, in our view this paper conceives that these terms have been taken for granted not based on tested hypotheses or subject to in depth examination. In other words, it is incautious and simplistic to adopt the cluster rhetoric without providing solid data that illustrates the relationship between the agglomerations of industries, the benefits the interaction among the localised actors and the territorial economic prosperity under an evidence-based view.

The European Commission report states the intention to build 'world class clusters' in Europe. Currently only 38% of all European employees work in enterprises that are part of a cluster' (European Commission 2008, p.25). The method used is (almost) the same than the Porterian one. Although it might allow comparing the two continents, the results have to be taken carefully. For instance, the report states that 'Europe lags on average behind the United States in terms of cluster strength' (European Commission 2008, p.26). However, other reasons such as differences in labour markets and regulatory frameworks, that is, in national and federal laws, could explain these differences between the US and Europe, rather than concentration of employment in clusters. There is also a volume of case study evidence on clusters, although few of these refer to the whole population of Europe (Rodríguez-Pose and Comptour 2010). It is assumed that 'the more specialised a region is the greater the potential for higher wages', but what kind of specialisation offers this result? Would it be better to use relative income available as a complementary indicator?

The question of how the cluster concept is used in the practice of policy making has been mostly overlooked (Ahedo, 2006). Some studies have been done on Spain (Trullén 2009). The present paper tries to separate the different meanings assigned to two regional concepts. (Trullén 2009) argues that the EC for the first time is using a different unit of analysis than sector and administrative unit. According to Trullén, the unit of analysis could guide current economic organization and political intervention aside from the conceptual differences between district and cluster. Trullén sees cluster as a fairly good choice, on the basis that the ambiguity of the concept of cluster has some benefit because it embraces different interpretations, given the diversity of the European countries. Thus, if the European Commission is proposing that the European Union uses cluster to mean a heterogeneous set of concepts (learning region, sector innovator, industrial district, etc.) these concepts could be again put into practice through the cluster lenses, for instance, at other levels of political action: local, regional or sectoral, for instance.

(5) It is well-known that the building cluster in Spain augmented economic activity for several decades. However, the consequences of its indiscriminate growth have become counterproductive in education, employment and other social terms.

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The European Commission 2008 report may help the reader to understand European Commission thinking about convergence towards a hegemonic way of understanding economic development offset by the inclusion of different ways to understand that economic development, e.g. as socio-economic development. We would highlight social as an under-represented dimension in the cluster model, in Porter's seminal work, and in the European Commission document.

It is important to note that industrial district and cluster policies are independent approaches. While industrial district policies were initially implemented in Italy in the 1980s, cluster policies have been used worldwide since the 1990s and have been taking over the idea of industrial district. The European Commission report is illustrative of this in adopting a single approach (based on the cluster perspective) in its aim to promote innovation. This is perhaps why the Commission Staff Working Document SEC (2008) 2637 (European Commission 2008) was delivered as a part of the activities developed by Europe Innova and PRO INNO Europe. Therefore, cluster can be seen as an umbrella concept which has absorbed other approaches.

In Spain, we find both types of policies (industrial districts and clusters) in various regional programmes. While cluster policies have been implemented in the Basque Country and Catalonia, the Valencia region is using the industrial district model. Central government sees the current approach as industrial district-based and Marshall-inspired. Programmes are mainly addressed to 'innovative business groupings' (IBGs) which cooperate on technological development projects.

Before 2004, the industrial district model was not officially recognized beyond the academic level. It can be seen as a bottom-up initiative based mainly on informal connections among the different stakeholders (such as firms, higher education institutions and governments). Since the level of analysis in both approaches tends to be local or regional, rather than national, there might be a conflict of competences and ideologies due to the fact that different political parties govern in different Spanish regions.

According to Trullén (2009, p.731) the district-based policy in Spain represents one of four possible paths:

> *- Support to large-scale 'industrial research' within large companies (à la Schumpeter), with an ambitious programme financing strategic national consortia for technological research (Consorcios Estratégicos Nacionales de Investigación Tecnológica, CENIT).*
>
> *- Support to 'technological development' based on 'propulsive companies' (à la Perroux), the idea being to finance industrial development projects driven by large companies, which however had the specific capacity to trigger knock-on effects towards SMEs (the PROFIT programme);*
>
> *- Support to 'permanent innovation'; this refers to the innovation machine put forward by Baumol (2002), aimed at improving the propensity to innovate of companies more generally regardless of their sector or size, through initiatives that impact on firms' investment decisions on R&D (for example tax breaks);*
>
> *- and, last but not least, a support to the innovation capacity of IDs, in particular those of the MID-type according to a Becattinian approach, based on the setting up of innovative business groups and the drafting of strategic plans (the General Office of Small and Medium-sized Companies' IBG Programme), and the financing of technological development projects (the CITD6 agency's financial support programme for IBG7s).*

In terms of policy, measurement and evaluation tools we need to highlight that 'A full assessment of their (clusters) impact is not possible at this stage, taking into account the lack of comparable data and the methodological difficulties to measure multiple and long-term effects of horizontal policies' (European Commission 2008, p.8). However, the EC report claims that there is correlation between clusters and prosperity: 'While many factors other than clustering can have an impact on prosperity, the data provides clear evidence that clusters are significantly related to prosperity' (European Commission 2008, p.29), though this has yet to be investigated.

Conclusions

This paper has provided a review, critique (Section 2) and comparison (Section 3) of the way in which two regional concepts (industrial district and cluster) are understood in the literature. It reflects (Section 4) on how the successful spread of cluster ideas has crowded out the concept of industrial district in a policy document (European Commission 2008).

We can draw some conclusions. First, throughout the paper the extensive use and popularity of territorial concepts was confirmed, particularly the use of those we have focused on. They are popular in all fields, such as academia, and for policy makers, among institutions or even among practitioners. Their use is inconsistent and inaccurate. Their conceptual relevancy and inaccurate application justify a critical examination.

Second, in relation to the unit of analysis, the Porterian cluster serves to build the foundations of the Theory of the Firm, by explaining for instance not only the firm boundaries, but also their heterogeneity and their performance. On the other hand, the industrial district concept aims to provide an alternative way to analyse industries, taking equally the social and the economic issues into account. The territorial dimension is crucial to define the unit of analysis. However, later implementation of the concepts in policy, as shown in the European Commission example, there is a great ambiguity about sites and objects of interventions. Regions or countries arise as administrative ambits toward policy addresses actions.

(6) Centre for the Development of Industrial Technology
(7) Innovative Business Groups, IBGs.

Third there is debate about the benefits of defining territorial concepts exhaustively or vaguely to enable wider applicability. Our findings show that one of the reasons why cluster is more popular than industrial district is probably because it is more vague and ambiguous. Policy makers and practitioners prefer simple concepts that capture basic ideas that allow generic and non-restrictive application. For instance, while the term cluster tends to homogenize how regions are addressing economic development, the industrial district approach concentrates on the idiosyncratic situations of particular regions (e.g. the region of Prato). The cluster rationale, following Porter's pragmatic perspective, sometimes omits social aspects that can be crucial to achieving ambitious targets such as prosperity, low unemployment rates, etc. Academics need to be accurate and precise in defining and developing concepts. In our view the examination in this paper helps to identify similarities and differences and reveal the reasons behind some application of these concepts.

Final remarks

Being so important to deal with the polarization of firms or even the disparities between regions or uneven development in the current European Union, we found problematic the goals and the means of the European Commission document analysed. First, the document is an annex to the European Commission Communication titled Towards world-class clusters in the European Union: Implementing the broad-based innovation strategy, which possibly amplifies the above-mentioned problems. Second, simplifying complex theories developed by geographers in the 20th century to achieve a unique approach (cluster) necessarily overlooks issues that historically were the subject of important discussion from economists, geographers and historians. Many geographers complain about this one-size-fits-all concept.

Also interesting is that the role of universities is as important without a provision of an in-depth analysis of its current role. It is assumed that university has to contribute to this line of thought but some of their members (the academics) are taking part of the debate or simply are unheard.

The authors of the two concepts examined are important. Giacomo Becattini comes from the Emilia Romagna region which has a Communist tradition. Porter is American and probably has a more neo-liberal ideology. Although it would be difficult to claim that Capitalism might be overthrown by, for instance, Communism, Becattini (2002) defends what Sir Samuel Brittan called 'Capitalism with a human face'. Is this last claim what cluster followers want to submerge?

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