Which organizational capabilities and inter-organizational knowledge dynamics enable innovation within an ecosystem ?

Laurent Scaringella

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UNIVERSITE BRETAGNE ECONOMIE LOIRE ET GESTION

UNIVERSITÉ DE RENNES 1

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Par
Laurent SCARINGELLA

Which organizational capabilities and inter-organizational knowledge dynamics enable innovation within an ecosystem?

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Rapporteurs avant soutenance :

Karine SAMUEL Professeur d'université, Grenoble INP
Thierry BURGER-HELMCHEN Professeur d'université, BETA - Université de Strasbourg

Composition du Jury :

Thierry PENARD Directeur Ecole doctorale EDGE, Université Rennes 1
Président

Dominique MARTIN Professeur d'université, Université Rennes 1
Karine SAMUEL Professeur d'université, Grenoble INP
Thierry BURGER-HELMCHEN Professeur d'université, BETA - Université de Strasbourg

Directeur de thèse
Dominique MARTIN Professeur d'université, Université Rennes 1

Invité(s)
Jean Luc PERROT Directeur, Pôle Valorial

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Résumé en Français : Quelles capacités organisationnelles et dynamiques de connaissances inter-organisationnelles permettent d'innover dans un écosystème ?

Mots clés: connaissance; capacité d'absorption; innovation; modèles d'innovation territoriale; écosystème

Débats actuels

Cette thèse aborde différents thèmes comme les écosystèmes, la capacité d'absorption et l'innovation radicale. Elle vise à apporter un éclairage nouveau sur cinq débats présentés ci-après.

Le premier débat porte sur la complémentarité, la compétition, la convergence ou la divergence des quatre axes de recherche émergents dans le domaine des écosystèmes : Les écosystèmes d'entreprises (Moore, 1993), les écosystèmes d'innovation (Adner, 2006), les écosystèmes entrepreneuriaux (Prahalad, 2005), et plus récemment, les écosystèmes de la connaissance (van der Borgh, Cloodt & Romme, 2012). Depuis Moore (1993) et l'introduction du concept d'écosystème dans le domaine des sciences de gestion, nous observons que ce terme est fréquemment utilisé, dans des contextes académiques et commerciaux. Cette attractivité grandissante du champ d'étude portant sur les écosystèmes se traduit par un nombre croissant de publications. Sur la base d'une recherche sur Web of Science (WoS), jusqu'en 2015, il était possible de compter 39 articles exclusivement liés aux sciences de gestion et à l'économie. Depuis 2015, nous avons observé un nombre grandissant de publications: 21 publications en 2015 et 26 en 2016. Cette prolifération scientifique a contribué à l'émergence, année après année, de différents courants de pensée comme les écosystèmes d'entreprises (Moore, 1993), les écosystèmes d'innovation (Adner, 2006), les écosystèmes entrepreneuriaux (Prahalad, 2005), et les écosystèmes de la connaissance (van der Borgh, Cloodt & Romme, 2012). Cependant, le lien entre ces différents courants de recherche est encore peu étudié. Par conséquent, il

est absolument nécessaire de procéder à une analyse systématique de la littérature afin de contribuer à la consolidation du champ des écosystèmes faisant face à l'émergence de différents courants recherche.

Le deuxième débat porte sur l'absence de fondement théorique du champ des écosystèmes, ce qui nécessite l'utilisation de théories existantes solides comme la théorie institutionnelle (DiMaggio et Powell, 1983), la théorie de dépendance aux ressources (Pfeffer et Salancik, 1978), l'open innovation (Chesbrough, 2003) ou les capacités dynamiques (Teece, 2007). Malgré tout, le champ des écosystèmes demeure assez fragile en l'état, comme nous le détaillerons par la suite, ce qui nécessite une consolidation significative, ce qui sera l'objet d'une partie significative de cette thèse. En particulier, le champ des écosystèmes pourrait fortement bénéficier des travaux issus de l'approche territoriale et en l'occurrence, des modèles d'innovation territoriale (Moulaert and Sekia, 2003).

Le troisième débat porte sur le rattrapage technologique des économies émergentes. Ce débat est enraciné dans la théorie considérant la connaissance comme la ressource la plus importante des entreprises (Nonaka et Takeuchi, 1995; Grant, 1996; Spender, 1996). Dans leurs quêtes d'innovation, les entreprises ont besoin de transférer et / ou de recevoir des connaissances afin d'acquérir un avantage concurrentiel, ce qui est particulièrement vrai pour les entreprises engagées dans des échanges internationaux (Kogut & Zander, 1993) entre pays développés et pays en développement. En comparant les pays entre eux, il est possible de s'apercevoir qu'une différence significative existe entre les pays bénéficiant grandement des transferts technologiques et les pays qui en bénéficient le moins. Le rattrapage technologique étant idiosyncratique (Ponomariov & Toivanen, 2014), les raisons quant à l'existence de telles différences, restent encore assez méconnues. Nous souhaitons donc mieux comprendre comment et pourquoi certains facteurs influencent l'apprentissage organisationnel, en particulier dans les pays émergents. Cela nécessite également d'étudier plus en profondeur les alliances stratégiques établies avec les pays en transition économique.

Le quatrième débat concerne le domaine de la capacité d'absorption. Ancré dans le travail séminal de Cohen et Levinthal (1990), il est nécessaire de poursuivre les études traitant de

l'assimilation des connaissances externes (Lane et al., 2006). Ce débat n'est pas nouveau. En 1991, Hamel affirmait déjà que l'accès à ces connaissances externes ne conduit pas nécessairement à une assimilation efficace de ces connaissances. Lane et Lubatkin (1998) ont alors expliqué qu'une dyade d'apprentissage, impliquant des entreprises jouant le rôle d'enseignants et d'étudiants, peut augmenter l'efficacité de l'absorption des connaissances au travers des alliances stratégiques. Cependant, la littérature dans le domaine de la capacité d'absorption ne considère les dyades d'apprentissage que dans le sens où les « étudiants » apprennent des « enseignants ». Par conséquent, la littérature existante ne traite pas des dyades d'apprentissage à double sens lorsque deux organisations jouent à la fois le rôle d'enseignant et d'étudiant, et en particulier dans le cas d'une joint-venture internationale.

Le cinquième débat porte sur le domaine du management de l'innovation et plus précisément sur le rôle des clients dans le développement de nouveaux produits. D'après la littérature, nous savons que les clients contribuent à nourrir le socle de connaissances des entreprises (Fang, 2008; Noordhoff, Kyriakopoulos, Moorman, Pauwels et Dellaert, 2011; Truong, Simmons et Palmer, 2012). Selon Coviello et Joseph (2012), nous savons également que les échanges avec les clients ont un impact positif sur la capacité des entreprises à effectuer des recherches et à développer des produits répondant aux attentes du marché, ce qui accroît la probabilité d'un retour financier (Danneels, 2007; Levinthal & March, 1993). Cependant, il est nécessaire de distinguer deux types d'innovation : l'innovation incrémentale et l'innovation radicale. Tandis que les clients contribuent aux développements de nouveaux produits dans le cadre d'innovations incrémentales, la littérature n'est pas claire quant à l'impact, positif ou négatif, de la participation des clients au développement de nouveaux produits, dans le cas spécifique d'innovations radicales (Markides, 2006). Suivant le degré de nouveauté et la poursuite ou non de trajectoires technologiques données, l'innovation radicale est rarement motivée par la demande. Il serait sans doute contre-productif d'impliquer des clients grand public dans le développement de ce type d'innovation. Ce débat actuel nous encourage donc à étudier les conditions

dans lesquelles la participation des clients peut aider ou desservir les entreprises au développement d'innovations radicales.

Questions de recherche

Dans l'économie et la société basée sur la connaissance, un large éventail de parties prenantes telles que les entreprises, les centres de recherche, les universités, les institutions publiques, et les clients, interagissent en permanence. Impliquer des parties prenantes externes n'est pas exempt d'une prise de risque car cela peut engendrer des effets contre-productifs. En particulier, le débat relatif à l'impact des clients sur les innovations radicales nécessite des études complémentaires (Markides, 2006).

A la suite d'un choix éclairé de parties prenantes, il est nécessaire de définir les bons types d'interactions. Ces interactions peuvent prendre différentes formes, allant des contacts les plus informels aux alliances stratégiques les plus formelles (Hamel, Doz, & Prahalad, 1989; Khanna, Gulati, & Nohria, 1998). La variété de choix d'alliances stratégiques permet aux organisations d'établir des dynamiques de connaissances spécifiques et donc de distinguer les transferts de connaissances explicites, des transferts de connaissances tacites (Nonaka, 1994). Par exemple, Kandemir & Hult (2004) soutient le fait que les joint-ventures permettent une absorption des connaissances tacites de manière plus aisée. L'origine des entreprises prenant part au sein d'une joint-venture, provenant d'un pays développé ou d'un pays en développement, n'est pas abordée dans la littérature traitant des capacités d'absorption des connaissances tacites.

Par ailleurs, malgré l'implication des bons partenaires dans des relations appropriées, le succès d'un transfert de connaissances nécessite que l'organisation elle-même soit capable d'assimiler ces connaissances externes (Cohen et Levinthal, 1990). Grâce à une capacité d'absorption adéquate, l'organisation est ensuite capable te tirer parti de ces connaissances en transformant ces dernières en innovation. Sur cet aspect spécifique, la littérature existante relative aux travaux de Lane et Lubatkin

(1998), ne traite pas des dyades d'apprentissage bidirectionnelles entre deux partenaires impliqués, au sein d'une joint-venture.

Enfin, il est important de noter que l'environnement, dans lequel les dynamiques de connaissances sont développées entre partenaires, joue un rôle important dans les succès et les échecs de ces échanges de connaissances. La perspective territoriale (Moulaert and Sekia, 2003), aujourd'hui fortement associée au champ émergent des écosystèmes (Moore, 1993), doit être pleinement considéré. Sur ce point précis, il est nécessaire, pour toute organisation, de mieux comprendre le rôle joué par les écosystèmes d'entreprises (Moore, 1993), les écosystèmes d'innovation (Adner, 2006), les écosystèmes entrepreneuriaux (Prahalad, 2005), et les écosystèmes de la connaissance (van der Borgh, Cloodt & Romme, 2012), en terme de complémentarité, concurrence, convergence ou divergence.

Par conséquent, ce manuscrit traite de la question de recherche principale suivante: *Quelles capacités organisationnelles et dynamiques de connaissances inter-organisationnelles permettent d'innover dans un écosystème ?*

Cette question de recherche peut être visualisée dans le schéma 1 ci-après dans lequel des dynamiques de connaissance sont développées entre une organisation et différents partenaires, comme des universités, des institutions publiques, des centres de recherche, des spin-offs, des entreprises, et des clients afin de développer des innovations, au sein d'un territoire et d'un écosystème.

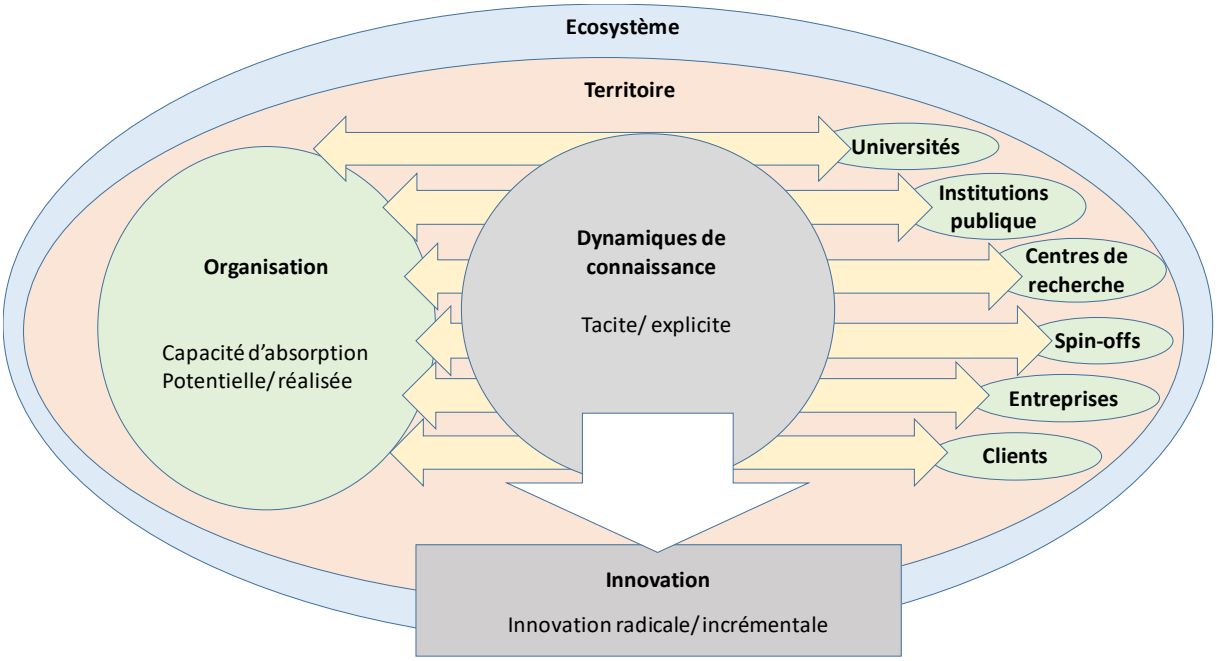


Schéma 1 : Modèle général d'analyse

Afin de répondre à cette question de recherche, nous faisons référence à la capacité d'absorption, la nature de la connaissance, le degré de nouveauté de l'innovation, les modèles d'innovation territoriaux et les écosystèmes.

Dans ce cadre, trois sous-questions de recherche ont été examinées:

- *Quelles sont les conceptualisations de l'approche par écosystème, ses invariants et ses liens avec l'approche territoriale?*

- *Quels sont les défis de l'innovation radicale, les obstacles au changement technologique et les difficultés liées au transfert de connaissances tacites et explicites entre deux organisations ayant des capacités d'absorption différentes?*

- *En quoi l'acquisition de connaissances auprès des clients peut faciliter ou entraver la poursuite d'innovation radicale des entreprises ?*

Objectifs de recherche

Pour chacune de ces trois sous-questions de recherche, différents objectifs de recherche ont été identifiés de la manière suivante:

- Explorer, identifier et modéliser les invariants des quatre courants d'écosystèmes commerciaux, d'innovation, d'entrepreneuriat et de connaissances, en lien avec la littérature traitant de l'approche territoriale, afin de construire un cadre conceptuel associant l'approche écosystème et l'approche territoriale

- Etudier le rattrapage technologique, les alliances stratégiques, et les facteurs influençant l'apprentissage organisationnel, au sein d'une dyade d'apprentissage bidirectionnelle entre deux entreprises ayant une base de connaissances et une capacité d'absorption différente, dans le cas spécifique d'un pays émergent

- Etudier les conditions et les relations dans lesquelles la participation des clients catalyse ou freine les innovations radicales des entreprises émanant d'un processus de développement de nouveaux produits

Méthodologies

Au travers de cette thèse, différentes méthodes ont été utilisées: (1) une revue systématique de la littérature des écosystèmes basée sur une sélection de 104 articles et livres, (2) une étude de cas approfondie d'une joint-venture créée par Freyssinet et Azaran pour construire le nouveau toit du stade de Mashhad (41 entretiens sur une période de 19 mois) et (3) une analyse multi-cas de l'implication des clients dans le développement d'innovations radicales au sein de trois entreprises de type spin-off (36 entretiens sur une période de 4 ans).

Après avoir considéré les trois étapes de la revue systématique selon Tranfield, Denyer et Smart (2003) et les phases de revue méta-narrative de Greenhalgh, Robert, Macfarlane, Bate, Kyriakidou et Peacock (2005), nous avons conçu notre propre procédure afin de conduire une revue systématique de la littérature des écosystèmes. Plus précisément, nous avons défini les sept étapes suivantes: (1) recherche initiale, (2) études de cadrage, (3) recherche d'articles, (4) sélection d'articles, (5) remontée de références, (6) analyse du contenu, et (7) analyse des invariants.

Durant les quatre tours de révision de notre article, nous avons été confronté à trois difficultés majeures: Le besoin de clarification de l'ensemble du processus de sélection et d'analyse des articles, la sous-représentation des journaux en science de gestion au sein de WoS, et le besoin de rétro-inspection des articles. Nous avons pu trouver des solutions suffisamment convaincantes pour nos rapporteurs, à savoir en rajouter un grand nombre de tableaux et de schémas explicatifs de la méthode, en faisant un comparatif des bases de données de type Scorpus, WoS, en faisant référence à 10 articles portant sur les statistiques bibliométriques, et en explorant l'ensemble des références bibliographiques des articles considérés dans notre revue systématique.

L'étude de cas approfondie de la joint-venture créée par Freyssinet et Azaran pour construire le nouveau toit du stade de Mashhad visait à mener une recherche exploratoire (Yin, 2003) afin de capturer les effets directs des décisions prises tout au long du projet (Golden, 1992; Yin, 2003; Dyer et Wilkins, 1991). Une approche inductive exploratoire a donc été mise en œuvre afin de capter une compréhension profonde des problèmes, des enjeux et des influences des parties prenantes (Strauss & Corbin, 1998). La source première des données provient des entretiens semi-directifs permettant d'explorer les événements et la participation des personnes. A cela se rajoute un ensemble d'observations, de documents sur le séquençage de l'assemblage des éléments, de rapports sur la qualité, d'articles de presse, de comptes rendus de réunion, de communications, d'échanges de courriers électroniques et de rapports fournis aux parties prenantes. L'ensemble de ces documents a permis d'effectuer une triangulation afin de recouper les sources d'information et ainsi de pouvoir comparer les différentes perspectives des acteurs (Easton, 1995; Miles & Huberman, 1994). Le codage, le regroupement et la réduction des données ont permis d'aboutir à un schéma de codage comportant six grandes catégories et un total de 43 codes (Strauss et Corbin, 1998; Araujo, 1995; Coffey et Atkinson, 1996).

D'un point de vue méthodologique, nous nous sommes confrontés à une difficulté majeure : La possibilité d'inclure des verbatims pouvant potentiellement conduire à des polémiques importantes.

En effet, lors des deux tours de révision de cet article, les trois rapporteurs nous ont demandé de modérer nos propos, voire même de supprimer certains verbatims car ces derniers étaient jugés comme faisant honte à l'Iran. Nous avons ainsi supprimé un verbatim très critique.

Le choix des trois spin-offs dans le cadre de notre analyse multi-cas est le fruit d'un processus en quatre étapes: (1) examen et catégorisation globaux de l'échantillon, (2) identification de plusieurs cas par catégorie, (3) choix final des cas et (4) considération des catégorisations post-collecte de données. À l'instar de la première étude empirique, nous avons adopté une approche inductive afin de comprendre en profondeur les problèmes, les enjeux et les influences qui étaient en jeu dans les trois spin-offs du CEA-LETI et donc de mieux comprendre les mécanismes d'implication des clients dans les innovations radicales. Le principal atout de cette collecte de données réside dans la réalisation d'entretiens périodiques ce qui confère à notre étude son caractère longitudinal. Ainsi, nous avons été en mesure d'étudier avec une plus grande précision les effets des décisions sur le processus d'innovation (Pettigrew, 1990).

Au cours des 3 révisions pour le journal Industrial Marketing Management s'étant soldé par un rejet, suivi de 3 révisions pour le journal Technological Forecasting and Social Change, nous nous sommes confrontés à deux difficultés méthodologiques : La justification de notre choix de codage et la suggestion quant à l'utilisation d'une méthode combinée (étude qualitative exploratoire suivie d'une étude quantitative confirmatoire). Le choix du codage a été justifié à la fois dans le corps du texte et dans un schéma explicatif. Quant au rajout d'une étude quantitative, nous avons simplement indiqué que l'article était déjà assez long, proche des 20 000 mots et qu'une étude quantitative viendrait rendre moins clair le message clef de l'article.

Contextes empiriques

Des contextes empiriques très différents ont été étudiés, allant des spin-offs grenobloises les plus high-tech aux entreprises iranienne de construction les plus traditionnelles.

Une opportunité de collecter des données en Iran s'est présentée à moi, ce qui explique le choix de ce contexte empirique spécifique. L'Iran investit constamment dans le transfert de connaissances pour soutenir son développement scientifique et technologique. Dans le but de réduire les écarts technologiques avec les pays développés, l'Iran soutient l'innovation de différentes industries (Ghazinoory, Riahi, Azar et Miremadi, 2014). Nous notons que le contexte iranien a rarement été exploré et qu'un nombre très limité d'études ont été menées en Iran, qui plus est par des chercheurs étrangers. Cela s'explique notamment par les différents embargos économiques subis par l'Iran. Par conséquent, il y a un besoin réel d'étudier les défis auxquels font face les entreprises opérant en Iran et les défis auxquels font face les entreprises iraniennes dans leurs collaborations avec des partenaires extérieurs.

Dans ce contexte iranien, le choix de l'industrie de la construction est non dénué de sens. Bessant et Francis (2005) ont fortement souligné le bénéfice que les pays hôtes peuvent tirer des projets de construction d'ouvrages d'œuvre de grande envergure. En ce sens, les entreprises étrangères offrent la possibilité aux entreprises locales de s'approprier certaines technologies avancées de conception et de construction (Ling, Ibbs et Cuervo, 2005; Ling, Pham et Hoang, 2009) et offrent donc un attrait en matière de transfert de connaissances. Le secteur de la construction iranien a particulièrement retenu notre attention puisqu'il représente une part importante de l'investissement national annuel tout en bénéficiant de manière non significative de la diffusion de nouvelles technologies (Tabassi, Ramli & Abu Bakar, 2012). Au-delà de son importance économique, la non appropriation technologique a un impact direct sur la faible résilience des bâtiments lors de tremblements de terre fréquents dans cette région (Tabassi & Abu Bakar, 2009). Ainsi, le secteur de la construction est fréquemment dans le viseur de la population, accusé d'être responsable du grand nombre de victimes au cours des séismes passés. Par conséquent, une meilleure compréhension des raisons de la lenteur de l'évolution technologique dans le secteur iranien de la construction pourrait nous permettre de formuler des

propositions intéressantes pour accélérer le rattrapage technologique iranien, la conception de bâtiments plus résilients et donc une plus grande sécurité pour les habitants.

Aux antipodes du contexte iranien, le deuxième cadre empirique choisi est axé sur les spin-offs technologiques issues d'un centre de recherche à Grenoble. Tandis que les start-ups ont régulièrement été étudiées, le cas spécifique des spin-offs issues d'une organisation mère, n'a guère retenu l'attention des chercheurs. Les retombées scientifiques des spin-offs diffèrent des start-ups ordinaires pour plusieurs raisons: bases de connaissances différentes (Colombo et Piva, 2012), lien privilégié avec les institutions mères (Basu, Sahaym, Howard et Boeker, 2015; Chatterji, 2009; Klepper, 2001), apprentissage plus riche au sein de relations dyadiques (Agarwal, Echambadi, Franco et Sarkar, 2004; Chatterji, 2009; Phillips, 2002), capacité d'absorption potentielle supérieure (Colombo et Piva, 2012), etc. Ce qui reste peu connu réside dans l'analyse conjointe des capacités d'absorption potentielles et réalisées dans le cas spécifique des spin-offs. Par ailleurs, nous notons que les principaux travaux de recherches ont davantage étudié les spin-offs technologiques émanant des universités et des entreprises privées, et dans une moins grande mesure les spin-offs issus des centres de recherche. Par conséquent, le choix d'étudier le cas spécifique des retombées technologiques d'un centre de recherche offre un cadre empirique prometteur pour étudier l'implication des clients dans le développement de nouveaux produits d'innovation radicale.

Résultats

À partir de notre étude systématique de la littérature, nous identifions les invariants des quatre courants divergents de l'approche par écosystème (Moore, 1993; Adner, 2006; Prahalad, 2005; van der Borgh, Cloodt & Romme, 2012) et les invariants des sept courants divergents de l'approche territoriale (Marshall, 1890 ; Becattini, 1990 ; Camagni, 1991; Cooke, 1992; Saxenian, 1994 ; Malmberg & Maskell, 1997 ; Porter, 1998a, b). Sur la base de cette liste d'invariants issus de deux cadres théoriques distincts, nous proposons un modèle de recherche basé sur les similitudes et les différences de l'approche par écosystème et de l'approche territoriale.

D'après notre première étude empirique de cette joint-venture dans le contexte iranien, nos conclusions indiquent que le développement d'une innovation radicale est associé à des problèmes de sécurité, de qualité et de planification, entraînant des retards, une non-conformité vis-à-vis du cahier des charges et des coûts supplémentaires. En conséquence, Freyssinet n'a pas réussi à transférer un savoir à la fois explicite et tacite, car Azaran souffrait d'une faible capacité d'absorption organisationnelle (Cohen et Levinthal, 1990). En revanche, grâce à sa capacité d'absorption supérieure, Freyssinet a pu adapter ses opérations aux routines d'Azaran basées principalement sur des connaissances tacites. Nos résultats permettent également de mieux comprendre les interactions tacites entre le riche client religieux Astân-e Ghods-e Razavi, le consultant en charge du développement de Khorasan, le partenaire de la joint-venture Azaran, et les nombreux sous-traitants au sein de l'écosystème de Mashhad.

Dans notre deuxième étude empirique sur les spin-offs technologiques grenobloises, nos résultats montrent l'importance de développer des capacités d'absorption potentielles et réalisées (Zahra and George, 2002 ; Lau & Lo, 2015 ; Jansen, Van Den Bosch, & Volberda, 2005; Martini, Neirotti, & Appio, 2015). Ces capacités d'absorption permettent en outre l'internalisation des connaissances du client et la prise de conscience d'émergence technologique, tout en palliant au manque de connaissances techniques des clients lors de la formulation de leurs besoins. Les connaissances techniques et commerciales semblaient être importantes pour les spin-offs, à la fois disponibles auprès des clients et du centre de recherche dont elles sont issues. Ainsi, les spin-offs ont besoin d'une capacité de compromis dans l'équilibre subtil à établir entre (1) les connaissances du marché et les connaissances techniques, (2) les approches guidées par la demande et les poussées par la technologie, (3) la participation des clients et la participation des centres de recherche, et (4) les capacités d'absorption potentielles et réalisées. Au sein de l'écosystème grenoblois, on note le rôle central du CEA initiant la création de spin-offs technologiques, directement intégrées dans un tissu d'entreprises, de laboratoires, et d'universités.

Contributions

La première contribution vise à enrichir le domaine des écosystèmes en identifiant les quatre principaux types d'écosystèmes : Les écosystèmes d'entreprises (Moore, 1993), les écosystèmes d'innovation (Adner, 2006), les écosystèmes entrepreneuriaux (Prahalad, 2005), et les écosystèmes de la connaissance (van der Borgh, Cloodt & Romme, 2012). De plus, nous avons identifié un certain nombre de concepts transversaux comme les écosystèmes des services, les écosystèmes d'open innovation, les écosystèmes industriels, les écosystèmes digitaux, les écosystèmes d'innovation régionale. Notre comparaison entre l'approche territoriale et l'approche écosystème apporte une lumière nouvelle dans le champ des écosystèmes. En effet, l'approche territoriale avait été en grande partie omise avant la réalisation de notre revue de littérature systématique.

La deuxième contribution vise à approfondir le concept de dyade d'apprentissage (Lane et Lubatkin, 1998) en caractérisant un phénomène bidirectionnel entre deux organisations jouant à la fois le rôle d'enseignant et d'élève dans une joint-venture au sein de l'écosystème de Mashhad. En particulier, nous avons identifié les différents obstacles aux changements technologiques et les défis de transfert de connaissance en lien avec la capacité d'absorption idiosyncratique, dans le contexte spécifique d'une joint-venture internationale. D'un point de vue empirique, l'étude d'une innovation radicale en Iran offre une perspective différente des innovations radicales ayant vu le jour dans les pays développés. Au-delà de l'apport théorique et empirique de cette étude, il est important de souligner l'impact économique et social fort de cette étude dans le secteur de la construction en Iran. Cette étude permet aux personnalités politiques iraniennes de mieux apprécier les défis du développement technologique nécessaires pour se conformer aux normes internationales inhérentes aux innovations radicales. En particulier, l'ensemble des parties prenantes de l'écosystème de Mashhad a bénéficié d'un apprentissage vicariant.

La troisième contribution vise à fournir un nouvel éclairage sur la participation des clients au processus d'innovation radicale (Markides, 2006). En effet, cette étude permet de mieux apprécier le

degré de participation des clients à différentes étapes et donc de voir en quoi leurs rôles peuvent accélérer ou ralentir le processus de développement d'innovations radicales au sein des spin-offs technologiques. L'une des contributions porte plus particulièrement sur le rôle de la capacité d'absorption organisationnelle dans l'internalisation des connaissances du client. Bien que la littérature existante mette davantage en exergue l'impact positif des clients sur la création et le développement de produits, principalement dans le cas de développement d'innovations incrémentales (Coviello et Joseph, 2012 ; Danneels, 2007; Levinthal & March, 1993), le défi posé par la capacité d'une entreprise à absorber ces connaissances, est beaucoup moins abordé dans le cas de développement d'innovations radicales (Markides, 2006). Cette étude fournit donc un cadre conceptuel sur les capacités organisationnelles nécessaires à la participation bénéfique des clients au développement d'innovations radicales et un ensemble de suggestions pouvant guider les recherches à venir. Cette étude détaille également les relations inter organisationnelles relatives aux propriétés intellectuelles sous-jacentes de l'écosystème grenoblois.

Structure du manuscrit

Suite à cette introduction, le manuscrit est divisé en trois parties dans lesquelles trois articles publiés sont présentés. Pour chacun de ces trois articles, je suis l'auteur principal et le correspondant durant toutes les étapes de révisions, jusqu'à la publication.

Scaringella, L., Radziwon, A., (2018), **"Innovative Entrepreneurial Business Ecosystems: Old wine in new bottles?"**, *Technological Forecasting and Social Change* – Special Issue on innovation Ecosystems: Theory, Evidence, Practice, and Implication, 136, 59-87

Scaringella, L., Burtschell, F. (2017), **"The Challenges of radical innovation in Iran: Knowledge transfer and absorptive capacity highlights - Evidence from a joint venture in the construction sector"**, *Technological Forecasting and Social Change* – Special Issue on the

Development of Science and Technology in Iran: The Challenges of Innovation and Commercialization, 122C, 151-169

Scaringella, L., Miles, R.E. and Truong, Y. (2017), **"Customers Involvement and Firm Absorptive Capacity in Radical Innovation: The Case of Technological Spin-Offs"**, *Technological Forecasting and Social Change* - Special Issue on Search mechanisms and innovation: An analysis across multiple perspectives, 120, 144-162

Etant donné que j'ai publié à quatre reprises dans le journal Technological Forecasting and Social Change, je souhaite simplement indiquer que je n'ai aucun contact de quelque nature que ce soit avec les éditeurs de ce journal. J'estime que les sujets sur lesquels je travaille sont en adéquation avec la ligne éditoriale de ce journal et les attentes des lecteurs.

La conclusion présente les résultats des trois articles et répond aux trois sous-questions de recherche, et ainsi qu'à la question de recherche principale. La conclusion met également en lumière les contributions principales de l'ensemble du manuscrit. Après avoir indiqué les limitations des travaux, différentes pistes de recherches futures sont détaillées.

Introduction

In this introduction, the current debates in the literature, the main research question and associated sub research questions, the set of research objectives, the methods used, the empirical contexts, the findings, the main contributions, and the structure of the manuscript will be presented.

Current debates

This dissertation is dealing with different topics such as ecosystem, absorptive capacity and radical innovation. This thesis aims at offering new perspectives on five debates.

The first debate is related to the complementary, supplementary, competing, convergence, or divergence of the four streams of research in the field of ecosystem: business ecosystem (Moore, 1993), innovation ecosystem (Adner, 2006), entrepreneurial ecosystem (Prahalad, 2005), and most recently, the knowledge (based) ecosystem (van der Borgh, Cloodt & Romme, 2012). Since Moore (1993) and the introduction of the concept of ecosystem in the management field, we observe that this term is frequently used, in academia and in business contexts. This increasing attractiveness has been translated in an increasing number of publications. Based on a search on Web of Science (WoS), until 2015, it was possible to count 39 articles exclusively related to business, management, and economics. Since 2015, we have observed an increasing number of publications: 21 publications in 2015 and 26 in 2016. We acknowledge the emergence, years after years, of business ecosystem (Moore, 1993), innovation ecosystem (Adner, 2006), entrepreneurial ecosystem (Prahalad, 2005), and the knowledge (based) ecosystem (van der Borgh, Cloodt & Romme, 2012). However, little is known about the connection between those streams of research. Therefore, there is a strong need to conduct a Systematic Literature Review to contribute to the consolidation of the field of ecosystem facing the emergence of different streams of research.

The second debate is about the lack of theoretical foundation of the field of ecosystems (to be explained later in the manuscript) that required the use of existing stronger theoretical background such as the institutional theory (DiMaggio & Powell, 1983), the resource dependency theory (Pfeffer & Salancik, 1978), open innovation (Chesbrough, 2003) or dynamic capabilities (Teece, 2007). However, there is a need to further strengthening the emerging field of ecosystem with other well-established theories, that will be done in a part of this thesis. In particular, the field of ecosystem could strongly benefit from investigating the similarities and differences with the territorial approach (Moulaert and Sekia, 2003).

The third debate is about technological catch-up of emerging economies. This debate is rooted in the knowledge-based view of the firm which considers knowledge as firms' most important resource (Nonaka & Takeuchi, 1995; Grant, 1996; Spender, 1996). In their pursuits for innovation, firms are in need to transfer and/ or receive knowledge to gain competitive advantage, especially for businesses engaged in international exchange (Kogut & Zander, 1993), particularly in developing nations endeavoring to grow their economies. Across nations, there is a significant difference between countries able to benefit from technology transfer and the countries, which benefit very little. Technological catch up being country specific (Ponomariov & Toivanen, 2014), there is a debate about the reasons of such differences. More specifically, we are interested in further understanding how and why some factors influence organizational learning, especially in emerging countries. In particular, there is a need for further studying strategic alliances in transition economies.

The fourth debate is related to the field of absorptive capacity. Anchored in the seminal work from Cohen & Levinthal (1990), there is a need for further study the assimilation of external knowledge (Lane et al., 2006). This debate is not new. Back in 1991, Hamel was already arguing that the access to external knowledge is not necessarily leading to the efficient assimilation of such knowledge. Contributing to this debate, Lane & Lubatkin (1998) argued that a “learning dyad” as

involving firms playing the roles of ‘teachers’ and ‘students’ can increase the likelihood of efficient knowledge absorption in strategic alliances. However, the literature in the field of absorptive capacity only consider a one-way learning dyad between the ‘teachers’ and the ‘students’. Consequently, there is a gap when considering a learning dyad as a two-way learning between two organizations playing both roles of ‘teachers’ and ‘students’ in joint ventures.

The fifth debate is related to the field of innovation management and more precisely on the role of customers in new product development (NPD). From the literature, we know that customers contribute to the firms acquisition of knowledge (Fang, 2008; Noordhoff, Kyriakopoulos, Moorman, Pauwels, & Dellaert, 2011; Truong, Simmons, & Palmer, 2012). According to Coviello & Joseph (2012), we also know that exchanges with customers have a positive impact on the firms’ ability to conduct research and to develop products meeting the market expectation, which, in turn, increase the probability of financial returns (Danneels, 2007; Levinthal & March, 1993). However, there is a need to distinguish two types of innovation: incremental innovation and radical innovation. While customers contribute to incremental innovation NPD, the literature is unclear about the impact, being either positive or negative, of involving customers in radical innovation (Markides, 2006). Indeed, given the degree of newness and the different technological trajectories, radical innovation is rarely driven by demand, and it may be counterintuitive to involve mainstream customers in the development of this type of innovation. This current debate encourages us to investigate the conditions under which customer involvement can help firms develop or stall radical innovations.

Research questions

In current knowledge-based economy and society, a large variety of stakeholders such as firms, research centers, universities, public institutions, customers, are continuously interacting. Involving external stakeholders is not free from risk and can lead to counterproductive effects. In particular, the debate about the impact of customers in radical innovation requires further studies (Markides, 2006).

Once a clear set of selected stakeholders has been defined, there is a need to set the right type of interactions. Those interactions can take different forms, from informal contacts to formal strategic alliances (Hamel et al., 1989; Khanna et al., 1998). Specific strategic alliances enable specific knowledge transfer when it comes to distinguishing tacit versus explicit knowledge (Nonaka, 1994). Kandemir & Hult (2004) argue that joint-ventures enable the absorption of tacit knowledge in an efficient way. The origin of firms taking part in a joint venture, coming from a developing country or developed country is not discussed in the literature dealing with absorptive capacity in the specific case of tacit knowledge.

Furthermore, when involving the right partners in the right relationships, knowledge transfer requires the organization itself to be able to assimilate such external knowledge through absorptive capacity, which in turn is transformed into innovation (Cohen et Levinthal, 1990). On that specific matter, there is a theoretical gap on the two-ways learning dyad between two partners taking part in a joint venture (Lane et Lubatkin, 1998).

Finally yet importantly, the surrounding environment of knowledge dynamics occurring between partners is known for playing a significant role in business successes and failures. The territorial perspective (Moulaert and Sekia, 2003), today strongly associated to the emerging field of ecosystem (Moore, 1993) truly matter. On that specific point, a clearer understanding of the role played by business ecosystem (Moore, 1993), innovation ecosystem (Adner, 2006), entrepreneurial ecosystem (Prahalad, 2005), and the knowledge (based) ecosystem (van der Borgh, Cloodt & Romme, 2012), in term of complementary, supplementary, competing, convergence, or divergence is important to any organization as it significantly impact its operations and its innovation outputs.

Consequently, the following research question has been considered: *Which organizational capabilities and inter-organizational knowledge dynamics enable innovation within an ecosystem?*

This research question can be pictured in the following figure 1, in which the knowledge dynamics developed between an organization and its partners like universities, public institutions, research centers, spin-offs, firms and customers, to develop innovation within a territory and an ecosystem.

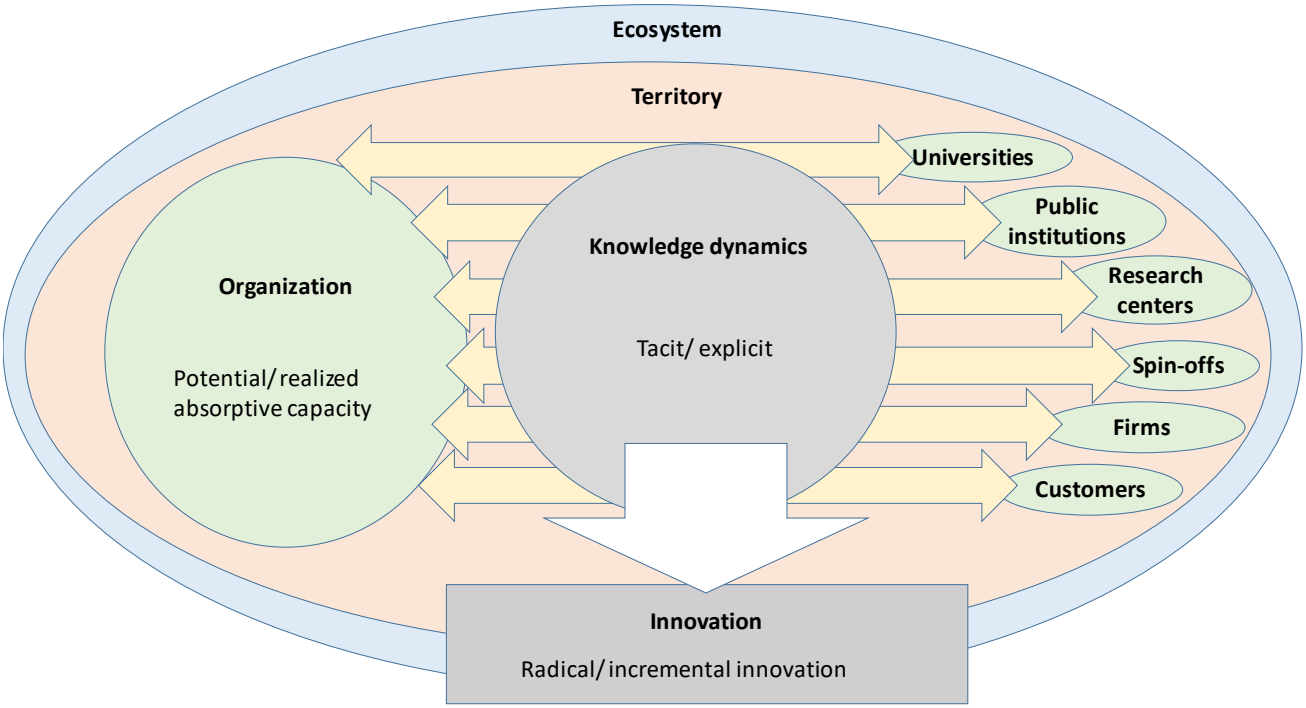


Figure 1: General analysis model

To answer this research question, we refer to the absorptive capacity, the nature of knowledge, the degree of newness of innovation, the territorial innovation models and the ecosystems.

To answer the main research question, three sub-research questions have been investigated:

- *What are the conceptualizations of the ecosystem approach, its invariants, and its links with the territorial approach?*
- *What are the challenges of radical innovation, the barriers to technological change, and the difficulties involved in the transfer of tacit and explicit knowledge between two organizations with different degrees of absorptive capacity?*

- *How acquiring knowledge from customers can either facilitate or hinder a firm's quest for radical innovation*

Research objectives

From the three sub-research questions, different research objectives have been identified as following:

- To explore, identify and modelize the invariants from the four streams of business, innovation, entrepreneurial, and knowledge ecosystems, linked to the literature dealing with the territorial approach, in order to build a framework merging the ecosystem approach with the territorial approach
- To investigate the technological catch up, the specific strategic alliances, and the factors influencing organizational learning, within a two-way learning dyad between two firms with a different knowledge base and a different absorptive capacity, in the specific case of an emerging country
- To investigate the conditions and the relations under which customer involvement catalyze or hinder firms' radical innovations as a result of new products development process.

Methodology

During the dissertation, different methods have been used: (1) a systematic literature review (SLR) of ecosystems based on a selection of 104 articles and books, (2) an in depth case study of a joint venture created by Freyssinet and Azaran to build a new roof to the Mashhad stadium (41 interviews over a 19 month period), and (3) a cross-case analysis about customer involvement in the development of radical innovations in 3 spin-offs (36 interviews over a 4 years period).

Following Tranfield, Denyer, and Smart's (2003) three stages of systematic review and Greenhalgh, Robert, Macfarlane, Bate, Kyriakidou, and Peacock's (2005) metanarrative review

phases, we designed our procedure for conducting a SLR. More precisely, we defined seven steps as following: 1) initial search, 2) scoping studies, 3) article search, 4) article selection, 5) reference backtracking, 6) content analysis, and 7) invariant analysis.

During the four rounds of revision of our paper, we have been facing three major difficulties: The need to clarify the entire process of selection and analysis of the articles, the under representation of journals from management science in WoS, and the need for backtracking. We have been able to find convincing answer to our reviewers by adding a certain number of tables and figures explaining our method, by comparing the different data bases such as Scorpus and WoS, by refereeing to 10 articles dealing with bibliometric statistics, and by exploring all the references from the articles we considered in our SLR.

The in-depth case study of the joint venture created by Freyssinet and Azaran to build a new roof to the Mashhad stadium was aiming at conducting research in a real-life environment in an exploratory research design (Yin, 2003) to capture the direct effects of decision along the project (Golden, 1992; Yin, 2003; Dyer & Wilkins, 1991). An inductive approach to explore this project has been implemented to capture a deep understanding of the issues, stakes, and influences involved (Strauss & Corbin, 1998). Our data source come from a semi-structured interview guide to explore events and people's involvement together with observations, documents on the sequencing of the assembly of elements, quality reports, press articles, meeting minutes, communications, e-mail exchanges, and reports to stakeholders. These were cross-checked via triangulation, which was very useful in comparing the perspectives of various stakeholders (Easton, 1995; Miles & Huberman, 1994). Coding, clustering, and reduction produced a code scheme, with six major categories and 43 codes (Strauss & Corbin, 1998; Araujo, 1995; Coffey & Atkinson, 1996).

From a methodological point of view, we faced a major difficulty: The inclusion of verbatims that could potentially lead to major controversies. Indeed, during our two rounds of revision of this

paper, the three reviewers were asking to temper our statement, and even to delete some of our verbatims that were considered as being a shame for Iran. As a consequence, we had to delete one very critical verbatim.

The choice of the three spin-offs of our cross case analyses about customer involvement in the development of radical innovations was based on a four steps process: overall sample consideration and categorization, identification of several cases per category, final choice of cases, and consideration of post-data collection categorization. Similarly to the first empirical study, we adopted an inductive approach to obtain an in-depth understanding of the issues, stakes, and influences that were at play within three spin-offs from CEA-LETI. In contrast, instead of collecting data from different respondents, we conducted longitudinal case studies to investigate the effect of decisions on the innovation process by conducting periodic interviews (Pettigrew, 1990).

During the three rounds of revisions for the journal Industrial Marketing Management that ended by being rejected, and three rounds of revisions for the journal Technological Forecasting and Social Change, we were facing two major methodological difficulties: The justification of our coding and the suggestion to use mix methods (an exploratory qualitative study followed by a confirmatory quantitative study). The choice of the coding was justified in both the body of the text and in a figure. Regarding the adding of a quantitative study, we simply argued that the paper was long enough, close to 20.000 words and the an additional quantitative study would have a negative impact on the clarity of the main message of the paper.

Empirical contexts

Very different empirical settings have been investigated, from the most high tech spin-offs of Grenoble to the most traditional construction firms of Iran.

I had the opportunity to collect data from an Iranian context. Iran is constantly investing in knowledge transfer to support its development in science and technology development. With the intent to reduce the technological gaps with developed countries, Iran supports innovation in different industries (Ghazinoory, Riahi, Azar, & Miremadi, 2014). We note that the Iranian context has been rarely explored and there is a limited number of papers which conducted their empirical studies in Iran, especially carried by foreign scholars. It can be partially due to economic embargo and important barriers to access Iran. Consequently, there is a clear empirical gap when it comes to the study of the challenges faced by firms operating in Iran and by Iranian firms collaborating with external partners.

In that Iranian context, the choice of the construction industry is meaningful. Bessant & Francis (2005) argued that major construction projects can strongly benefit to the host countries. In that sense, foreign firms are providing a way for local firms to learn advanced design and new construction technologies (Ling, Ibbs, & Cuervo, 2005; Ling, Pham, & Hoang, 2009). The Iranian construction sector triggered our attention since it represents a significant part of the total national annual investment while benefiting the least from new technologies diffusion (Tabassi, Ramli & Abu Bakar, 2012). Beyond its economic significance, what matters most is the impact of technology non-acquisition on the poor resilience of buildings during frequent earthquakes occurring in this region (Tabassi & Abu Bakar, 2009). The construction sector is frequently accused of being responsible of the large number of fatalities in past earthquakes. Consequently, better understandings the reasons of the slow technological change in the Iranian construction sector could enable us to formulate valuable propositions toward a quicker technological catch-up, the design of more resilient buildings, and a greater safety for the Iranian people.

Contrasting with the Iranian context, the second chosen empirical setting is focusing on technological spin-offs emerging from a research center in Grenoble. The interest of studying this particular cases are motivated by the fact that, while regular start-ups have been frequently studied,

the specific case of start-ups emerging from a mother organization, namely scientific spin-offs, have received limited attention by scholars. Scientific spin-offs are different from regular start-ups for multiple reasons: Different knowledge bases (Colombo & Piva, 2012), privileged link with parent institutions (Basu, Sahaym, Howard, & Boeker, 2015; Chatterji, 2009; Klepper, 2001), learning in dyadic relationships (Agarwal, Echambadi, Franco, & Sarkar, 2004; Chatterji, 2009; Phillips, 2002), superior potential absorptive capacity (Colombo & Piva, 2012), etc. What remains unclear is the study of both potential and realized absorptive capacities in the specific case of spin-offs. Furthermore, while technological spin-offs emerging from universities and corporations have been more frequently studied, we acknowledge little understanding about spin-offs emerging from research centers. Consequently, the choice of studying the specific case of technological spin-offs from a research center offers a new empirical setting to study the impact of involving customers in radical innovation new product development.

Findings

From our SLR, we identify the invariants across the four diverging streams from the ecosystem approach (Moore, 1993; Adner, 2006; Prahalad, 2005; van der Borgh, Cloodt & Romme, 2012) and the seven diverging streams from the territorial approach (Marshall, 1890 ; Becattini, 1990 ; Camagni, 1991; Cooke, 1992; Saxenian, 1994 ; Malmberg & Maskell, 1997 ; Porter, 1998a, b). Based on this list of invariants from two different theoretical background, we propose a research framework based on the comparison between key invariants from both approaches and discuss their similarities and differences.

From our first empirical study of the joint venture in the Iranian context, our findings indicate that radical innovation is characterized by safety, quality, and planning challenges which engender delays, non-conformity to specifications, and additional costs. As a consequence, Freyssinet was unsuccessful in transferring explicit and tacit knowledge because Azaran suffered from poor

organizational absorptive capacity (Cohen et Levinthal, 1990). Freyssinet was able to adapt its operations to Azaran's tacit knowledge routines thanks to its high absorptive capacity. Our results enabled us to better understand the tacit interactions between the rich religious client Astân-e Ghods-e Razavi, the consultant in charge of the development of Khorasan, the partner of the joint-venture Azaran, and the numerous subcontractors within the ecosystem of Mashhad.

From our second empirical study of technological spin-offs in Grenoble context, our findings show the importance of spin-offs developing both potential and realized absorptive capacities (Zahra and George, 2002 ; Lau & Lo, 2015 ; Jansen, Van Den Bosch, & Volberda, 2005; Martini, Neirotti, & Appio, 2015) to internalize customer knowledge and technology emergence awareness and to simultaneously offset customers' lack of technical knowledge in formulating their needs. Both market and technical knowledge appeared to be important for spin-offs, and these were available from both customers and the parent research center. Furthermore, spin-offs need a blending capability to balance between (1) market and technical knowledge, (2) market-pull and technology-push approaches, (3) the involvement of customers and parent research centers, and (4) potential and realized absorptive capacities. Within the ecosystem of Grenoble, we note that the CEA is playing a central role initiating the creation of technological spin-offs, immediately integrated to a network of firms, laboratories and universities.

Contribution

The first contribution aims at enriching the field of ecosystem by identifying and discussing the four main types of ecosystems: Business ecosystem (Moore, 1993), innovation ecosystem (Adner, 2006), entrepreneurial ecosystem (Prahalad, 2005), and the knowledge (based) ecosystem (van der Borgh, Cloodt & Romme, 2012). In addition, we identified transversal concepts such as Service Ecosystems, Open Innovation Ecosystems, Industrial Ecosystems, Digital Ecosystems,

Regional Innovation Ecosystems. Our comparison between the territorial approach and the ecosystem is novel to the field. Indeed, the territorial approach was been largely omitted prior to our study.

The second contribution aims at providing further development of the concept of "learning dyad" (Lane et Lubatkin, 1998), by characterizing a two-way learning between two organizations playing both roles of teachers and students in joint ventures, within the Mashhad ecosystem. In particular, we identified the challenge, barriers to technological change, and the difficulties of transferring knowledge related to absorptive capacity in the specific context of an international joint venture. From an empirical perspective, the study of a radical innovation in Iran is somewhat unusual and offer a different perspective than radical innovation being developed in developed countries. Beyond the theoretical and empirical contribution of this study, studying the construction sector in Iran have an economical and a social impact. This study enable Iranian to better understand the challenges of technology development needed to catch up with radical innovation standards. In particular, all stakeholders of the Mashhad ecosystem benefited from a vicarious learning.

The third contribution aims at providing new insights to the area of customer involvement in the radical innovation process (Markides, 2006). Indeed, this study provides further understanding by examining how the level of customer involvement at different stages has improved or hindered the process of developing radical innovations within young technological firms. In particular, one of the contribution is focusing on the role of firms' absorptive capacity in internalizing the knowledge gained from customers. While the exiting literature largely discuss the positive impact of customers in product creation and development in the case of incremental innovation (Coviello & Joseph, 2012 ; Danneels, 2007; Levinthal & March, 1993), much less is known about the challenge of a firm's capacity to internalize these insights from the perspective of absorptive capacity in the specific case of radical innovation (Markides, 2006). This study contributes a conceptual framework on the blending capability of customer involvement in the development of radical innovations and a set of propositions

for future research. This study also provides a detailed view on the inter-organizational relationships based on Intellectual Property Rights embedded in the ecosystem of Grenoble.

Structure of the manuscript

Following this introduction, the manuscript is divided into three sections in which three published articles are presented. In all three papers, I have been the leading and corresponding author during all revision stages until all three papers have been in press.

Scaringella, L., Radziwon, A., (2018), **"Innovative Entrepreneurial Business Ecosystems: Old wine in new bottles?"**, *Technological Forecasting and Social Change* – Special Issue on innovation Ecosystems: Theory, Evidence, Practice, and Implication, 136, 59-87

Scaringella, L., Burtschell, F. (2017), **"The Challenges of radical innovation in Iran: Knowledge transfer and absorptive capacity highlights - Evidence from a joint venture in the construction sector"**, *Technological Forecasting and Social Change* – Special Issue on the Development of Science and Technology in Iran: The Challenges of Innovation and Commercialization, 122C, 151-169

Scaringella, L., Miles, R.E. and Truong, Y. (2017), **"Customers Involvement and Firm Absorptive Capacity in Radical Innovation: The Case of Technological Spin-Offs"**, *Technological Forecasting and Social Change* - Special Issue on Search mechanisms and innovation: An analysis across multiple perspectives, 120, 144-162

While I have already been publishing four papers in the journal Technological Forecasting and Social Change, I would like to state that I have no contact what so ever with the editorial board of this journal. I just believe that the topics I am working on are strongly matching with the readership of this journal and the current discussions that this journal welcome.

After the three papers, the conclusion summarizes all the findings of the three research articles; answer the three sub-research questions, and ultimately the main research question. The conclusion also highlights the main contributions of the entire manuscript. After addressing the limitations, paths for further studies are detailed.

Part 1: Innovation, Entrepreneurial, Knowledge, and Business Ecosystems: Old Wine in New Bottles?

Abstract

Rooted in the territorial approach, this theoretical paper offers a systematic literature review (SLR) of ecosystems based on a selection of 104 articles and books and their archetypes. First, we identify and discuss the four main types of ecosystems – business, innovation, entrepreneurial, and knowledge ecosystems – and indicate the presence of other transversal concepts. Second, we provide an overview of related and well-established theories from the territorial approach that have been largely omitted although they are ecosystem archetypes. Third, we identify the invariants across the four diverging streams from the ecosystem approach and the seven diverging streams from the territorial approach. Finally, we propose a research framework based on the comparison between key invariants from both approaches and discuss their similarities and differences that could serve as a foundation for future empirical research. This study therefore links the ecosystem and territorial approaches under the complex evolutionary system umbrella by creating a theoretical framework that reflects the complex interconnection between models, theories, and emerging concepts.

1. Introduction

Only two decades after the introduction of an *ecosystem* parallel (Moore, 1993) in the management field, researchers have started to use this term more frequently. According to Web of Science (WoS), until 2015, one could only find 39 articles exclusively related to business, management, and economics that responded to the search string ‘ecosystem*’ AND ‘busines*’ AND ‘innovat*’. In contrast, in 2015 and 2016 alone, one could find 21 and 26 new publications, respectively. This rapid growth justifies the recent emerging discussions, such as by de Vasconcelos

Gomes et al. (2016), Dedehayir, Mäkinen, and Ortt (2016), Oh, Phillips, Park, and Lee (2016), and Ritala and Almpanopoulou (2017).

Scholars contributed to the early development of research in this field by first considering the concept of the *business ecosystem* (Moore, 1993), then the *innovation ecosystem* (Adner, 2006) and the *entrepreneurial ecosystem* (Prahalad, 2005), and most recently, the *knowledge (based) ecosystem* (van der Borgh, Cloodt & Romme, 2012).[1] We ask, are those concepts complementary, supplementary, competing, convergent, or divergent? Because of its relatively broad conceptual scope, the ecosystem term runs the risk of being overused and only temporarily settling into the literature until it goes out of fashion (Oh et al., 2016). Therefore, there is a need for conducting a systematic literature review (SLR) to identify the common invariants across the diverging streams of literature dealing with ecosystems to better structure the existing knowledge and avoid potential misuse of this term.

Ecosystems have been studied through the lens of different theories, such as the institutional theory (DiMaggio & Powell, 1983) or the resource dependency theory (Pfeffer & Salancik, 1978), and at three different levels of analysis: the industrial or network level (Nambisan & Sawhney, 2011; Teece, 2007), the firm level (Zott & Amit, 2010), and the individual level (Nambisan & Baron, 2013). Furthermore, scholars have linked the concept of ecosystems with open innovation (Chesbrough, 2003) or dynamic capabilities (Teece, 2007). Nevertheless, more theoretical works grounded in well-established theories are urgently needed to strengthen the foundation of the field of ecosystems.

However, following Mitleton-Kelly's (2003) perception of the business ecosystem as a complex evolutionary system, we see a promising direction in coupling the ecosystem approach with the literature that deals with the territorial approach. Exploring the ecosystems' roots and archetypes and anchoring the growing literature on ecosystems to more established theories can contribute to

[1] To simplify the terminology used in the article, we will often refer to the extended notion of a business, entrepreneurial, innovation, or knowledge ecosystem by using the shortcut term *ecosystem*, unless we are providing some insights into a particular literature stream.

greater legitimacy. More precisely, what is needed is an investigation into the similarities and differences between the ecosystem approach and the territorial approach as well as development of a common research framework that will constitute a sound base for further research.

The objectives of this study are (1) to explore and present the terminology that management scholars use when referring to the various streams of research dedicated to ecosystems by systematically reviewing a wide range of papers from business, management, and economics; (2) to list the invariants that appear unchanged despite the timing and framing of a literature stream; (3) to link the ecosystems' growing stream of literature to the well-established and mature literature dealing with the territorial approach; and (4) to build the framework that will be a base for further research.

In order to reach these objectives, we address the following research question: *What are the conceptualizations of the ecosystem approach, its invariants, and its links with the territorial approach?*

Our intended contribution is (1) to build a common understanding of the term ecosystem by identifying and discussing four main types of ecosystems; (2) to define the ecosystems invariants and thus fill the gaps between various ecosystem approaches and conceptualizations; (3) to position the literature on ecosystems at the intersection of not only business and management but also the economic geography by identifying and exploring the ecosystems archetypes, such as the territorial approaches; and (4) to bridge business and territorial approaches by proposing a research framework based on the key invariants that will constitute a conceptual base for identifying the future research agenda.

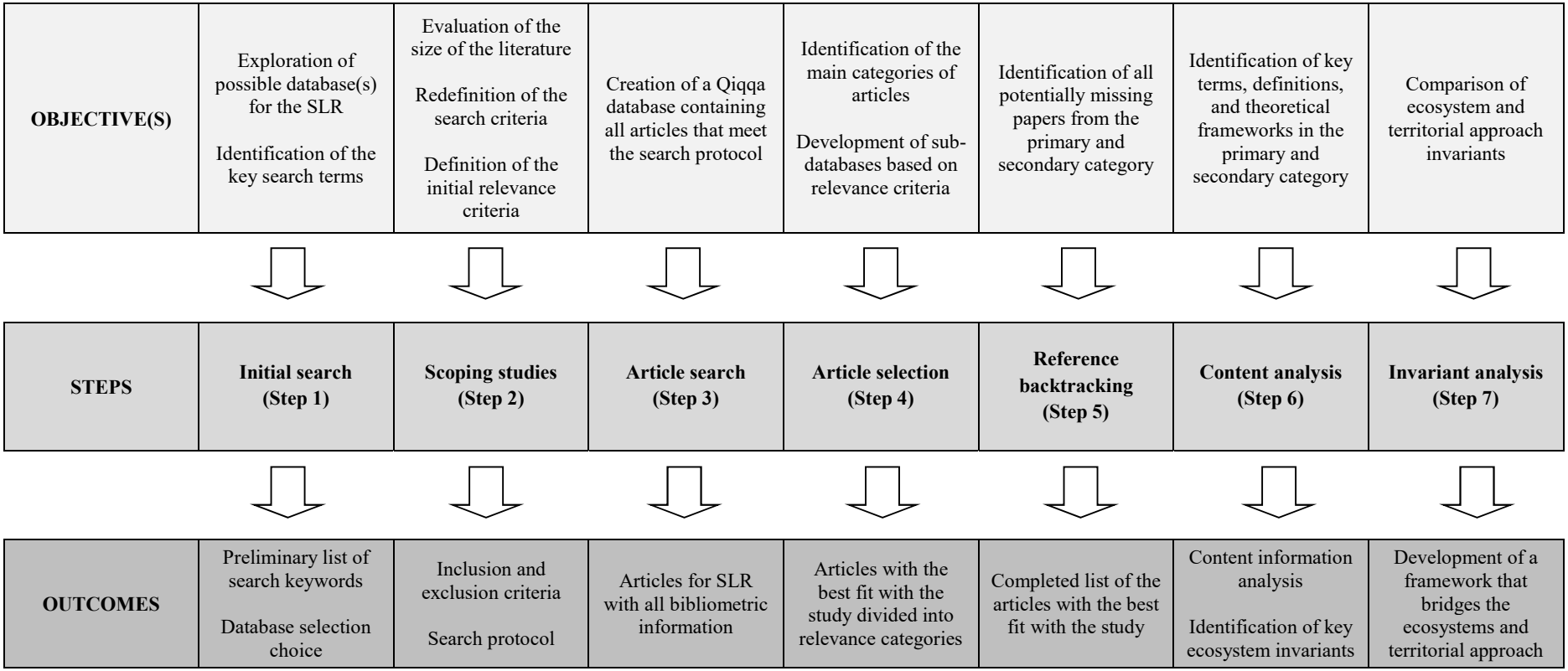
The article is structured as follows: first, we introduce the review design of the systematic literature review on ecosystems; second, we characterize the emergence of the ecosystem approach along with four major streams of literature; third, we present the ecosystems archetypes through the territorial approach; fourth, we scrutinize, analyze, and combine the ecosystems and territorial approaches to discuss a set of invariants by taking part in a research framework that bridges these two perspectives; and finally, we proceed to the conclusion and propose further research.

2. Review Design

The concept of an ecosystem is neither well-defined nor well-established. As a term, it emerges in various literature streams within biology, environmental engineering, agriculture, computer science, marketing, management, and economics. Therefore, before further conceptualizations and discussions, there is a strong need to clarify the different taxonomies, which requires the use of a structured literature review.

In this study, we conducted an SLR following Tranfield, Denyer, and Smart's (2003) three stages of systematic review and Greenhalgh, Robert, Macfarlane, Bate, Kyriakidou, and Peacock's (2005) metanarrative review phases. We specifically explored peer-reviewed research studies related to ecosystems from a management perspective. Figure 1 presents our entire literature review process with all its objectives, steps, and outcomes. The seven steps that will be elaborated upon are: 1) initial search, 2) scoping studies, 3) article search, 4) article selection, 5) reference backtracking, 6) content analysis, and 7) invariant analysis.

Figure 1: Systematic Literature Review Process



2.1. Search Protocol

The database selection process concluded with the selection of the WoS database. We considered the Ulrich list, the European Research Index for the Humanities (ERIH), the Norwegian reference list, the Australian Excellence in Research list (ERA), WoS, and Scopus. This raises a question about the academic relevance and quality of those journal lists. The incompleteness of WoS versus the inclusiveness of the non-scholarly content in Scopus are some of the issues presented by Hicks and Wang (2011). The following three arguments made us choose WoS instead of Scopus: First, Ball and Tunger (2006) argued that WoS has the highest number of quality journals and articles and, consequently, can be considered the worldwide number one. Second, Bauer and Bakkalbasi (2005) contended that WoS best retrieves older sources. Third, Hicks and Wang (2011) used Venn diagrams to represent the coverage across the various lists. The results indicate that almost all journals included in WoS are also included in Scopus and other lists. The authors argued that it is necessary to achieve a hundred percent overlap between the lists to ensure consensus on what is considered scholarly literature within social sciences and humanities. Being the most restrictive, WoS also seems to be the most appropriate because it only includes well-recognized content.

Subsequently, we performed a few initial searches (Step 1) based on the preliminary list of search keywords and started the scoping studies (Step 2). Following Tranfield et al. (2003), we initially considered journals and also conference proceedings, industry trials, and internet sources, but after reviewing the content of some of these records, we resolved to narrow our search criteria. Consequently, to generate the most "reliable knowledge" (Tranfield et al., 2003, p. 5), we decided to exclude proceedings and only focus on peer-reviewed articles and books (see Table 1).

Since the term ecosystem is widely used, especially in environmental sciences and in computer science, we modified the search criteria to reduce our search to management, business, and economics studies. An overview of all inclusion and exclusion criteria is outlined in Table 1.

Table 1: Inclusion and Exclusion Criteria

Inclusion criteria	
Research area (WoS category)	Management, business, economics
Language	English
Timespan	From 1900 to November 2015
Exclusion criteria	
Document types	No proceedings papers

In one of the oldest studies of ecosystems in the field of management, Moore (1993) introduced the term *business ecosystem,* which became a starting point for our search. Later studies further developed the ecosystem concept by focusing on innovation (Adner, 2006; Adner & Kapoor, 2010). That is why 'ecosystem*', 'business*' and 'innovat*' were the most frequently used keywords. Other keywords such as 'entr*' was added after the initial scoping studies had identified another type of ecosystem, namely the entrepreneurial/entrepreneurship ecosystem. Finally, 'network*' as a keyword was added after consulting a list of potential keywords by scholars having published influential studies in the field, as explained in the data collection discussion.

2.2. Data Collection

During the process of searching for and collecting articles (Step 3), we also identified the most influential (most-cited) studies (articles and/or books) and sought advice from experts in the field (as suggested by Greenhalgh, Robert, Macfarlane, Bate, and Kyriakidou (2004)) by contacting the authors from such studies to collect a set of keywords/terms that they associate with ecosystems. The most frequent terms – platforms, innovation, networks, and orchestration – were used in the data collection, the (sub)categorization, and the process of identifying the ecosystem invariants.

In order to get the most relevant results, we conducted three rounds of searches:

1) the core search (searches 1-3), which gave us a total of 133 different records;
2) the supporting searches (searches 4-6), which numbered 153 records; and

3) the saturation check searches (searches 7-10), which totaled 354 records, but only gave us 8 additional core items.

All ten searches totaled 35 primary, 30 secondary, 117 peripheral, and 172 non-relevant records. All the data (number of records) are presented in Appendix 1.

2.3. Data Categorization

In order to identify the core papers, we started the selection process by clustering papers into several subdivisions. To conduct the selection and the clustering (Step 4), we analyzed the title, the abstract, and the keywords and searched for the term *ecosystem* in the body of the text of all 354 records. We categorized the articles based on their relevance: primary, secondary, peripheral, and not relevant. We then identified the key subcategories where scholars used the word ecosystem in a very distinctive way and conveyed the same theoretical focus throughout their studies (such as strategic management, entrepreneurship, etc.). The same categorization criteria were later used for the additional publications sourced from the backtracking. Furthermore, within these subcategories, we also divided the papers based on type, applied theoretical perspective, key findings, and key referencing; this overview is available in Appendix 2 and Appendix 3.

During the process of selecting papers and dividing them into categories and subcategories, we applied appraisal techniques that assured the quality of the selected papers (Greenhalgh et al., 2004, Greenhalgh et al., 2005, Parris & Peachey, 2013). Among other things, authors assessed the appropriateness of empirical and non-empirical studies (see Appendix 4 and 5) by evaluating whether the method was appropriate, whether the data collection and analysis were rigorous, whether the findings were clearly stated, and whether the concept was well-developed (Parris & Peachey, 2013). Factors like sufficient background and clear focus and purpose were secured by the initial selection and clustering method.

We divided the manuscripts into categories mostly based on the relevance and the extent to which the ecosystem concept was elaborated in the manuscript. Subcategories were identified based

on the clustering by theme. In the section dedicated to the findings, we only focused on the primary and secondary categories; the peripheral categories were excluded because those scholars were referring to ecosystem either as a subtype of a business ecosystem (e.g., digital ecosystem) or as a well-established term present in a particular literature stream (e.g., service ecosystem in marketing).

Additionally, in line with the recommendations from Greenhalgh et al. (2004), we applied the citation tracking method. We conducted the backtracking of ecosystem-related references (Step 5) from the primary and secondary papers to make sure we covered the entire scope of ecosystem-related manuscripts. Reference backtracking gave us 39 additional items, including 31 articles and 8 books (or book chapters) that were subject to analysis. Finally, the 35 primary items, the 30 secondary items, and the 39 additional items from backtracking constituted our final list of 104 items to be considered in the data analysis.

2.4. Data Analysis

After completing the list of 104 records (94 articles and 10 books) with the best fit with our study, we conducted the content analysis. Appendixes 6 and 7 present an overview of the most frequently appearing journals along with the number of papers included in the content analysis (Step 6) and outline the most frequent authors and co-authors of the analyzed papers. The content analysis focused on identifying key terms, definitions, and theoretical frameworks related to (a) an ecosystem at large and (b) the various types of ecosystems.

We divided the selection and analysis of the papers into two stages. First, each author focused on one of the approaches (the ecosystem approach or the territorial approach). Second, each author reviewed the synthesis of analyzed articles of the other author and provided a critical evaluation. As an outcome of Step 6, content analysis of both ecosystem and territorial approach records, each of the authors developed a list of invariants that were further analyzed and compared in Step 7, which resulted in the development and synthesis of a framework that bridges both perspectives (Adams, Jeanrenaud,

Bessant, Denyer & Overy, 2015). Both the ecosystem approach and the territorial approach and the framework have been discussed with experts in related areas at conferences and seminars.

In section 3, we present what emerged from the ecosystem approach, and in section 4, we discuss what arose from the territorial approach.

3. The Ecosystem Approach

Based on the clustering criteria and the selection of 104 key items, we identified the following main ecosystem concept types that the scholars refer to: business, innovation, entrepreneurial/entrepreneurship, and knowledge ecosystem. The entire taxonomy along with definitions can be found in Table 2. In the next sections, we elaborate on these four main concepts of ecosystems and discuss their main elements.

Table 2: Ecosystem Taxonomy

Ecosystem	Definition	Selected references
Business ecosystem (62 records)	"Loose networks—of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations—affect, and are affected by, the creation and delivery of a company's own offerings. Like an individual species in a biological ecosystem, each member of a business ecosystem ultimately shares the fate of the network as a whole, regardless of that member's apparent strength." (Iansiti & Levien, 2004, p. 2). "An economic community supported by a foundation of interacting organizations and individuals […] produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies." (Moore, 1996, p. 26).	Iansiti & Levien, 2004; Li, 2009; Moore, 1993; Moore, 1996; Zhang & Liang, 2011.
Innovation ecosystem (25 records)	"The collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. Enabled by information technologies that have drastically reduced the costs of coordination, innovation ecosystems have become a core element in the growth strategies of firms in a wide range of industries." (Adner, 2006, p. 1).	Gastaldi et al., 2015; Leten et al. 2013; Li & Garnsey, 2014; Nambisan & Baron, 2013.
Entrepreneurial/ entrepreneurship ecosystem (9 records)	"The entrepreneurship ecosystem consists of a set of individual elements—such as leadership, culture, capital markets, and open-minded customers—that combine in complex ways." (Isenberg, 2010, p. 4) "The market-based ecosystem allows private sector and social actors, often with different traditions and motivations, ad of different sizes and areas of influence, to act together and create wealth in symbiotic relationship. Such an ecosystem consists of wide variety of institutions coexisting and complementing each other." (Prahalad, 2005, p. 65).	Prahalad, 2005; Isenberg, 2010; Spigel 2015; Autio et al., 2014; Suresh & Ramraj, 2012.
Knowledge ecosystems (3 records)	"The flow of tacit knowledge between companies and the mobility of personnel have been advanced as the main advantages of geographic colocation which characterize these hotspots. Such hotspots have been characterized as knowledge ecosystems where local universities and public research organizations play a central role in advancing technological innovation within the system." (Clarysse et al., 2014, p. 1).	Clarysse et al., 2014; van der Borgh et al., 2012.

3.1. Business Ecosystems

The idea of business ecosystems has been adapted from biology, where ecologically homogenous units constitute a community of living organisms interacting as a system with various components of their environment. Moore (1993) drew a parallel between a biological system and a business counterpart where companies striving for new innovations interact with each other and exist in a given business environment. In its simplest form, an ecosystem could be a combination of different members that interact closely with one another, not only within but also outside the cluster.

Scholars differ in their characterization of business ecosystems. Li (2009) pointed out three traits of a business ecosystem: (1) loose network or horizontal and vertical actors, (2) a platform, and (3) an evolution/coevolution of these actors. Additionally, Basole (2009) considered the main business ecosystem attribute to be the ability to adapt to changes that take place both inside and outside of the ecosystem. Furthermore, Clarysse et al. (2014) referred to two main characteristics of the business ecosystem: a loose network of interconnected participants (Iansiti & Levien, 2004) and an orchestrator or a *keystone* company. The latter is usually firmly established in the network because of its many connections and is therefore in a position to develop and maintain the ecosystem, thus enhancing the participants' performance (Iansiti & Levien, 2004; Moore, 1996). Finally, Rong, Wu, Shi, and Guo (2015) conceptualized the business ecosystem as an independent economic community, which through various dynamic mechanisms supports transformation of a so-called passive social network (Burt, 2010; Eisingerich, Bell & Tracey, 2010) into an active value creation chain (Shang & Shi, 2013).

Scholars have also been discussing three dimensions of the business ecosystem: context (Lu, Rong, You & Shi, 2014; Moore, 1993; Rong, 2011), configuration (Iansiti & Levien, 2004; Rong, Lin, Shi & Yu, 2013), and cooperation (Chen, Rong, Xue & Luo, 2014; Moore, 1996; Rong, Shi & Yu, 2013). Distinguishing and analyzing business ecosystems in the perspective of these three dimensions facilitate a comprehensive picture of not only the nature of this ecosystem but also the potential industries that may emerge within such an ecosystem (Hu, Rong, Shi & Yu, 2014). Business context,

in its most extended form, covers six phases: emerging, initiating, diversifying, converging, consolidating, and renewing (Lu et al., 2014). Configuration considers different roles, connections, and interactions between various ecosystem stakeholders (under different contexts). Iansiti and Levien (2004) described the four typical ecosystem roles, namely those of keystone, niche player, dominator, and hub landlord, which could be supported by non-direct business-related stakeholders, like governments and industry associations (Moore, 1993). Cooperation serves as the glue between context and configuration and focuses on the roles ecosystem stakeholders play in the different phases. Furthermore, the literature offers insight into two types of cooperation inside the ecosystems. The first is the ecosystem roles' strategy for expressing the interactions between the keystone, focal firms and their complementors. This strategy aims at nurturing the ecosystem (Iansiti & Levien, 2004; Rong et al., 2013). The second is a collective, process-based strategy that covers adjustment, adoption, and convergence (Rong et al., 2013).

A business ecosystem includes different organizational members and, due to their close interaction, inter-organizational networks are created (Moore, 1993). Given the importance of a collaborative approach along the value network, creating and capturing value through innovation is one of the aims of business ecosystems (Basole, 2009). No less important is the achievement of competitive advantage (Clarysse et al., 2014; Iansiti & Levien, 2004), which usually happens through collaboration that leads to economies of scale. Clarysse et al. (2014) referred to a very particular type of value creation, namely interactions based on mutual complementarity. When a company is not able to commercialize a product or service because it lacks internal competencies, innovation resource synergy (Chen & Chen, 2013; Li & Garnsey, 2014), skills, or assets (Eisenhardt & Galunic, 2000), external sources may be needed to overcome these internal deficiencies.

Moore (1993), however, pointed out the existence of coopetition relationships, in which firms simultaneously collaborate and compete. In most cases, scholars refer to business ecosystems as networks of companies located in fairly close proximity to each other (Iansiti & Levien, 2004) or

simply as inherently local (Kanter, 2012). Nevertheless, in the specific case of platforms, the latter constitutes an anchor point to an ecosystem (Isckia & Lescop, 2013), and such a virtual co-creation community is then the main place for interaction (Mäkinen, Kanniainen & Peltola, 2014). Platforms appear both in business and innovation ecosystems, but they are primarily discussed in and associated with an innovation context. Therefore, the innovation ecosystem seems to be a response to the growing interest in innovation studies that has both extended and shifted from the business ecosystem conceptualization to social media and various internet platforms.

3.2. Innovation Ecosystem

According to Wright (2014), research on innovation ecosystems only recently emerged. The main difference between business and innovation ecosystems seems to be a lack on the demand side (customer/user) in the latter (Clarysse et al., 2014; Gawer, 2014; Wright, 2014). In the business ecosystem perspective, the way to approach a customer is more *tangible* than in an innovation ecosystem, which takes the user for granted.

Understanding the value creation/capture logic is essential for the development of successful innovation ecosystems (Adner & Kapoor, 2010; Iansiti & Levien, 2004; Moore, 1993). Adner (2006) asserted that no single firm could achieve value creation on its own and that research in this domain often depicts a large firm (in a high-tech industry) as the ecosystem orchestrator (Adner, 2006; Adner & Kapoor, 2010; Rohrbeck, Hoelzle & Gemünden, 2009). An innovation ecosystem consists of interdependent actors such as firms, non-governmental organizations (NGOs), governmental organizations, and other types of resource providers (like funders) (Adner, 2006, Carayannis & Campbell, 2009; Li & Garnsey, 2014; Wright, 2014).

Stakeholders in innovation ecosystems play different roles in the value creating process (Adner & Kapoor, 2010; Eisenhardt & Galunic, 2000; Moore 1993; van der Borgh et al., 2012; West & Bogers, 2014). In an innovation ecosystem, as in a business ecosystem, an orchestrator (Adner 2006), hubs, stewards, or keystone companies (Dobson, 2006) may or may not have to emerge depending on the

ecosystem structure. Such keystone companies should create a strategy that coordinates the knowledge flows and accounts for all the challenges inherent in collaborative networks. Nevertheless, the concept of an innovation ecosystem is constantly evolving in new directions, be they virtual spaces, platforms, etc., centered on the keystone companies, who usually play a significant role in the ecosystem emergence and further development process. Unfortunately, due to the lack of consensus on and strict definitions of the different types of ecosystems, scholars have been using various ecosystem names interchangeably. For instance, when a business ecosystem consists of firms focusing on new product development, scholars refer to it as to an *innovation ecosystem* or as a *business ecosystem.*

3.3. Entrepreneurial/Entrepreneurship Ecosystem

The entrepreneurial ecosystem is different from other ecosystem types. First, in the entrepreneurial ecosystem, the government and its leaders should nurture and sustain entrepreneurship and thus the related ecosystem through direct or indirect support (Isenberg, 2010). Second, the entrepreneurial ecosystem purposely builds its business environment centered on an entrepreneur or entrepreneurial teams. Prahalad (2005) coined the term entrepreneurial ecosystem, which mainly focuses on economic wealth and the generation of prosperity. This type of ecosystem is a combination of various stakeholders, including individuals, entrepreneurial teams, firms, and supporting organizations (Autio et al., 2014), which, despite their differences in objectives and expectations, jointly work towards economic growth (Suresh & Ramraj, 2012). The ecosystem emerges through successful interaction between the actors at the national and individual level, which is an intersection of national culture and political and legal systems and entrepreneurial cognition (Nambisan & Baron, 2013) along with their personality and behavior (Suresh & Ramraj, 2012).

This distinctive combination goes beyond the traditional triple helix relationship (Etzkowitz & Leydesdorff, 2000) and leads to establishing a quadruple helix model, in which Carayannis and Campbell (2012) added civil society to government, university, and industry. Prahalad and Ramaswamy (2013) focused on a very particular part of the society – the bottom of the pyramid (BoP)

– which constitutes the largest and poorest socioeconomic group, a very active sector developing new business models and establishing new ventures. That is why, despite issues with legal frameworks and democratic values, the entrepreneurship ecosystems work most effectively in emerging and developing economies (Isenberg, 2010).

Nevertheless, ecosystem development is not just a two-actor (government and entrepreneur) game; it also involves established enterprises, universities, and the non-profit sector, all of whom share the responsibilities in developing business environments. The process of involving established market players should start as early as possible, because their role is to advise the policymakers about potential entrepreneurial-friendly frameworks, programs, and structural barrier reduction (Isenberg, 2010). Their input is crucial for building *venture-friendly* business environments and shaping the direction of their long-term growth. Remaining ecosystem actors, such as venture capitalists, law firms, accountants, and others, constitute an entrepreneurial support network (Kenney & Patton, 2005). Additionally, large companies may not necessarily serve as an anchor to the ecosystem (especially if they are not available in some of the newly emerging clusters or regions). Nevertheless, Garud, Gehman, and Giuliani (2014) proposed a concept of *anchor events* initiated by policymakers that could serve as networking platforms for various ecosystem stakeholders.

3.4. Knowledge Ecosystems

Clarysse et al. (2014) explicitly made a distinction between a knowledge and a business ecosystem. The main differences fall into three categories: the ecosystem's focus activities, the players' connectivity, and the keystone player (Clarysse et al., 2014). In the knowledge ecosystems, the key activities are centered on the university and the dense network of surrounding companies. These are usually geographically clustered/localized (Bathelt & Cohendet, 2014), and along with the keystone player, they focus on knowledge generation.

Based on their study of innovative Flemish start-ups, Clarysse et al. (2014) concluded that participating in a knowledge ecosystem, which might be understood as knowledge sourcing from a

particular region, does not automatically make a company a member of a business ecosystem. Nevertheless, these knowledge and business ecosystems are not mutually exclusive.

In contrast, van der Borgh, Cloodt, and Romme (2012) used a knowledge-based business ecosystem frame to investigate how value is created and delivered in a sustainable way. Van der Borgh et al. (2012) defined a knowledge-based business ecosystem as an interdependent set of heterogeneous and knowledge-intensive companies. In their study, the participating companies are not geographically dispersed (in line with Iansiti and Levien (2004)). The presence in the geographical hot spot is a purposive action centered on knowledge. This knowledge-generating institution, also called an anchor tenant, could be a university or a public research organization (Clarysse et al., 2014). The main role of an anchor tenant is to facilitate research commercialization processes and to connect all the players. The latter function is especially important when the ecosystem consists of many players with diverse organizational forms.

3.5. The Need for Invariants

We observed that, despite some overlaps, these four ecosystem conceptualizations represent different views of an ecosystem. Therefore, our intent is to define the ecosystem invariants to provide an overview of the similarities, differences, and complementarities of these ecosystems. In comparing these four conceptualizations, we developed a list of invariants, which are outlined in Table 3.

Table 3: Invariants of the Ecosystem Approach

Invariants		Business Ecosystem	Entrepreneurial Ecosystem	Innovation Ecosystem	Knowledge Ecosystem
Territory	Anchoring	Platform as an anchor point to the ecosystem			Presence of an anchor tenant
	Territorial size	Close proximity; inherently local	The country or region	Spatial proximity (in case of innovative business ecosystems) or/and virtual spaces	Close proximity
	Industry		Disruption of existing industries and creation of new ones	Wide range of industries	Technological clusters
Values	Trust	Trust		Trust	Trust
	Belonging to a community	Virtual/co-creation community		Mutual dependence on exchange relationships	Collective sense of belonging to a special group
	Mutual understanding		Understanding, of one's own entrepreneurial cognitions	Understanding as a key controllability factor	
	Uncertainty reduction		Visible success reduce the perception of risk	Mitigation of interdependencies risks	
	Culture, history, routine		Culture impacts the ecosystem development		Promotion of culture of innovation
Stakeholders	Firms	Inter-organizational/interfirm networks	Entrepreneurial firms embedded in networks, Interconnected companies	Firms embedded in networks	Large firms with established R&D departments, SMEs, and start-ups
	Networking among firms	Learning, connectivity, and mutually influencing interactions	Interaction between entrepreneur and ecosystem	Interdependence	Collective learning Networking between residents
	Other stakeholders	Complementors; a large volume of innovating entities	Individuals and entrepreneurial teams; social, institutional, industrial, organizational, temporal and spatial networks,	Complementors, government organizations, funders, resource providers, standard setters, and complementary innovators	The universities, public research organization
	Value chain	Customers, suppliers, distributors, outsourcing firms, makers of related products or services, technology providers	Open-minded customers, specialized suppliers, service providers, training institutions, and support organizations	Customers, suppliers, intermediaries	Diversity of organizational forms
	Governance	Orchestrator	'Anchor events' as governance platform	Leading firm/ecosystem orchestrator/network orchestrator	University or public research organization (PRO)
Economics	Localization economics				Collective resources
	Localized spillovers				Local spillovers
	Economies of scale	Economies of scale			Economies of scale and scope
Social	Economic and non-economic		Economic progress stimulation, social-economic interactions	Shared economic and social value	
	Collaboration versus competition	Collaboration and competition resulting in coopetition relationships; symbiosis	Private enterprises coexisting in symbiotic relationships	Simultaneous cooperation and competition	Knowledge-based R&D collaboration
	Workforce	Job creation function	Mobility of innovative entrepreneurs; job creation		Mobility of personnel
Knowledge	Type of knowledge	Protected i.e. Patents			Tacit and protected
	Knowledge dynamics	Knowledge mobility	New knowledge production through interaction	Coordinated knowledge flows: purposive knowledge inflows and outflows	Make use of knowledge available in the region: proximity to knowledge generators
	Synergies	Synergies of innovation resources		Synergistic relationships of people, knowledge, and resources	
Outcomes	Economic	Value creation; performance enhancement	GDP growth		
	Innovation	Innovation	Radical innovation	Innovation	Innovation
	Competitiveness	Competitive advantage through collaboration in value network			
	Entrepreneurship		Venture creation		Cross-realm transposition
	Development	Adaptation and evolution	Co-creation and evolution, which are fostered by policymakers and drives innovation	Co-creation	

The concept of business ecosystems was developed many years ago. It focuses on inter-organizational networks located in close proximity to each other and on large firms that take on the orchestration role. This type of ecosystem heavily emphasizes the business-related value-creation process that emerges due to close collaboration between various firms. The emergence of entrepreneurial, innovation, and knowledge ecosystems seems to represent a somewhat multidirectional development.

The first direction towards an entrepreneurial ecosystem focuses greatly on a particular territory, specifically a region or a country, and underlines the importance of both governmental level actors and entrepreneurs. In this sense, the entrepreneurial ecosystem acknowledges the contribution and impact of the actors on the individual and team level on the economy. However, in order to make sure that this contribution to the economy takes place, support of the policymakers is necessary.

The second direction towards an innovation ecosystem drives an ecosystem in the direction of a virtual route. The innovative products/services can be developed by companies from different industries that are located in close (geographical or cognitive) proximity to one another. Those companies serve as a demand side (customer or user) spreads around the globe. For this reason, the uncertainty level related to both the supply side and the demand side is definitely higher in an innovation ecosystem than in the other ecosystem cases. In the case of an innovation ecosystem, the virtual presence is also a distinguishing factor between national and regional innovation systems (which are inherently local).

The knowledge ecosystem constitutes a bridging concept between the business ecosystem and the territorial approaches. It covers important elements of collaboration and knowledge exchange, and it acknowledges the value-creating intersection of the business world and the academic world. Furthermore, the role policymakers play in both knowledge and entrepreneurial ecosystems makes the knowledge ecosystem conceptually closest to the territorial approach.

Even though this SLR focuses on the four ecosystem types, we have also encountered other transversal ecosystem concepts, as for instance industrial ecosystems, service ecosystems, and technology/digital ecosystems. The industrial ecosystems represent another emerging literature stream related to industrial ecology. These focus on the transformation of unsustainable industrial systems (Korhonen, von Malmborg, Strachan & Ehrenfeld, 2004) and are strongly linked to organizational ecology (Hannan & Freeman, 1977). Service ecosystems, on the other hand, focus on firms' direct customer-supplier network and deprioritize other stakeholders. Finally, technology/digital ecosystems represent two conceptually distinct streams of research. Technology ecosystems (Feijóo et al., 2009) usually emerge in computer science and thus refer to computer networks, whereas digital ecosystems, if not referring to computer networks, represent a subtype of business ecosystems.

Despite the discussed ecosystems' seeming connection to systems theory found in this study, we focus on a very particular link between the business ecosystem concept (an umbrella term for innovation, entrepreneurial, and knowledge ecosystem) and a complex evolutionary system (Mitleton-Kelly, 2003). Mitleton-Kelly (2003) specified 10 generic characteristics such ecosystems should include: (a) connectivity, (b) interdependence, (c) feedback, (d) emergence, (e) self-organization, the creation of new order, (f) exploration-of-the-space-of-possibilities, (g) far-from-equilibrium, (h) coevolution, (i) historicity, and (j) path dependence. These characteristics could be explicitly or implicitly seen in the territorial models, which indicates that the ecosystem archetypes could be looked for in the territorial approach.

4. Ecosystem Archetypes – the Territorial Approach

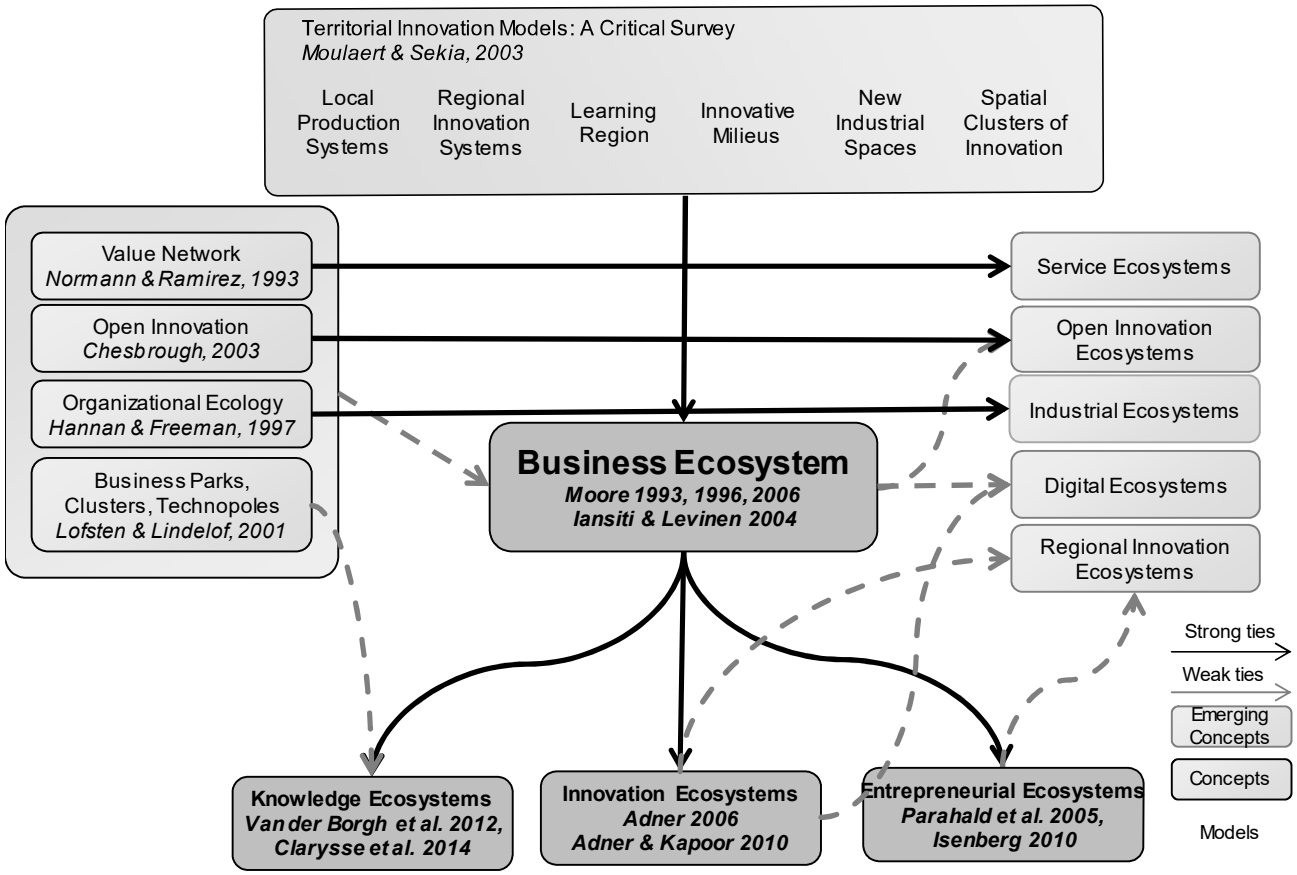
Scholars have acknowledged the possible roots and interconnections between ecosystems in a business/management sense and other taxonomies or other literature streams. Li (2009) highlighted related taxonomies such as biologically inspired industrial ecosystems (Korhonen et al., 2004), evolutionary economics within innovation systems (Cooke, Uranga & Etxeberría, 1997; Malerba, 2002; Martin & Sunley, 2006), organizational ecology (Amburgey & Rao, 1996; Hannan & Freeman,

1977; Trist, 1977), and open innovation (Chesbrough, 2003). Clarysse et al. (2014) found business ecosystem roots in the idea of value networks (Normann & Ramirez, 1993), and van der Borgh et al. (2012) recognized similarities between (knowledge-based) business ecosystems and business parks, clusters, and technopoles (Löfsten & Lindelöf, 2001).

Spatial agglomeration has raised the interest of both economists and scholars within the management literature. By backtracking the possible roots of the ecosystem concept, we found that the theory developed by Marshall (1890) was most probably the starting point. This theory was subsequently complemented by more complex frameworks from the territorial approach that take into account not only economic factors but also social factors important for the exchange of knowledge.

Figure 2 suggests that the various streams of the territorial approach, such as industrial districts, Marshallian districts, innovative milieus, and regional innovation systems, have strongly inspired Moore's (1993) early definition of the business ecosystem. From this early definition, we identified three emerging streams of research: knowledge ecosystems, innovation ecosystems, and entrepreneurial ecosystems. In addition, some transversal views of what business ecosystems are about have been augmented with the emerging concepts of service ecosystems, open innovation ecosystems, digital ecosystems, and regional innovation ecosystems.

Figure 2: The Key Ecosystem Concepts and Their Roots



In addition to the ecosystem field, several systematic literature reviews on the territorial approach exist, including Moulaert and Sekia (2003); Bell, Tracey, and Heide (2009); Crescenzi and Rodríguez-Pose (2012); Crevoisier (2014); and Scaringella and Chanaron (2016). In the scientific community, the critical survey conducted by Moulaert and Sekia (2003) is commonly accepted by scholars and considered as a starting point for comparing various streams of literature.

Based on the existing works, especially the paper from Moulaert and Sekia (2003), we identified seven major streams of literature related to 1) industrial districts, 2) Marshallian districts, 3) innovative milieus, 4) regional innovation systems, 5) new industrial spaces, 6) localized learning, and 7) regional clusters. We investigated all the streams of literature that may constitute possible archetypes of the ecosystem approach.

Similar to the field of ecosystem, the territorial approach's seven streams of literature are not necessarily convergent and also require a search for invariants. To determine the key invariants of the literature on geographic economics, the seven main streams were organized in chronological order. Major schools of thought developed during overlapping time periods; therefore, there is an ongoing debate on *which school did it first*. After the presentation of the main schools of thought, we will compare them to identify the key invariants that emerged from the literature.

4.1. Marshall's Seminal Work

About a century before Moore's (1993) introduction of the term ecosystem, the neo-classical scholar Alfred Marshall identified that some industrial districts were characterized by a specific territory, a certain business area, a population of firms, and the relationships between these firms (Marshall, 1890). He argued that "the mysteries of the trade become not mysteries, but are as it were in the air" (p. 271). Marshall (1927) later found that clusters "have acquired industrial 'atmospheres' of their own, which yield gratis to the manufacturers of cutlery great advantages, that are not easily to be had elsewhere; and an atmosphere cannot be moved" (p. 284).

Based on his studies of the agglomerations of economic activity and agglomeration impact on regional economies and success, Marshall (1920) argued that industrial districts are related to the agglomeration of firms in a given industry sector within a small geographic area. Other scholars found that localized knowledge spillovers within regions create agglomeration (Acs, Anselin & Varga, 2002; Audretsch & Feldman, 1996; Jaffe, Tratjenberg & Henderson, 1993). Consequently, the cost of knowledge acquisition declines within a small geographic area. Overall, such agglomeration has an impact on economic growth, innovation, and competitiveness (Asheim & Isaksen, 2002; Krugman, 1998; Porter, 2000).

4.2. Italian Industrial Districts

In the 1980s, Giacomo Becattini rediscovered a Marshallian district in the Tuscan textile industry while researching the need for renewal in industrial districts facing financial and social

difficulties. Consequently, Marshallian industrial districts became a popular focus with Becattini (1989), and a stream of literature was written by various scholars, such as Best (1990), Boschma and Lambooy (2002), Boschma and ter Wal (2007), Gordon and McCann (2001), Iammarino and McCann (2006), and Langlois and Robertson (1995). Under the name of the Florence School, the concept of the Marshallian district (Becattini, 1990; Becattini, Bellandi & Dei Ottati & Sforzi, 2003; Dei Ottati, 2003; Sforzi, 2003), also named industrial districts and science parks (Bagnasco, 1977; Becattini, 1992, 2003; Benko & Lipietz, 1992; Camagni, 1991; Dei Ottati, 1994a, 1994b; Garofali, 1992), was created.

Grounded in the agglomeration economies, the Marshallian externalities are based on economies of scale achieved by firms. A high degree of industrial localization offers good opportunities to achieve economies of scale and reduce costs. Dei Ottati (2003) highlighted that the reduction of frictions also has a positive impact on the reduction of transaction costs. Consequently, an industrial district is characterized by its ability to divide tasks, jobs, and the value chain activities among local small and medium-sized enterprises (SMEs). Bagnasco (1977) further argued that SMEs are strongly affected by the industries within their geographic areas. In that specific setting, small and very small firms benefit from knowledge spillovers. All in all, colocation, limited transaction costs, and high specialization are important elements of the Marshallian districts.

In districts, firms benefit from economic and non-economic factors, such as trust and the sense of belonging to a community. We cannot dissociate these economic and social factors because there is an interplay between both economic and social structures that must be balanced (Dei Ottati, 2003). Thus, Becattini (1990) introduced the idea that an industrial district is a socioeconomic organization that creates the *industrial atmosphere* of Marshallian districts. More recently, Becattini (2003) defined an industrial district as a *socio-economic vortex*.

The social aspect of an industrial district has an important impact on knowledge dynamics. Organizations that are part of industrial districts benefit from Marshallian externalities, such as tacit

knowledge (Best, 1990; Boschma & Lambooy, 2002). Roveda and Vecchiato (2008) researched the generation and exploitation of both the tacit and explicit knowledge of Italian districts, in which the community of people and the historical background of organizational collaboration matter. Within a local context, one can observe more trusted knowledge sharing, a greater degree of mutual understanding, and communal sharing of values and language (Becattini, 1990). Overall, this stimulates people to develop a feeling of belonging to a community based on common social and political values (Best, 1990; Boschma & Lambooy, 2002). Local interaction intensity and stability lend an *institutional thickness* to some regions (Amin & Thrift, 1995). According to Camagni (1991), local institutions play a central role in reducing uncertainty in knowledge dynamics and implementing collective learning processes.

Operating within an industrial district is not only about sharing knowledge. Empirical studies in Italian clusters indicate that there is a coexistence of collaboration and competition (Becattini, 1992; Best, 1990; Boschma & Lambooy, 2002). Dei Ottati (2003) argued that competition and cooperation coexist in the Italian industrial districts as well as in dynamic local production systems. Dei Ottati (1994a, 1994b) focused on the mode of this coordination and suggested that the quality of information and the ability to share this information facilitate arrangements among local agents. The coordination of knowledge transfer is easier within a short distance (Boschma & Lambooy, 2002), competition encourages people and organizations to perform their best, and cooperation enables organizations to reduce risks and ensures specialization.

Firms tend to be more successful in a district due to external economies, availability of a skilled labor force, specialization of partners/suppliers, reduction of transaction costs (Amin & Thrift, 1992), division of labor based on trust among stakeholders, and the existence of social capital (Storper, 1995). This is specifically true for start-ups. De Marchi and Grandinetti (2014) argued that industrial districts are characterized by a high number of newly established firms and provide fertile ground for spin-offs. Industrial districts can be distinguished by intensive knowledge dynamics thanks to the presence of a

skilled workforce (Markusen, 1996) and the fact that organizations that are located within short distances of each other tend to innovate more intensively (Breschi & Malerba, 2001). In the case of the Italian industrial districts, this proximity strongly inspired policymakers to make decisions related to long-term economic development (Becattini, 1990; Garofoli, 1992). Becattini (1990), Brusco (1990), and Sforzi (2003) argued that the social interaction between co-located individuals and organizations is one of the sources of the success of Italian clusters.

4.3. Innovative Milieus

In the 1980s, the innovative milieu was developed by GREMI (Groupe de Recherche Européen sur les Milieux Innovateurs), which explored the link between innovation activities and space (Aydalot, 1986; Camagni, 1991b; Camagni & Maillat, 2006; Ratti, 1989). Camagni (1991a) was an early contributor to GREMI and defined an innovative milieu as

> "the set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal "representation" and sense of belonging, which enhance the local innovative capability through synergistic and collective learning processes" (p. 3).

Fromhold-Eisebith (2004) argued that a milieu is composed of three aspects: 1) network/ informal social aspect, trust/tacit knowledge exchange, emotional support of innovation; 2) spatial proximity, because human capital is more mobile in a region than across regions, common culture, and history, which enhance technology transfer; and 3) a sense of belonging, value system, and convention.

Camagni (1991b) argued that

> "spatial proximity matters not really in terms of a reduction in physical "distance" and in the related transport costs, but rather in terms of easy information interchange, similarity of cultural and psychological attitudes, frequency of interpersonal contacts and cooperation, and density of factor mobility within the limits of the local area" (p. 2).

One important aspect of innovative milieus is the development of trustworthy relationships between actors (Camagni, 2004; Camagni & Capello, 2005; Capello & Nijkamp, 2004; Crevoisier, 2004; Rémy, 2000). In a local area, knowledge is shared with a greater degree of trust and mutual understanding, and people share the same values and language (Capello & Faggian, 2005). Such mutual understanding contributes to the institutional thickness, composed not only of collaboration but also of competition and rivalry on a regional scale (Amin & Thrift, 1995).

Social aspects enhance the learning and collective learning processes that occur within an innovative milieu which can learn from its universities (Camagni, 1991b). Ratti (1989) advocated for the importance of learning within a milieu in which agents are independent of local spillovers. According to Lundvall and Johnson (1994), knowledge acquisition is a critical process because knowledge itself is the most significant strategic resource. Some organizations encourage knowledge externalities, which contribute to collective learning occurring within networks (Crevoisier, 2004), and Morgan (1997) emphasized the positive effect learning has on the innovation and social capital within a network.

Networks also offer the advantage of achieving economies of scale in complementary relationships. Building networks enhances the cooperation and the synergies (Capello, 2000), which in turn encourages urban economics theory to consider network behavior (Camagni, 1993).

Jaffe et al. (1993) compared countries, states, and metropolitan areas and argued that knowledge spillovers are geographically localized and concentrated. The smaller the geographical area, the more significant the localization of spillovers. A city can also be a rich context for developing networks, and in support of this, Capello (2000) argued that "non-excessive city sizes in fact facilitate environmental equilibrium, efficient mobility and the possibility of conserving a sense of belonging as far as the population is concerned" (p. 1926).

However, the concept of city does not have the same features as the notion of innovative milieus (Maennig & Ölschläger, 2011; Rémy, 2000). Cities rely on geographical proximity, whereas innovative milieus depend on social proximity between individuals.

Cappellin (2006) argued that territorial knowledge capital is likely to be the utmost measure of innovation within a region. Social and economic interactions have been studied by Aydalot (1986), who argued that entrepreneurs are the outcome of a specific innovative milieu. In the philosophy of GREMI, the local environment has an impact on innovation activities that in turn increase the economic performance of firms. Relationships and collaborations contribute to technical changes and economic growth within a territory.

Similar to the Marshallian district, the innovative milieu considers both economic and social aspects. We note that there is a greater emphasis on the social aspect of knowledge dynamics in this stream of literature compared to the literature on the Italian district, which, strongly influenced by Marshall, instead focuses on the economic aspects.

4.4. Regional Innovation Systems

The regional scale appears to be very relevant (Cooke, 1992) and well-established in Europe (Cooke et al., 1997). Philip Cooke contributed to the stream of literature (Braczyk, Cooke & Heidenreich, 1998; Cooke, 1992, 1998, 2003; Cooke et al., 1997) related to the *regional innovation system* that has strongly inspired European policymakers (Asheim & Coenen, 2005; Tödtling & Trippl, 2004) and greatly contributed to the research in the field. According to Cooke (2003) and Malmberg and Maskell (2002), there is a shift towards regional innovation systems (RISs), which define innovation as a *social and interactive process*. According to Cooke (1998), norms, trust, routines, and other informal means of collective learning strongly affect RISs (Carrincazeaux & Gaschet, 2006). Research on RIS is still meaningful today (Keller, Markmann & von der Gracht, 2015).

Knowledge externalities make it possible for firms to capture external knowledge and to learn (Dosi, 1984; Storper, 1995), and overall, knowledge externalities benefit organizations co-located within a cluster (Antonelli, 1988; Cooke, de Laurentis, Tödtling & Trippl, 2007). When firms collaborate in close proximity, the learning process becomes more interactive (Lundvall, 1988). Additionally, the exchange of knowledge becomes easier, cheaper, and more reliable, which may affect public institutions currently involved in stimulating innovation activities and inspiring local stakeholders to develop social connections to enhance regional growth (Cooke & Morgan, 1998).

Edquist (1997) argued that innovation systems are developed on the interactive learning process between various stakeholders. In RISs, much attention is devoted to research institutes (Asheim & Coenen, 2005; Cooke, 1992; Cooke et al., 1997). RIS allows for the inflow of external knowledge (Asheim & Coenen, 2005; Tödtling & Trippl, 2004), and therefore, the organizations taking part in RISs, whether they are large firms or start-ups, benefit from external knowledge developed by research institutes and universities (Asheim & Coenen, 2005; Iammarino, 2005; Lundvall, 1992).

4.5. New Industrial Spaces

The concept of *new industrial spaces* was introduced and developed by Storper and Scott (1988) and focuses on the contribution to the knowledge of stakeholders popularized by Saxenian (1994). The new industrial spaces idea centers on the industrial district that is enhanced with flexible production systems, social regulation, and local community dynamics. Existing economies of scale and interdependencies explain the initial spatial clustering, but Saxenian (1994) provided an explanation of regional economic competitiveness and localized *industrial systems* that combine local institutions, the local industrial structure, and related relationships between firms and the internal organizational structures of firms.

The Californian School of Economic Geography added new insights to the concept of innovative milieus (Saxenian, 1994; Scott, 1986; Storper & Walker, 1989) and prompted Saxenian

(1994) and Scott (1986) to study the success of clusters in Silicon Valley, California, and Orange County, California. Saxenian (1994) found that in order to nurture technopoles, networks must encourage entrepreneurial initiatives. Druilhe and Garnsey (2000) argued that dominant firms, local universities, and policymakers are spawning new technopoles. A technopole is highly path dependent and relies on knowledge developed by research institutes, and this knowledge is often converted into the creation of technological spin-offs.

4.6. Localized Learning

Malmberg and Maskell (1997, 1999) found that *localized learning* intends to explore spatial proximity and how local stakeholders learn. This stream of literature investigates the reasons for specialization of the regional economics and the co-location of stakeholders (Maskell & Malmberg, 1997, 1999).

Malmberg and Maskell (1997) indicated that tacit knowledge is embedded within a localized system and that its transfer is enhanced by geographical proximity. In other words, tacit knowledge transfer between organizations is enhanced when organizations are localized in the same geographical area or in the same industrial cluster (He & Fallah, 2009) in trusted, densely tied networks (Uzzi, 1996).

Concentration of knowledge within a geographical area is linked to the idea that knowledge is sticky (Morgan, 2004; von Hippel, 1994), and therefore, within the cluster, firms benefit from knowledge spillovers due to knowledge's stickiness and tacitness (Bathelt, Malmberg & Maskell, 2004). Asheim and Isaksen (2002) suggested that knowledge is tacit and sticky because it is difficult to transfer knowledge when there is no physical proximity. Morgan (2004) added that tacit knowledge is sticky, anchored within its location, and transmitted thanks to physical proximity.

Similarly, Malmberg and Maskell (1997) posited that tacit knowledge and networks are very difficult to transfer outside of the region. Moreover, the social capital related to clusters is based on both tacit and explicit knowledge spillovers (Almeida & Kogut, 1999; Bathelt et al., 2004; Owen-

Smith & Powell, 2004). The high degree of tacit/sticky knowledge has an impact in term of routines, habits, and, to some extent, path dependency in localized learning processes among clients and suppliers, but also competitors – all of whom are involved in a face-to-face network (Maskell & Malmberg, 1999).

More recently, the concepts of *local buzz* and *global pipelines* have emerged (Bathelt, 2007; Bathelt et al., 2004). Knowledge creation comes from different theoretical backgrounds, such as urbanization economies synonymous with *buzz* (Bathelt et al., 2004; Storper & Venables, 2002), *local broadcasting* (Owen-Smith, Riccaboni, Pammolli, & Powell, 2002), and *noise* representing current happenings and the creation of a dynamic environment (Grabher, 2002). Practical knowledge creation occurs through "chatting, gossiping, brainstorming, in-depth discussions, and problem analysis" (Bathelt et al., 2004, p. 12). Storper and Venables (2004) found that there is a local buzz when agglomeration occurs locally. The relational aspect of economic geography has been defended by Bathelt (2006) and Bathelt and Glücker (2003); however, local buzz is not limited to knowledge exchange, and the mobility of inventors across companies impacts the knowledge flow, keeping it localized in a limited spatial area (Almeida & Kogut, 1999).

However, Bathelt et al. (2004) argued that there is a "need of extra-local linkages by referring to the dangers of local networks that are too close, too exclusive and too rigid" (p. 15). Consequently, to supplement face-to-face contacts, the co-location and co-presence of people/organizations from the same industry through local buzz require long-distance interactions through global pipelines (Bathelt et al., 2004). The creation of knowledge across clusters is called pipelines because of distances that may be significant and are developed among partners that possess different knowledge bits. For instance, Uzzi (1997) demonstrated the importance of external linkages in the textile industry.

4.7. Regional Clusters

Inspired by Marshall and Becattini, Porter (1998a, 1998b) developed the concept of *regional clusters* as a socioeconomic organization. Similar to Becattini's contention, Porter (1998a) stated that

firms and other organizations, including universities and research institutes, not only cooperate but also compete in clusters. Contrary to the industrial district, Porter (1998b) did not consider the spatial dimension of the clusters, some of which could be the size of a city, a state (e.g., California), a country (e.g., Sweden), or even a group of neighboring countries. The research on the creation of knowledge within clusters has been heavily influenced by Porter (2000) who defined a cluster as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (p. 15).

Clusters are determined by the geographical concentration and connection among companies, suppliers, service providers, firms, and institutions (Porter, 1998a). This definition was extended two years later to include local institutions providing support and qualified workforces as well as the existence of local competition (Porter, 2000). Porter argued that technology transfers are important in clusters and involve scientific institutes. Moreover, in a cluster, both public and private research institutes have a specific role (Asheim & Coenen, 2005).

In clusters, external economies of scale are available (Fujita, Krugman & Venables, 2000; Krugman, 1991), including those achieved by customers and suppliers (Porter, 1998a) and research institutions and universities (Andersson, Evers & Griot (2013). Engel and Del-Palacio (2011) defined a cluster of innovation as "an environment that favors the creation and development of high potential entrepreneurial ventures, and is characterized by heightened mobility of resources, including people, capital and information" (p. 27). Finally, Moulaert and Djellal (1995) developed *locational and urbanization economies*, which are very similar to what Porter (1996) referred to as *agglomeration economies*.

4.8. Territorial Innovation Models (TIMs) Facing Major Challenges

The territorial approach is composed of multiple models: the innovative milieus (Aydalot, 1986; Camagni & Maillat, 2006; Ratti, 1989), industrial districts and science parks (Bagnasco, 1977; Becattini, 1992, 2003; Benko & Lipietz, 1992; Camagni, 1991; Dei Ottati, 1994a, 1994b; Garofali,

1992), new industrial spaces (Saxenian, 1994; Storper, 1995, 1997; Storper & Scott, 1988), clusters of innovation (Fujita et al., 2000; Krugman, 1991; Porter, 1990, 1996, 1998a, 1998b, 2000), regional systems of innovation (Braczyk et al., 1998; Morgan, 1997), learning regions (Florida, 1995; Lundvall, 1992; Maillat & Kebir, 1999), systems of innovation (Leborgne & Lipietz, 1988), and others – the list is not exhaustive.

The concept of territorial innovation models (TIMs) was introduced by Moulaert and Sekia (2003) who argued that TIMs are based on the various models dealing with regional innovation and the local interactions between institutions.

The first problem in the study of TIMs is that industrial districts are not homogeneous (De Marchi & Grandinetti, 2014). In other words, real-life territorial areas are very unique. Bathelt (2001) studied the economic recovery of Massachusetts' Route 128 and focused on the institutional factors and their actions on the cluster from the mid-1990s onwards. Comparing Massachusetts' Route 128 and California's Silicon Valley, Saxenian (1994) found that innovation processes and governance between local actors are different and unique. He and Fallah (2011) also argued that "different industries tend to support different types of cluster typologies. In other words, an individual cluster's typology is to some extent shaped by the industry group it belongs to" (p. 945).

The second problem, pinpointed by He and Fallah (2011) after having studied 15 clusters in the United States and developed a typology of technology clusters in high-tech industries, is that "the real-world clusters rarely feature any single type of typology; a mixed type of typology is much more prevalent in reality" (He & Fallah, 2011, p. 945).

The third problem has been raised by some scholars who contended that those streams of literature dealing with TIMs are clearly diverging, not converging. Tödtling and Trippl (2005) argued that although the definitions of a cluster and RIS are considered similar, they are not congruent.

The fourth problem is the difficulty of creating a *metafamily* of models. In relation to the theories on related topics, the main streams of literature are not perceived as being equally important.

Moulaert and Nussbaumer (2005) noted that essentially the TIMs can be categorized into three main groups: 1) the innovative milieu model (Aydalot, 1986) and the industrial district model, 2) the system of innovation on a regional scale (Cooke, 1992), and 3) the Californian School (Scott, 1988). According to Moulaert and Nussbaumer (2005), regional clusters (Porter, 1998a) do not fall into the main categories. Additionally, Kajikawa, Mori, and Sakata (2012) studied networks in regional clusters and found that the low density of networks in a regional cluster means that it is very challenging for firms to find partners within an industrial cluster.

Meanwhile, Cainelli (2008) held that there are three distinct approaches to spatial agglomeration: 1) Marshallian industrial districts, 2) innovative milieus, and 3) regional innovation systems. O'Gorman and Kautonen (2004) have previously inferred that the three most significant models of agglomeration are: 1) the technopole model, 2) the regional cluster model, and 3) the innovation milieu model, while recently, De Marchi and Grandinetti (2014) have argued that a Marshallian industrial district is a specific type of industrial district (cf. Becattini (1990)), which is a specific type of cluster (cf. Porter (1998b)). They made an attempt to create a typology of three families of models; an attempt, however, that failed to reach consensus in the research community.

Overall, the literature related to the territorial approach faces the multiplication of TIMs, the difficulty of ensuring homogeneity within each model, the poor match between the TIMs and reality, the non-convergence of TIMs, and the struggle to create a metafamily of models.

4.9. What Those Theories Have in Common?

As we have seen, it seems impossible to position all theories under the name territorial innovation models because the streams of literature diverge. Therefore, our intent is to focus on the invariants – what those theories have in common.

Overall, the major streams of literature have seven things in common:

1. a given territory with a unique atmosphere, the anchoring of an industry, and varying sizes;

2. a set of common values, such as trust, belonging to a community, a mutual understanding built over time through common history, culture, and routine;
3. a set of various stakeholders, such as firms of different sizes, research institutes, universities, and policymakers, all positioned at different stages of the value chain;
4. a strong economics foundation based on localization economies, agglomeration economies, transaction cost theory, localized spillovers, and economies of scale;
5. a strong social foundation based on the coexistence of collaboration and competition, which focuses on the increasing importance of both social and human capital;
6. a central position of knowledge of a different nature (tacit versus explicit), which circulates well through transfer, is well-absorbed through intensive learning, and offers synergies; and
7. important outcomes, which are the catalysts of innovation, entrepreneurial initiatives, and competitiveness and lead to economic growth, long-term development, performance, and success.

In comparing these seven conceptualizations, we developed a list of invariants, which are presented in Table 4.

Table 4: Invariants of the Territorial Approach

Chronological order / Stream		1 Industrial districts	2 Marshallian district	3 Innovative milieu	4 Regional innovation systems	5 New industrial spaces	6 Localized learning	7 Regional cluster
	Invariants	**Marshall (1890)**	**Becattini (1990)**	**Camagni (1991)**	**Cooke (1992)**	**Saxenian (1994)**	**Malmberg & Maskell (1997)**	**Porter (1998a, b)**
Territory	Atmosphere	Atmosphere	Industrial atmosphere	Emotional support of innovation			Local buzz	
	Anchoring	Anchoring	Anchoring	Spatial proximity	System	Initial spatial clustering	Anchoring	
	Territorial size	Small geographical area	Geographic areas	Limited geographical area	Region	Region	Physical proximity	City, state, country
	Industry	Industrial sector	Industries				Same industry	Particular field
Values	Trust		Trust	Trust	Trust		Trust	
	Belonging to community		Belonging to community	Sense of belonging		Local community dynamics		
	Mutual understanding		Mutual understanding	Mutual understanding				
	Uncertainty reduction		Uncertainty reduction	Interpersonal contacts				
	Culture, history, routine			History, culture	Similar norms, routines		Similar routines, path dependency	
Stakeholders	Firms	Population of firms	Co-location of firms (SMEs)		Large firms, start-ups	Dominant firms	Co-location of organizations	Interconnected companies
	Networking among firms	Networking among firms	Specialized partners	Complex network	Learning network		Densely tied networks	
	Other stakeholders			Universities	Research institutes, universities	Universities, policymakers	Competitors	Research institutes, university
	Value chain	Balance supply/demand	Divided value chain				Clients, suppliers	Customers, specialized suppliers
Economics	Localization economics	Localization economics	Limited transaction costs			Flexible production systems		
	Localized spillovers	Localized spillovers	Knowledge spillovers	Localized spillovers	Knowledge externalities		Tacit knowledge spillovers	
	Agglomeration	Spatial agglomeration	Agglomeration economies				Agglomeration economies	Agglomeration economies
	Economies of scale	Economies of scale	Economies of scale	Economies of scale		Economies of scale		External economies of scale
Social	Economic and non-economic interactions	Economic factors	Balance economic and social interactions	Social-economic interactions	Social-economic interactions	Social-economic interactions	Social-economic interactions	Socioeconomic organization
	Collaboration vs. competition		Collaboration vs. competition	Cooperation and rivalry				Cooperation and competition
	Social capital		Social capital	Informal social aspect	Informal means		Social capital	
	Human capital		Skilled workforce	Human capital			Co-presence of people	Qualified workforce
Knowledge	Type of knowledge		Tacit knowledge	Tacit knowledge			Embedded tacit knowledge	
	Knowledge dynamics		Efficient information flows: Knowledge transfer coordination	Easy information interchange	Inflow of external knowledge		Global pipelines	Technology transfers
	Learning			Collective learning	Collective learning		Localized learning	
	Synergies		High specialization	Synergies				Complementarities
Outcomes	Innovation	Innovation	Innovation	Innovation			Innovative output	
	Entrepreneurship			Creation of entrepreneurs		Creation of spin-offs		
	Competitiveness	Competitiveness		External image	Regional growth	Entrepreneurial initiatives		
	Economic outcomes	Economic growth	Long-term economic development	Economic growth	Economic performance	Economic success		

5. Invariants Discussion

In this section, we compare the list of invariants from the ecosystem approach (Table 3) to the list of invariants from the territorial approach (Table 4).

5.1. The Blended Territorial Ecosystem Approach: What Are the Common Invariants?

The ecosystem literature does not elaborate on the **sense of belonging** in Maslow's definition. Nevertheless, there are strong interconnections and interdependencies between ecosystem stakeholders that may reflect similar ties. Moore (1996), while discussing business ecosystem characteristics, acknowledged that the economic community is created by interacting organizations and individuals. Iansiti and Levien (2004) approached it from an existential perspective and talked about the keystone's contribution, which is crucial to the overall survival of the local community. In the territorial approach, people are part of a community and organizations contribute to the development of a common history of a given territory (Becattini, 1990; Camagni, 1991a). The sense of belonging to a community exists due to the sharing of social and political values and conventions (Best, 1990; Boschma & Lambooy, 2002; Fromhold-Eisebith, 2004). The size of the territory matters in the perception of the sense of belonging. In that connection, medium-sized cities appear to be the most optimal size (Capello, 2000).

Trust is not something that can be demanded from ecosystem members, but it is considered a governance mechanism supplemental to contracts (Ritala, Agouridas, Assimakopoulos & Gies, 2013). It could also have a positive influence on the reduction of transaction costs, which is one of the *clustering advantages* (Pitelis, 2012). There is a tight link between trust, reputation, and credibility, especially if we take into consideration relationships that are formed between various stakeholders coexisting and coevolving in a special proximity (Buciuni et al., 2014; Li, 2009). Particularly, trust and trustworthy relationships are discussed across most of the territorial models. In the territorial

approach, scholars strongly emphasize the fact that the success of a certain region is also a matter of non-economic factors. Trust is part of it. More specifically, the innovative milieu strongly discusses the need for trust in networking and in the exchange of tacit knowledge between actors (Camagni, 2004; Camagni & Capello, 2005; Capello & Nijkamp, 2004; Crevoisier, 2004; Rémy, 2000).

The ecosystem literature covers **various stakeholders involved in the value chain**; their presence is reflected both in their size and different levels of analysis. First, there are the basic value chain actors, such as the focal firm and its suppliers and customers (Iansiti & Levien, 2004; Moore, 1993), expanding to the universities and public research institutions (Clarysse et al., 2014; van der Borgh et al., 2012) and governmental organizations (Autio et al., 2014; Li & Garnsey, 2014) through individuals and entrepreneurial teams (Autio et al., 2014) to other supporting organizations. Similar to the body of knowledge dedicated to ecosystems, the territorial approach highlights the fact that a region can share an entire value chain among local partners of different types (firms, research centers, or universities) and of different sizes (large firms or SMEs). Such division of work enables the smaller entities to learn from the leading institution in a given territorial area (Bagnasco, 1977).

Knowledge dynamics, which characterize the interaction between ecosystem members, are perceived as an important source of innovation. From a university-centric approach, Van der Borgh et al. (2012) considered knowledge as the foundation of an ecosystem. The use of purposive inflows and outflows of knowledge (Chesbrough, Vanhaverbeke & West, 2006) is also perceived as a core element of an open innovation-based business environment. The central questions for territorial knowledge are: how can knowledge be transferred, how can partners identify relevant information, and what are the existing knowledge dynamics among not only local but also external partners. Such questions are common to the various models presented in this manuscript. For instance, in the Marshallian district model, Dei Ottati (1994a, 1994b) argued that the sharing, the quality, and the coordination of information improve when occurring between local stakeholders. In various models, knowledge dynamics take the form of knowledge transfer by which the reduction of the distance (also called

spatial proximity) facilitates both the coordination (Boschma & Lambooy, 2002) and the collaboration between skilled people (Markusen, 1996). In the innovative milieu, Camagni (1991b) strongly emphasized that spatial proximity enhances the exchange of information. Broadening the scope of endogenous knowledge exchange, the recent stream on localized learning encourages the local network to develop external linkages, especially with the development of global pipelines, which complement existing local buzz (Bathelt et al., 2004).

Another important feature of ecosystems is the strong presence of different types of interactions between ecosystem members. **Cooperation and competition** between established firms and new ventures are measures of the ecosystem's success (Adner & Kapoor, 2010; Moore, 1993; Zahra & Nambisan, 2012). These two behaviors could be performed either independently between different stakeholders or simultaneously between the same partners, thus leading to coopetition relationships (Calcei & M'Chirgui, 2012; Isckia, 2009; Ritala et al., 2013). Various territorial models have investigated the dual existence of collaboration and competition between local stakeholders, and this is the case in Italian industrial districts (Becattini, 1992; Best, 1990; Boschma & Lambooy, 2002) as well as the regional clusters of Porter (2000).

The presence of complementary skills in the ecosystems stimulates the creation of **synergies** (Iansiti & Levien, 2004; Moore, 1993), which may not arise if participants are purely heterogeneous. Eisenhardt and Galunic (2000) claimed that coevolving, which takes place in an ecosystem of closely connected actors, is the factor that makes the synergies work. Leveraging synergies can lead to reduction of risks, extension of design space, and creation of buzz (Hienerth, Lettl & Keinz, 2014). Nevertheless, the value creation process, which takes place when many players are combining their capabilities, may also create some challenges and risks that should be mitigated (Adner, 2006). Synergies are developed within a specific innovative milieu when local stakeholders learn collectively and enable others to learn from their experiences in related activities (Camagni, 1991a). Overall, the cooperation between organizations encourages synergies (Capello, 2000), and these synergies are

possible to achieve because the companies are interconnected, have much in common, and complement each other well (Porter, 2000).

Adner (2006) found three fundamental types of risk associated with innovation ecosystems: initiative, interdependence, and integration risks, and these must be mitigated by an appropriate innovation strategy. The risks are subsequently linked with project management uncertainties, interdependencies and coordination of joint activities with the complementors, and the adoption process of the entire value chain. Sharing among other stakeholders to properly assess and **mitigate risks** could be a key to the survival as well as success of an innovation ecosystem (Ritala et al., 2013). The objective of operating locally is to reduce the risks, and to that end, local institutions are acting to reduce risks and promote trustworthy relationships within the territory (Camagni, 1991a, 1991b). When organizations cooperate, they tend to share the value chain and, consequently, the risk with other partners. The aggregation of various stakeholders in a given territory constitutes an institutional thickness that guarantees a low level of risk among partners (Amin & Thrift, 1995).

Iansiti and Levien (2004) claimed that large ecosystems consisting of thousands of firms benefit from **economies of scale/scope** and thus have an advantage over smaller ecosystems. Economies of scale and scope are also listed as some of the advantages of belonging to the knowledge ecosystems (Clarysse et al., 2014; van der Borgh et al., 2012). This type of leverage could also be observed in the platform research context (Thomas, Autio & Gann, 2014). In the territorial approach, the subject of economies of scale/scope was introduced by Marshall (1920), whose seminal work emphasized that firms achieve economies of scale in industrial districts. While the literature dedicated to ecosystems only addresses economies of scale, the literature on Marshallian districts clearly establishes a link between the agglomeration economies/industrial localization and economies of scale achieved by firms, and in terms of cost savings, the reduction of transaction costs has been discussed (Dei Ottati, 2003). Economies of scale/scope are available because of the existence of complementarity relationships, networks, interdependencies, the existence of industrial systems, the support of local

institutions, the involvement of customers/suppliers, etc. (Fujita et al., 2000; Krugman, 1991; Porter, 1998a; Saxenian, 1994).

According to Basole (2009), delivering **innovation** is one of the aims of an ecosystem. Since innovative businesses neither emerge nor evolve in a vacuum, the creation of a cooperative network is essential for their quick and effective evolution (Moore, 1993). "Successful innovation requires tracking your partners and potential adopters as closely as you track your own development process"(Adner, 2006, p. 1), and that is why Adner (2006) recommended matching a firm's innovation strategy with its innovation ecosystem. The innovation output is both supported and positively influenced by *knowledge generators*, such as universities or public research institutions (Clarysse et al., 2014). In both the ecosystem and territorial approaches, one of the major outcomes expected when operating within an ecosystem/certain territory is encouragement of innovation. Such innovation can take the form of the creation of spin-offs or start-ups in general (Aydalot, 1986; Breschi & Malerba, 2001).

5.2. The Territorial Approach: What Are the Invariants from the Inner Perspective?

The ecosystem perspective fails to consider certain key features of the territorial approach; therefore, this section aims to further present an *inner perspective* from the territorial approach that can offer deeper insights into the ecosystems concept.

Marshall (1890) introduced the idea that an industrial district's **territorial atmosphere** is something unique – a specific territory in a given business area with a set of interrelated firms. This concept of *atmosphere* is the foundation of the territorial approach because it offers an advantage to local stakeholders. This was later followed by other schools of thought that further explored the innovation activities conducted within a specific space (Aydalot, 1986; Camagni, 1991b; Camagni & Maillat, 2006; Ratti, 1989).

These territories base their uniqueness on a variety of stakeholders: not only large and small firms (Iammarino, 2005; Lundvall, 1992) but also **research centers and universities** (Asheim & Coenen, 2005). The importance of universities and research institutes has been heavily documented in the territorial approach but underestimated in the case of some ecosystem types. In some instances (e.g., the state-centered typology), large public or non-profit organizations, such as universities and research institutes, can drive both large and small firms in industrial districts (Markusen, 1996). Research institutions and universities enable local stakeholders to benefit from knowledge spillovers and learn collectively in innovative milieus (Camagni, 1991b).

Between various stakeholders, there is a need to exchange explicit knowledge, but equally or more important is the transfer of **tacit knowledge**. One of the great debates regarding the territorial approach vs. the ecosystem approach is the distinction between explicit and tacit knowledge. Industrial districts offer a specific setting that encourages stakeholders to share their tacit knowledge within a localized system (Malmberg & Maskell, 1997). Within these localized systems, there are regular knowledge exchanges, and co-located organizations benefit from knowledge spillovers (Bathelt et al., 2004). Conversely, at a distance, tacit knowledge is not transferable (Asheim & Isaksen, 2002; Malmberg & Maskell, 1997).

By developing a certain cooperation **routine**, stakeholders contribute to the strengthening of the institutional thickness (Amin & Thrift, 1995). Routines foster several aspects, such as trust and norms, that enhance the informal collaboration of its members who in turn learn more easily (Carrincazeaux & Gaschet, 2006; Cooke, 1998). Moreover, organizations develop habits to facilitate learning from clients, suppliers, and other competing firms. However, because past experiences shape future behavior, scholars have argued that, as a drawback of routines, the territorial approach may also suffer from **path dependency** (Maskell & Malmberg, 1999).

Norms, trust, routines, and tacit knowledge exchange are the antecedents of collective **learning** (Cooke, 1998). The cognitive aspect of the territorial approach has been well-documented compared

to the ecosystem approach and has been highly popularized in the innovative milieu model that investigates the collective learning processes (Camagni, 1991a; Lundvall & Johnson, 1994; Ratti, 1989). This topic has become the central focus of *localized learning*, which investigates the conditions that facilitate cognitive processes among co-located stakeholders in specialized geographical economics (Maskell & Malmberg, 1997, 1999). On one side, organizations can offer knowledge externalities to their networks (Crevoisier, 2004); on the other, learning process capabilities enable stakeholders to capture such external knowledge and knowledge spillovers (Dosi, 1984; Ratti, 1989; Storper, 1995).

The interplay between various institutions, tacit knowledge exchange, and intensive learning processes create a **social capital**, which is a subject of considerable discussion in the territorial approach. Social aspects were introduced by the Marshallian districts (Becattini, 2003) and then amplified in the innovative milieu, which particularly focused on informal social relationships (Camagni, 1991a). Social capital is built on the division of work in trusted relationships (Storper, 1995). Furthermore, innovation is based on a social and interactive process in the RIS model (Cooke, 2003; Malmberg & Maskell, 2002).

The social and economic aspects of the territorial approach are closely related: strong social capital strengthens the **agglomeration** of firms. A set of firms located in the same area and working in the same industry has a positive impact on the availability of **localized knowledge spillovers** in the geographical area (Acs et al., 2002; Audretsch & Feldman, 1996; Jaffe et al., 1993). These agglomeration and localization economies then contribute to reducing transaction costs, encouraging innovation, fostering competitiveness and economic growth/development, and bolstering the success of the local economies (Amin & Thrift, 1992; Asheim & Isaksen, 2002; Becattini, 1990; Garofoli, 1992; Krugman, 1998; Porter, 1996, 2000).

Furthermore, agglomerations strengthen the **anchoring** of knowledge within a specific area, which constitutes *territorial knowledge* (Cappellin, 2006). The knowledge is anchored within a

specific context and a specific territory (Morgan, 2004; von Hippel, 1994) because it is sticky. Consequently, anchored knowledge both enhances local buzz (Bathelt et al., 2004; Storper & Venables, 2002) and positively affects the territorial atmosphere in a virtuous circle.

5.3. The Ecosystem Approach: What Are the Invariants from the Broader Perspective?

In the ecosystem approach, as opposed to the territorial approach, scholars go beyond the *inner perspective* and take advantage of the support from different types of institutions, not only those that are local (e.g., those located on the governmental level), and consequently allow inflows (and outflows) of external knowledge (Chesbrough, 2003).

One of the main differences between the ecosystem approach and the territorial approach is the perception and the role of the structures and institutions. In the entrepreneurial ecosystem, the role of government (national or local) seems to be important, but it is different from its role in national (territorial) innovation systems (Autio et al., 2014). Entrepreneurial activities naturally cluster in certain locations because these places usually offer considerable benefits, and these benefits support the emergence of business or technology clusters in the entrepreneurial ecosystem. In these cases, government's role is to help them grow organically and make sure they are not overengineered (Isenberg, 2010). In the knowledge ecosystem, which is the closest to the territorial approach, the main institutions are the universities or public research organizations (Clarysse et al., 2014; van der Borgh et al., 2012). Therefore, in general, ecosystems consist of **firms and (entrepreneurial) innovation** (Zahra & Wright, 2011).

In business and innovation ecosystems, universities and public institutions play a rather peripheral role, **and the duty of the orchestration falls to the large firm**. Business and innovation ecosystems seem to be overwhelmingly industry-driven – **a firm guides the development of the ecosystem** (Adner, 2006) – in comparison to the entrepreneur in an entrepreneurial ecosystem and the university in the knowledge ecosystem. In this sense, industry in the management perception is much

broader than in the territorial approach because it is composed of a large variety of stakeholders, including those in emerging and disruptive industries.

Furthermore, territorial approach partners share various tasks, whereas in ecosystems, the members develop **strong interdependence**. This interdependence offers **synergetic interactions** between **complementors** and **coopetitors**. When firms establish cooperation and together strive for shared business objectives, the interdependencies between them start to become more visible, and proper management and risk mitigation strategies allow them to reduce uncertainty. Nevertheless, only through knowledge exchange and spillovers can the innovative products and services be created. Ecosystem stakeholders are usually **interconnected,** not only co-located, as is often the case in the territorial approach. Partnership leads to a joint **evolution** and **co-creation of value** that none of the partners would be able to create alone. This value creation and sharing process design may be the role assigned to the ecosystem orchestrator (Iansiti & Levien, 2004), and this anchor tenant should be neither disinterested nor directly competing with the other ecosystem members (Clarysse et al., 2014).

5.4. Towards a Conceptual Framework

Based on the common invariants from the blended territorial ecosystem approach and the invariants from the territorial approach (the inner perspective) and from the ecosystem approach (the broader perspective), we developed the framework presented in Figure 3. The framework highlights the interconnection of the three complementary layers: ecosystem, territorial ecosystem, and territorial. The external layer (ecosystem) offers a broader view, the internal layer (territorial) offers an inner view, and the intermediate layer (territorial ecosystem) is the point of friction between the two complementary streams of literature.

We believe that (a) there is a causality between the invariants at each layer, (b) there are virtuous circles at each layer where an interaction strengthens the next iteration, and (c) there is a high degree of porosity among the three layers and a certain influence between invariants: from the

ecosystem to the territorial approaches (broad-inner dynamics) or from the territorial to the ecosystem approaches (inner-broad dynamics).

5.4.1. The Ecosystem Approach

Regarding the external layer (light grey color), **entrepreneurial activities** clustered in an entrepreneurial ecosystem offer the possibility for large firms to play the role of **orchestration**, which shapes **knowledge sharing** between the members, involves a form of **coopetition**, **complementarity**, and **interdependence**, determines the joint **evolution** and the **co-creation** of value, and finally, reinforces the **entrepreneurial activities**.

5.4.2 The Territorial Approach

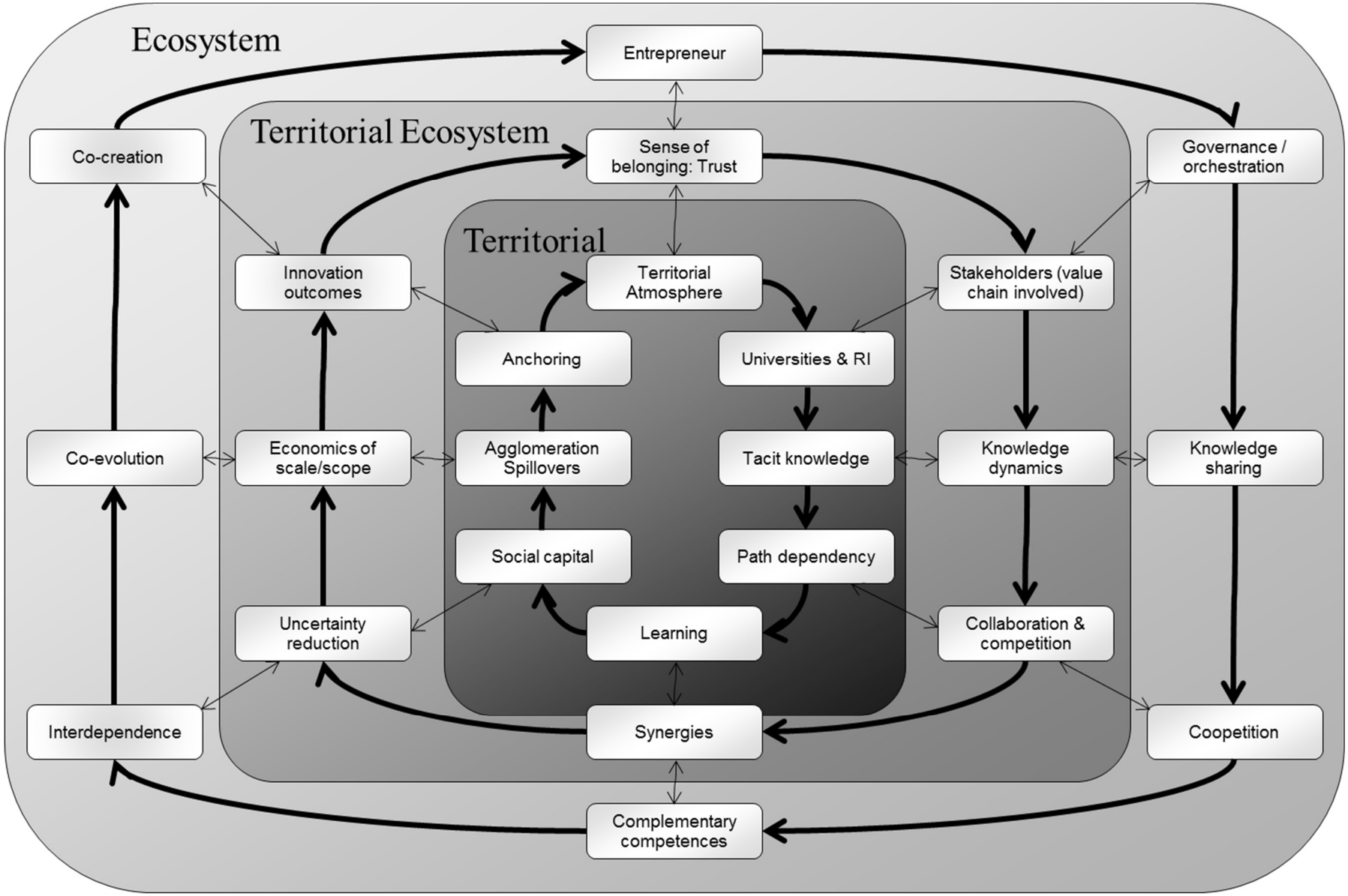
As regards the internal layer (dark grey color), **territorial atmosphere** supports the development of **research centers and universities** and the exchange of **tacit knowledge**, which consequently creates a certain **path dependency**; it shapes the **collective learning**, the development of a **social capital**, and the **agglomeration** of firms benefiting from localized **knowledge spillovers**, which strengthens the **anchoring** of knowledge; and finally, it reinforces **the territorial atmosphere**.

5.4.3 The Territorial Ecosystem Approach

As for the intermediate layer (grey color), the **interconnections** and **interdependencies** between ecosystem stakeholders create a **trusting** atmosphere and a **sense of belonging**, which encourages various **stakeholders** to become involved in the value chain. Consequently, the stakeholders also engage in **knowledge dynamics** as purposive inflows and outflows of knowledge, and this creates an environment where there is a dual existence of **collaboration and competition**, which is needed to create **synergies** between closely connected actors and **reduce** initiative, interdependence, and integration **risks**, benefit from **economies of scale/scope**, and offer **innovation** as a social and iterative process, reinforcing the **sense of belonging**.

This framework fills the knowledge gap in the field of ecosystems for the following reasons. First, our framework bridges business and territorial approaches and provides a better understanding of the position of ecosystems in comparison with other highly related fields of research, such as the territorial approach. Second, we have built the framework based on theoretical work on the territorial approach, which is novel research. Third, we propose a framework that considers the convergent elements between four various streams of literature: the business ecosystem, the innovation ecosystem, the entrepreneurial ecosystem, and the knowledge ecosystem.

Figure 3: Framework of the Invariants from the Ecosystem Approach, the Territorial Approach, and the Blended Territorial Ecosystem Approach



6. Conclusions

6.1. Findings

Following Tranfield et al. (2003), we conducted a systematic literature review on ecosystems based on 393 references: 383 articles and 10 books. We concentrated our SLR on 104 selected items and identified four major but diverging research streams: 1) business ecosystems, 2) innovation ecosystems, 3) entrepreneurial ecosystems, and 4) knowledge ecosystems. We identified the common invariants to strengthen the foundations of this growing field.

The archetypes of the ecosystems were explored by considering established theories that tend to be omitted in the existing literature. Although the link between ecosystems and open innovation exists and the link between ecosystems and dynamic capabilities has been considered, the link between the ecosystem approach and the territorial approach has not yet been studied. We focused on this theoretical gap by exploring the very rich literature composed of seven major but divergent streams: 1) industrial districts, 2) Marshallian districts, 3) innovative milieus, 4) regional innovation systems, 5) new industrial spaces, 6) localized learning, and 7) regional clusters. Similar to the literature on ecosystems, we created invariants to identify the common factors that remain unchanged despite the literature stream.

In order to compare the ecosystem approach with the territorial approach, we evaluated each approach's list of invariants to identify the similarities and the differences. We argue that these two approaches have many elements in common: a sense of belonging/trust, stakeholder involvement in the value chain, knowledge dynamics, collaboration/competition, synergies, uncertainty reduction, economics of scale/scope, and innovation outcomes.

Our results suggest that ecosystem and territorial approaches are two sides of the same coin: one broader side (entrepreneur, governance/orchestration, knowledge sharing, network/sharing tasks, complementary competencies, interdependence, coevolution, and co-creation) and one narrower inner side (territorial atmosphere, universities and research institutes, tacit knowledge, routine/path

dependency, learning, social capital, agglomeration spillovers, and anchoring). Consequently, policymakers should not restrict their governance to the recommendations provided by the literature on ecosystems that is popular at the present time; rather, with the same energy, they should consider the older literature that has intensely shaped the territorial approach. Because the ecosystem approach and the territorial approach are complementary, experts from both fields should mutualize their efforts to provide holistic solutions to current policy issues.

Overall, we have contributed to the ecosystem literature by 1) identifying the four main streams of literature and other transversal new concepts that emerge from a systematic literature review and were integrated in a conceptual framework; 2) suggesting a list of ecosystem invariants that are true whatever the streams that contribute to the stabilization of the field; 3) exploring the ecosystem archetypes, in particular the territorial approach, which is composed of several well-established models linked to the core aspects of the ecosystem approach; and 4) developing a second framework that bridges the ecosystem approach and the territorial approach that identifies the common invariants, the invariants suitable for the ecosystem approach (broader side), and the invariants appropriate for the territorial approach (inner side).

6.2. Research Agenda for Further Studies

In this paper, we explore both the ecosystem and the territorial approach as two complementary fields of study. There are some limitations to our study, which are mainly related to the selection criterion of only including peer-reviewed articles in English from the WoS database. Consequently, we encourage further research to investigate additional databases and to consider non-English articles. Additionally, we developed the following research agenda for further studies.

6.2.1. Establishing Links with Other Research Communities

We believe that, in addition to developing new competing streams of literature, there is a need to stabilize the field of research, cultivate a common understanding, plan the next steps, and develop

a research agenda. That is why the competition between streams of literature in the ecosystem approach or in the territorial approach hinders the progress of the overall literature.

Therefore, it is even more important to make sure that new taxonomies and conceptualizations are not developed to accommodate a temporary need but are well-grounded in the established literature streams and build on other well-developed theories. While conducting our systematic literature review, we also identified other related taxonomies and lenses through which ecosystems can be viewed and analyzed. These are organizational ecology (Amburgey & Rao, 1996; Hannan & Freeman, 1977; Trist, 1977), institutional theory (Geels, 2004), and value networks (Normann & Ramirez, 1993).

In our view, the organizational ecology could offer very valuable insights. Hannan and Freeman (1977) studied organizational ecology by developing the population ecology theory, which analyzes the response of organizations to the changes occurring in the environment. Some organizations adapt to the changes in the environment, while others do not. This leads to the question, can an ecosystem impact the ability of firms to adapt? In the organizational ecology theory, success and failure are determined by population density, industry life cycle, organization age, and organization size. When the number of incumbents increases, the chances of failure also increase. This major aspect of the literature on organizational ecology contradicts the literature on ecosystems. Therefore, for further research, we recommend scholars explore this and also the other archetypes of the ecosystem approach.

Knowledge of the archetype avoids the trap of trying to invent something that already exists and the criticism that this is an *old wine in new bottles* phenomenon. Further research could focus on analyzing how an ecosystem is perceived by other scholarly communities and identifying any frameworks that could be used for more a comprehensive analysis of the ecosystems.

6.2.2. Broader and Inner Scope

We believe that the ecosystem approach and the territorial approach complement each other by presenting an apt combination of broad and narrow focuses. Most recent theories tend to be very

global, inclusive, and broad. However, we believe that there is a need for combining both broad and more specific scopes. That is why it would be interesting to investigate geographical proximity versus cognitive proximity and their role and influence on globalization processes and technological development in both the established and emerging ecosystems. Further research could also investigate the emergence of territorial approach elements in the local and global ecosystems (i.e., innovation platforms). To us, such research seems crucial to better understand the disparities between well-performing territory/ecosystems and underperforming territory/ecosystems. There is a need to study not only ecosystems' positive factors but also their failures and the reasons behind them.

6.2.3. Ecosystem Life Cycle Guidelines for Practitioners

As with clusters, there is a need to study the ecosystem life cycle's embryonic, established, mature, and declining elements. However, should we be studying ecosystem renewal and how ecosystems reinvent themselves to be sustainable in the long run? Investigation into the processes that steer the creation and the dynamics of ecosystems could bring some new perspectives and understanding on the role of different partners in every life cycle stage. This could have interesting implications for both scholars and practitioners, especially ecosystem orchestrators, because knowledge about all the life cycle processes that take place inside ecosystems and the causality relationships between them could serve as guidelines for practitioners who wish to develop alignment between firm and ecosystem strategies.

6.2.4. The Role of Policymakers

To best offer recommendations to policymakers, we believe that detailed knowledge about the specificities of each territory and each ecosystem is needed. Success in one setting does not guarantee success in another because each atmosphere is unique (e.g., replicating the success of Silicon Valley in another environment has not worked). We believe that trying to understand the good territorial ecosystem strategies that work and those that do not is more efficient than trying to replicate the best

cluster. This calls for empirical research that investigates entrepreneurial and interfirm perspectives and the role of institutions, especially policymakers, in the process of ecosystem creation and development.

6.2.5. The Research Framework Exploration

Further research could also focus on the implementation and validation of our framework in empirical studies. Both qualitative exploratory research and early quantitative studies would help to further develop this framework and offer recommendations to policymakers and other regional actors. It would be beneficial to consider not only different regions or industries but also different levels of analysis (e.g., inter-organizational aspects), seeing that a multilevel perspective could provide more insights into various actors' perceptions of the regional setups they are involved in.

Research questions that could further develop this study include: How can the framework be operationalized with quantitative measurements? How can the growing number of communities (i.e., four in the ecosystem and seven in the territorial approach) work together and learn from each other? How can the ecosystem field strengthen its own anchoring in existing theories?

Part 2: The Challenges of radical innovation in Iran: Knowledge transfer and absorptive capacity highlights - Evidence from a joint venture in the construction sector

Abstract

We investigate the collaboration between an Iranian and a French company in a joint venture aimed at developing radical innovation in the construction sector. We identify the challenges involved, the barriers to technological change, and the difficulties of transferring knowledge related to absorptive capacity.

We conduct an in depth case study of a joint venture created by Freyssinet and Azaran to build a new roof to the Mashhad stadium. We conducted 41 interviews over a 19 month period.

Our findings indicate that radical innovation is characterized by safety, quality, and planning challenges which engender delays, non-conformity to specifications, and additional costs. Freyssinet was unsuccessful in transferring explicit and tacit knowledge because Azaran suffered from poor organizational absorptive capacity. Its high absorptive capacity allowed Freyssinet to adapt its operations to Azaran's tacit knowledge routines.

Our research is meaningful to the construction sector, an economically and socially significant sector in Iran that faces serious issues. Our study has practical implications for Iranian firms and for foreign firms operating in Iran. We contribute to strengthen the understanding of Iranian technology development by focusing on radical innovation standards, joint venture specific learning dyads, and complex knowledge transfer.

1. Introduction

> "I am positively impressed by the design of the roof added to the Imam Reza Stadium in Mashhad. If this technology is now available in Iran, it would be great if we reuse such technology to build the roof to the Azadi stadium in Tehran."
>
> Mahmoud Goudarzi, Minister of Youth Affairs and Sports, during a visit to the Imam Reza Stadium, May 2015

Emerging economies seek to transform and improve their domestic capabilities by acquiring new technology, by absorbing new knowledge, and by supporting innovation (Ponomariov & Toivanen, 2014). Inspired by the resource-based view of the firm (Barney, 1991), the knowledge-based view of the firm considers knowledge as firms' most important resource (Nonaka & Takeuchi, 1995; Grant, 1996; Spender, 1996). Thus, organizations seek to acquire knowledge to gain competitive advantage. Transferability of knowledge is critical for businesses engaged in international business exchange (Kogut & Zander, 1993), especially in developing nations endeavoring to develop their economies. Technology transfer between developed and developing countries has drawn interest, not only among scholars, but also among firms, policy makers, and financial institutions.

Several studies have been conducted on knowledge flows in many emerging economies. Some countries have greatly benefited from technology transfer. However, we note that others face more difficulties in their attempt to achieve technological catch up (Ponomariov & Toivanen, 2014). We believe, in line with Argote, McEvily, & Reagans (2003), that there is a need to further study how and why some factors influence organizational learning, especially in emerging countries facing obstacles to making technological progress.

Over the last two decades, Iran has made significant progress in science and technology development. As a developing country, Iran aims to capture knowledge, imitate best practices, learn from partners, innovate in various sectors, and consequently reduce the technological gaps between it and developed countries (Ghazinoory, Riahi, Azar, & Miremadi, 2014). Guided by a "national technology strategy" which combines both "national technology policy" and "firm technology

strategy" (Ghazinoory, Divsalar & Soofi, 2009), the next step for Iran will be to turn its traditional economy into a knowledge-based economy. There are a limited, but growing, number of empirical studies on Iranian technology development. We identified 39 articles on knowledge and organizational capabilities in various sectors in Iran (see Appendix 8), but technological knowledge, R&D, and innovation in Iran require further study (Ghazinoory & Ghazinouri, 2009). More specifically, investigations are needed into the challenges faced by firms operating in Iran and Iranian firms collaborating with external partners. Soofi & Ghazinoory (2011) argued that technological knowledge gained in one industry can benefit other industries, and highlighted positive spillovers from the chemicals, chemical products, rubber, and plastics industries to other related sectors.

The construction industry is becoming increasingly global (Ngowi, Pienaar, Talukhaba, & Mbachu, 2005). Technology transfer in this sector contributes to the technological development of emerging nations (van Egmond, 2012). Construction projects implemented in developing host countries are considered to be of potential benefit to the latter (Bessant & Francis, 2005). Local firms can learn advanced design and new construction technologies from foreign firms (Ling et al., 2005, 2009). Chatterji (1990) believes that emerging nations must implement policies that promote technology transfer between foreign and local firms so as to reinforce the capabilities of the latter and reduce their dependence on foreign businesses.

The construction industry is characterized by complicated projects with unique designs, complex environments and unpredictable working schemes, etc. (Ochieng & Price, 2009). Knowledge management in this sector is also considered to be very challenging: Difficulty to transfer knowledge (Osabutey, Williams, & Debrah, 2013), poor absorptive capacity (Gann, 2001; Eapen, 2012), a low degree of innovation (Barlow, 2000), and poor project performance (Rwelamila, 2012). Those issues are particularly prevalent in developing countries (Ling & Hoi, 2006; Zhi, 1995). Significant differences with developed countries have been well documented (Lizarralde, Tomiyoshi, Bourgault, Malo, & Cardosi, 2013).

However, we observe that the construction industry, one of the most significant sectors in Iran, did not appear to be benefitting from the diffusion of new technologies. This sector represents a large part of Iran's employment (3.9 million people) and investments (40% of total annual investment) (Tabassi, Ramli & Abu Bakar, 2012), and studying it is important because Iran is located on a very active seismic region which is part of the Alpine-Himalayan belt where 130 major earthquakes have occurred over recent centuries (Tabassi & Abu Bakar, 2009). Poor construction design, lack of standard materials, disorganized supervision, poor workmanship, and in fine the low quality of Iranian buildings have been identified as the causes of the large number of fatalities in past earthquakes. Jafari & Love (2013) argued that "quality failures remain an endemic problem within the construction industry" (p. 1244). We believe it is important to identify the barriers to technological change in the Iranian construction sector, and that answering such questions could help the construction sector close the existing technological gaps and consequently increase the resistance of future buildings to recurrent earthquakes.

To resist them better, and so avoid future tragedies, radical changes and innovations are needed in the Iranian construction sector. Abernathy & Clark (1985) define radical innovations as those that diverge from conventional technological trajectories and offer a high degree of technological newness to an industry, to its firms, and to their customers (Garcia & Calantone, 2002). While satisfying clients' wants and needs, firms also need to control the costs of radical innovation to remain competitive. Modular innovation (Clark, 1985; Henderson & Clark, 1990; Ethiraj & Levinthal, 2004) can contribute to cost and time saving by assigning the manufacturing of technological modules to external partners. Modular-based innovation requires the development of strategic alliances to obtain missing evidence about new knowledge and capabilities (Emden, Calantone, & Droge, 2006; Harrison, Hitt, Hoskisson, & Ireland, 2001; Chesbrough, 2003). A few studies have focused on transition economies seeking to develop alliances (Hitt, Ahlstrom, Dacin, Levitas, & Svobodina, 2004; Hitt, Dacin, Levitas, Arregle, & Borza, 2000; Young, Ahlstrom, Bruton, & Rubanik, 2011).

As a specific form of strategic alliance, joint ventures enable mutual and reciprocal learning, but developing a radical innovation within a joint venture may be very risky, since it combines the risks of failure of both the radical innovation and of the joint venture. These two types of risk are usually studied separately in the existing literature, so we need to develop knowledge in this area by studying the development of radical modular innovations within joint venture strategic alliances.

The assimilation of external knowledge is an important but insufficiently studied aspect of absorptive capacity (Cohen & Levinthal, 1990), which requires further study (Lane et al., 2006). Having access to external knowledge does not necessarily mean that an organization will assimilate that knowledge efficiently (Hamel, 1991). To increase the likelihood of efficient knowledge absorption in strategic alliances, the existing literature typically sees a "learning dyad" as involving firms playing the roles of 'teachers' and 'students' (Lane & Lubatkin, 1998). Our intention is to study two-way learning between two organizations playing these roles in joint ventures. We are particularly interested in studying two-way learning between firms that have different degrees of absorptive capacity.

In such two-way learning, we consider flows of both tacit and explicit knowledge to transfer entire bodies of knowledge. Joint ventures appear to be a relevant type of strategic alliance for the transfer and absorption of know-how embedded within organizations (Kandemir & Hult, 2004). The transfer of tacit and explicit knowledge is characterized by different challenges: articulation, transfer, learning, use of performance indicators, communication, 'stickiness', costs, path-dependency etc.

Our aim is to answer the following research question: *"What are the challenges of radical innovation, the barriers to technological change, and the difficulties involved in the transfer of tacit and explicit knowledge between two organizations with different degrees of absorptive capacity, which are involved in a joint venture in the Iranian construction sector?"*

The article proceeds as follows. We first present a theoretical framework related radical modular innovation, absorptive capacity, and consider the nature of knowledge transfer in alliances. We then discuss our case study method, and subsequently present an in-depth case study of the

construction of a new roof of the Mashhad stadium in Iran. We conclude by discussing the challenges of radical innovation, the barriers to technological change, and the difficulties of transferring tacit and explicit knowledge.

2. Theoretical background

Our theoretical background considers Iran's current technological development and the need for radical and modular innovation in its construction sector. A joint venture appears to be a relevant form of strategic alliance to develop mutual and reciprocal learning for transferring knowledge about radical innovations. More specifically, a joint venture can enhance the absorption of the tacit knowledge on both sides.

2.1. Alliances in radical modular innovation

Radical changes are needed to support the transition of Iran toward a knowledge-based economy, and to address quality failures in its construction sector, including the development of modular innovation, and of international strategic alliances.

2.1.1. Radical innovation

The improvement of the quality of building works requires a significant effort in innovation to support radical changes in construction. Studying the Iranian construction and housing industry, Akhlagh, Moradi, Mehdizade & Ahmadi (2013) argued that innovation strategies could impact its performance. They further argued that a proactive strategy has a positive impact on industry performance because it encourages flexibility, innovativeness, a greater perception of opportunities, and better anticipation of market changes.

Abernathy & Clark (1985) defined the difference between incremental and radical innovation. Radical innovations are characterized by a clear divergence from existing technological trajectories (Abernathy & Utterback, 1978; Anderson & Tushman, 1990). An innovation is considered as radical

according to the degree of its technological newness - newness to firms, to the industry and to the customers (Garcia & Calantone, 2002). The degree of such innovations may be evaluated by experts in the field, or by the producer (Dewar & Dutton, 1986; Kleinschmidt & Cooper, 1991; Veryzer, 1998). With the exception of Ghazinoory & Ghazinouri's (2009) study of nanotechnologies, radical innovation has been rarely studied in the Iranian context.

A firm that introduces a new product to the marketplace can be considered as a first mover (Schilling, 2008). Firms have to be market-oriented, and must aim to satisfy clients' wants and needs (Bennett & Cooper, 1981), and Sandberg (2008) argued that innovations are successful when they meet customers' needs, while Bennett & Cooper (1981) discussed the payment of a price premium for superior goods (e.g., usefulness, safety, availability, rarity). However, radical innovations are associated with high R&D costs, uncertainty, and the difficulty of setting standards (Schilling, 2008; O'Connor & DeMartino, 2006).

2.1.2. Modular Innovation

Radical innovation can be achieved by recombining existing technological modules (Saviotti, 1996; Saviotti, de Looze & Maupertuis, 2005). The design and reconfiguration of modules into a new hierarchy can offer the particular advantage of modular innovation, which consists of putting things together in new ways (Clark, 1985; Henderson & Clark, 1990; Ethiraj & Levinthal, 2004).

Firms have to manage the 'modularity' by which complex products are composed of smaller subsystems. Baldwin & Clark (2000) argued that modularity intends "to make complexity manageable; to enable parallel work; and to accommodate future uncertainty" (p. 175). While modular-in-use and modular-in-production are widely used, modularity-in-design appears to be more challenging for engineers (Baldwin & Clark, 2000). Product design (sometimes termed as industrial, surface or aesthetic design) offers the choice between different parameter settings in the design of new products (Baldwin & Clark, 2000).

A large number of studies have observed positive links between modularity and performance

(cost, flexibility and cycle time) (Jacobs, Vickery, & Droge, 2007; Worren, Moore, & Cardona, 2002; Lau et al., 2007). For instance, Schilling (2000) argued that modularization decreases the costs of coordination, production and time to market; and Langlois & Robertson (1992) find that organizations proceed through trial-and-error learning to pursue modular product innovation more quickly.

2.1.3. Alliance

Conducting internal modular innovation may not be sufficient to meet the tight deadlines required in some industries. Time constraints are too tight to allow organizations to innovate alone (Borys & Jemison, 1989; Dunning & Boyd, 1997; Hergert & Morris, 1988; Ireland, Hitt, & Vaidyanath, 2002; Nohria & Garcia-Pont, 1991). Consequently, innovation is pursued with external partners because of limits on resources and time (Lambe & Spekman, 1997; Swan & Allred, 2003). External knowledge is important for fostering firms' innovation and improving performance (Ireland, Hitt, & Vaidyanath, 2002; Zollo, Reuer, & Singh, 2002; Laursen & Salter, 2006). And developing alliances enable firms to find external sources of knowledge (Hamel et al., 1989; Khanna et al., 1998). Modular-based innovation mobilizes both internal and external stakeholders (von Hippel, 2005), and the latter may be involved in manufacturing specific modules which are then absorbed into the leading organization’s processes (Ethiraj & Levinthal, 2004).

Working with external stakeholders necessitates strategic alliances, which Dussauge & Garrette (2000) define as “an arrangement between two or more independent companies that choose to carry out a project or operate in a specific business area by coordinating the necessary skills and resources jointly rather than operating alone or merging their operations” (p. 99).

Knowledge management in strategic alliances has raised the interest of several scholars (Hamel, 1991; Kale et al., 2000; Mowery, Oxley, & Silverman, 1996). Organizations acquire and create relevant knowledge through engaging in strategic alliances (Dussauge, Garrette, & Mitchell, 2004; Grant, 1996; Spender, 1996; Mowery, Oxley, & Silverman, 1996; Reuer, Zollo, & Singh, 2002).

Strategic alliances are developed to access missing knowledge and capabilities (Emden, Calantone, & Droge, 2006; Harrison, Hitt, Hoskisson, & Ireland, 2001; Chesbrough, 2003), and their main purpose is to enable mutual and reciprocal learning (Grunwald & Kieser, 2007; Lubatkin, Florin, & Lane, 2001), so alliance modes must be chosen to facilitate the effective transfer of knowledge (Cantwell & Colombo, 2000; Gulati & Singh, 1998; Mowery, Oxley, & Silverman, 1996; Sampson, 2004; Collins & Hitt, 2006; Kale et al., 2000; Lane & Lubatkin, 1998). Strategic alliances are widely used in the global economy (Grant & Baden-Fuller, 2004; Anand & Khanna, 2000; Dyer, Kale, & Singh, 2004).

Additional learning can be obtained via other partnerships, such as R&D consortia, joint ventures, equity partnerships and other arrangements (Vermeulen & Barkema, 2001). As a very specific type of strategic alliance, a joint venture is a co-enterprise created by two or more firms owning variable shares. Joint ventures promote knowledge sharing and acquisition (Kogut, 1988; Diestre & Rajagopalan, 2012; Oxley & Wada, 2009). Ofori (1994) argues that foreign-local joint ventures provide good opportunities for technology transfer in the construction industry. Kaufmann & O'Neill (2007) found that cultural differences could pose an number of difficulties in international joint ventures, although Kogut & Singh (1988) originally argued that joint ventures between culturally distant countries constituted beneficial strategic alliances. Meier (2011) calls for further research into differences in knowledge management practices according to different cultural contexts.

There have been few studies on joint ventures in Iran, where there have been successful and less successful examples. Joint ventures only represent 6.66% of technology transfer methods in the biopharmaceutical industry (Madani et al., 2012). Jafari & Love (2013) studied a successful joint venture between two Iranian companies - MAPNA in charge of procurement and the Kayson Company in charge of engineering and construction - in constructing the Qom monorail in Iran. In an early study, Asheghian (1982) examined the differences between the efficiencies of Iranian firms and Iranian-American joint ventures, finding that the latter are the more efficient.

In contrast, Simiar (1983) studied the reasons why joint ventures in Iran fail, finding that failures were mainly due to human relations problems between Iranian and foreign partners, and to mistrust caused by the lack of congruence of partners' goals. Maroofi & Sadqi (2012) argued that inter-organizational trust was correlated with local firm's performance.

Consequently, there is a need for more empirical studies on joint ventures in Iran, especially into those between Iranian and foreign partners. We are particularly interested in studying the absorptive capacity of organizations involved in such alliances.

2.2. Absorptive capacity

The question of the absorption of knowledge was first introduced by Cohen & Levinthal (1990), who defined absorptive capacity as "the ability to recognize the value of new external information, assimilate it and apply it to commercial ends" (p. 128). Absorptive capacity can be considered at the individual, organizational, and multi-organizational levels (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998).

2.2.1. Individual absorptive capacity

Organizational learning routinely involves both individuals and groups (Nelson & Winter, 1982). Cohen & Levinthal (1990) argued that "due to the intangible nature of absorptive capacity, a firm may be reluctant to sacrifice current output as well as gains from specialization to permit its technical personnel to acquire the requisite breadth of knowledge that would permit absorption of knowledge from new domains" (p. 150). The ability of individuals to learn new knowledge depends on the extent of their existing knowledge (Ellis, 1965; Estes, 1970; Bower & Hilgard, 1981), and the strength of their intentions to learn from others (Kim, 1998).

Studying the construction sector in Mashhad, Tabassi & Abu Bakar (2009) argued that the low degree of construction workers' qualifications (which was is not surprising, since 73.5% of companies do not offer training programs) represented a problem for 53% of the companies, and led to financial

problems in 77% of projects and delays in 36.5% of them. In the construction sector, they argued that it was necessary to (1) identify employees' training needs (2) implement on-the-job training (via knowledge transfer from managers and supervisors to employees) and off-the-job training (delivered via external institutions); and (3) monitor the improvements (or their lack) attributable to such training (Tabassi & Abu Bakar, 2009). Also studying construction projects in Iran, Pournader, Tabassi & Baloh (2015) argued that empowerment and training have a significant impact on projects' performance.

However, there are different barriers to learning and to the increase of individuals' absorptive capacities, such as the associated costs and the required time for training. Employees' low basic education, turnover, and lack of motivation have also been identified as barriers to learning (Tabassi & Abu Bakar, 2009), so it is necessary to increase construction workers' motivation (via worker participation, recognition, and team belonging, etc.). The authors called for further research to study how firms could adapt to such environments, could stimulate workers' motivations and encourage them to follow up on training opportunities, and so how the individual absorptive capacity of firms' construction workers could be increased.

2.2.2. Organizational absorptive capacity

Cohen & Levinthal (1990) find that the absorptive capacity of individuals contributes to the development of organizational absorptive capacity, and that cumulative learning is central to the concept of absorptive capacity at the organizational level. They argue that "two related ideas are implicit in the notion that the ability to assimilate information is a function of the richness of the pre-existing knowledge structure: learning is cumulative, and learning performance is greatest when the object of learning is related to what is already known" (p. 131).

Since prior knowledge shapes the future accumulation of knowledge, we can consider absorptive capacity as being path dependent: consequently, path dependency conditions an organization's ability to perceive the technological potential of new technologies (Cohen & Levinthal, 1990; Zahra & George, 2002). Cohen & Levinthal (1990) argued that firms with high absorptive

capacities are more likely to be proactive and to be able to sense and capture external opportunities. Such learning directly affects the general efficiency of firms, cost reductions, process improvements, and product development performance (Dosi, 1988). From their empirical studies of 161 Iranian firms, Tavani, Sharifi, Soleimanof & Najmi (2013) argued that absorptive capacity has positive direct impacts on both financial and non-financial performance.

The acquisition and assimilation of new external knowledge then contributes to further strengthening absorptive capacity and the renewal of knowledge stocks (Jansen, Van Den Bosch & Volberda, 2005). The fact that absorptive capacity is path dependent encourages firms to continuously invest in R&D and to strengthen their absorptive capacity in the pursuit of future developments (Nekoei Moghaddam & Beheshti Far, 2007).

In Iran, for example, organizational learning appears to be efficient in several sectors such as health care (Bahadori, Hamouzadeh, Qodoosinejad & Yousefvand, 2012), manufacturing (Tohidi, Seyedaliakbar & Mandegari, 2012), the petroleum industry (Mousaei, Moghaddam & Ghadirian, 2006), services (Sharifirad, 2011), tourism (Ahmadi, Mirzaie Daryani & Bevrani, 2014), etc.

However, the effects of R&D spending on knowledge transfer in alliances are not always supported empirically. Schoenmakers & Duysters (2006) found that R&D spending had a low effect on knowledge transfer. Mowery et al. (1996) found no significant effect of R&D spending on the quality of the knowledge transfer process. In other words, the amount of money spent by organizations on R&D does not guarantee that they will benefit from knowledge transfers.

Given that the acquisition of external knowledge is costly, some organizations may neglect investing in their absorptive capacity (Cohen & Levinthal, 1989): Cohen & Levinthal (1990) argued that "a systematic and enduring neglect of technical opportunities may result from the effect of absorptive capacity on the organization's aspiration level when innovative activity (e.g., R&D) contributes to absorptive capacity, which is often the case in technologically progressive environments" (p. 137). Schilling (2002) argued that firms' lack of investment in learning leads to

them being locked out of new technologies (because of their low absorptive capacity), and can lead some organizations to invest less and thus learn less in a path dependent vicious circle.

Ghazinoory & Ghazinoori (2006) argued that the Iranian economy is guided by the government, or affiliated companies, or by public divisions under the supervision of religious leaders. The government and other public institution control 90% of the country's exports and 60% of its Gross National Product (Ghazinoory & Farazkish, 2010). The Iranian government shares part of the responsibility for the low absorptive capacity of its companies by maintaining low levels of R&D investment. While the number of researchers financed by the government has grown from 82 per million inhabitants to 1,500 per million between the 1980s and 2011 (Soofi & Ghazinoory, 2011), these numbers remain insufficient to support a change towards a knowledge-based economy in Iran.

The concept of absorptive capacity should not be considered solely from an internal perspective. The literature on firms' absorptive capacity focuses primarily on the effect of their existing capabilities on their ability to acquire external knowledge, but little has been said about the influence of external knowledge on firms' internal capabilities.

2.2.3. Multi-organizational absorptive capacity

The relational approach holds that firm's internal resources alone are insufficient for achieving competitive advantage, and that the latter can only be realized through inter-firm relationships (Dyer & Singh, 1998; Gomes Casseres, 1984; Smith, Carroll, & Ashford, 1995; Lavie, 2006). Dyer & Singh (1998) argued that learning alliances help firms achieve superior performance through knowledge transfer processes**.** Firms' absorptive capacities have been examined in the context of inter-firm alliances (Dyer & Singh, 1998; Lane & Lubatkin, 1998; Volberda, Foss, & Lyles, 2010). In keeping with the relational view, we consider that absorptive capacity is not limited to the development of the firm's internal knowledge, and that it involves the acquisition and exploitation of external knowledge, through inter-firm relationships or "learning dyads.

Absorptive capacity enables firms to acquire and exploit external knowledge (Bierly III, Damanpour, & Santoro, 2009) and to learn from their partners (Steensma & Lyles, 2000). The assimilation of external knowledge, as a dynamic organizational capability (Zahra & George, 2002), is central to the concept of absorptive capacity. Cohen & Levinthal (1990) argued that prior scientific and technical knowledge is necessary to identify and assimilate value from external knowledge. On that point, Hamel (1991) argues that obtaining access to skills and internalizing them are two separate abilities. Absorptive capacity of "host" firms consequently determines the effectiveness of technology transfer (Blalock & Simon, 2009; Girma, 2005; Spencer, 2008; Eapen, 2012). Surprisingly, the assimilation of knowledge as a learning process remains largely unexplored in the current literature (Lane et al., 2006).

The assimilation of valuable new knowledge requires transformative learning (Lane et al., 2006). Learning theory studies the transfer of knowledge across organizations (Doz, 1996), and we consider knowledge transfer to be a process that catalyzes knowledge-sharing routines, which Dyer & Singh (1998) define as “regular pattern[s] of inter-firm interactions that permit the transfer, recombination, or creation of specialized knowledge” (p. 665). Routines are developed between partners to gather, interpret and transfer information (Simonin, 1999).Dyer & Singh (1998) argued that absorptive capacity is specific to a given strategic alliance (pre-alliance knowledge, interaction routine between the partners, etc.). Lane & Lubatkin (1998) argued that “the ability of a firm to learn from another firm is jointly determined by the relative characteristics of the two firms” (p. 473). They studied the relative absorptive capacity of ‘student-teacher pairings’, also known as ‘learning dyads’ between teacher and student firms in strategic alliances. They argue that “a student firm’s absorptive capacity, its ability to value, assimilate, and apply new knowledge from a learning alliance partner, depends upon: (a) the specific type of new knowledge offered by the teacher firm; (b) the similarity between the student and the teacher firm’s compensation practices and organizational structures: and (c) the student firm’s familiarity with the teacher firm’s set of organizational problems” (Lane &

Lubatkin, 1998, p. 462). Consequently, learning is dyad-specific, meaning that the connection between two organizations create a unique setting (Revilla, Jesús, & Knoppen, 2013).

Effective learning dyads enable learning processes to take place, thanks to the partners' absorptive capacity (Knoppen, Sáenz, & Johnston, 2011). Both Lane & Lubatkin (1998) and Dyer & Singh (1998) examine one-way learning perspectives, and consider absorptive capacity as a learning dyad. What appears to be missing in the current literature is the study of the type of two-way learning between two organizations that characterizes strategic alliances.

There is a clear need to build complementarity between the knowledge sender and receiver teams prior to knowledge transfer (Abecassis-moedas & Mahmoud-jouini, 2008). The situation is significantly different when there is or is not overlapping prior knowledge in strategic alliances (Lubatkin, Florin & Lane, 2001). Consequently, a certain element of redundancy and cumulative knowledge is needed to facilitate overall understanding between the different organizations involved in knowledge sharing. Familiarity with being involved in strategic alliances encourages organizations to develop effective knowledge-sharing routines (Dyer & Singh, 1998).

Lane & Lubatkin (1998) argued that in order for the knowledge transfer to be successful, a degree of overlap between the partners' knowledge bases is necessary. The degree of dissimilarity between sets of specialized knowledge has an impact on knowledge creation and knowledge transfer. Overall, similarity between firms' knowledge bases facilitate knowledge transfer and absorption. The need for a degree of similarity should be taken into account in the choice of the technology to be transferred between the members of learning dyads. Ofori (1994) argued that the appropriate choice of technology must be made in order to ensure that the technology transfer is successful: it must be easy to use in the host country, it must be compatible with the technologies already used in the host firm, the development of the technology must contribute to the development of the host country and stimulate the latter's other activities.

D'Aspremont & Jacquemin (1988) and Kamien, Muller & Zang (1992) have argued that such

cooperation between organizations has certain deployment and maintenance costs (Henderson & Cockburn, 1996). Organizations need to consider whether the values of potential learning outcomes are greater than the costs of developing absorption capacity: small ventures may simply not have sufficient resources to invest in building their absorptive capacity (Dadfar, Dahlgaard, Brege, & Alamirhoor, 2013).

Further empirical study is needed into the absorptive capacities of Iranian firms - specifically in the case of joint ventures - which has not been undertaken in previous research. Overall, it is the challenges of assimilating external knowledge within joint ventures in Iran that have caught our attention. These can be even greater when organizations do not have the same degree of absorptive capacity (e.g. one organization invests strongly in R&D but the other is locked out of new technologies). In joint ventures, organizations are both teachers and students, and have to exchange both tacit and explicit knowledge routinely.

Kandemir & Hult (2004) argued that a joint venture is a specific form of strategic alliance that allows for the efficient absorption of technology, especially of the tacit knowledge and know-how embedded within organizations. Similarly, Mesquita, Anand, & Brush (2008) argued that among the most important conditions for learning dyads to gain a competitive advantage are their ability to acquire know-how, to develop specific assets and capabilities, and to design an ad hoc relational governance mechanism. Lane et al. (2006) argued that further research is needed to integrate absorptive capacity into a broader process-oriented perspective that can foster the efficient deployment of manufacturing know-how. This further research path appears to be particularly relevant in the Iranian context, where the management of tacit knowledge is crucial.

2.3. The nature of knowledge

There is an ongoing discussion about the distinction between explicit and tacit knowledge (Polanyi, 1967). “Knowledge that can be expressed in word and numbers only represents the tip of the iceberg of the entire body of knowledge” (Nonaka, 1994, p. 439). Nonaka & Takeuchi (1995)

developed the SECI model to illustrate the conversion of knowledge from one type to another to foster the creation of new knowledge.

2.3.1. Tacit and explicit knowledge

Looking at the tip of the iceberg, explicit knowledge (which is codified, documented, and formalized) is transmittable in systematic language modes (Steinmueller, 2000), such as patents, documents, memos, manuals, project reports, process diagrams, etc.. But tacit knowledge (knowledge that is not written, is not expressed in words and numbers) represents the larger part of the iceberg, and includes working solutions, job experience, learning, interaction between employees, expertise, intuition, skills, know-how, and memories.

We identified few papers that discussed the distinction between explicit and tacit knowledge in the Iranian context. Both types are needed, for instance, in knowledge transfer (Madani et al., 2012) and in the development of technological capabilities (Mohammadi, Elyasi, & Mohseni Kiasari, 2014). Explicit and tacit knowledge are two distinctive and complementary layers that contribute to the development of the Iranian National Innovation System (Chu et al., 2014).

Managing explicit knowledge is much easier than managing tacit knowledge, which is more context dependent and more personal in nature (Polanyi, 1962; Nonaka & Takeuchi, 1995), and likely to be deeply rooted in action, highly experiential, judgmental, difficult to fully document, ephemeral and transitory, making it very difficult to articulate what people know and to disseminate tacit knowledge (action or experience) (Nonaka, 1994). As tacitness, low codification and complexity increase, so do the barriers to knowledge transfer (Foss, Knudsen, & Montgomery, 1995; Kogut & Zander, 1993; Szulanski, 1996; Zollo & Winter, 2002; Lord & Ranft, 2000). For instance, it is difficult to use procedures to encourage implicit learning (Reber, 1993) or to use objective performance indicators to monitor such learning (Mcevily & Chakravarthy, 2002). Eriksson, Johanson, Majkgard & Sharma (1997) find that experiential knowledge is rarely taught, transferred or acquired, and Mowery & Oxley (1995) argue that managing the transfer of tacit knowledge requires a set of skills

that include learning and problem solving.

Technology transfer is important for Iran, where technology upgrades, new technology development and productivity improvements are needed (Madani et al., 2012). In studying Iranian SMEs, Nowshahr, Pool et al. (2014) argued that organizational cultures and traits have significant impacts on the employees' attitudes to knowledge sharing. Iranian firms face difficulties in managing tacit knowledge (Mohammadi et al., 2014).

According to Mansfield et al. (1981) and Teece (1986), the tacitness of knowledge hinders it from being communicated easily. Consequently, cognitive 'bridges' must be developed between people or organizational units (Noteboom, 2000). For instance, project management requires procedural routines and governance (Nonaka, 1994; Ahn, Lee, & Lee, 2006). Cognitive proximity consists of sharing technological capabilities in broad contexts (Noteboom, 2000).Tacitness increases the 'stickiness' of knowledge, which can also increase the costs of transferring it between organizations. Tacit knowledge tends to be idiosyncratic and path-dependent (Nelson & Winter, 1982; Teece, 1986, 2006; Zander & Kogut, 1995). Maintaining knowledge tacitness can create gaps (McEvily & Chakravarthy, 2002) between the knowledge embedded within people and observed performance outcomes (Polanyi, 1962; Nelson & Winter, 1982).

2.3.2. The SECI Model

Transferring knowledge from a sender to a receiver can be seen as an act of knowledge management (Leonard & Sensiper, 1998). Ordanini et al. (2008) present the key outcomes of knowledge management as knowledge creation (new knowledge), retention (embedded knowledge) and transfer (shared knowledge). Within projects, knowledge management is of increasing importance, and requires procedural and governance routines (Nonaka, 1994).

Rarely used in research in the Iranian context (Mehralian et al., 2014), we refer to the SECI model of knowledge management, a Japanese concept developed by Nonaka & Takeuchi (1995) that defines four processes of knowledge transfer: socialization (from tacit to tacit knowledge),

externalization (from tacit to explicit knowledge), combination (from explicit to explicit knowledge), and internalization (from explicit to tacit knowledge).Socialization suggests that tacit knowledge sharing often occurs in face-to-face relationships in which experiences can be shared. Socialization addresses the social aspect of knowledge in dialogue - it is a privileged learning mode between a trainee and a tutor. Socialization capabilities reflect a shared understanding of rules (Camerer & Vepsalainen, 1988; Volberda, 1998). According to Cohen & Levinthal (1990), socialization influences the ability to mobilize external knowledge. More specifically, it leads to the processes of exploiting new external knowledge (Adler & Kwon, 2002). Various tools can enhance socialization: communication enablers, video conferencing, e-learning, digital whiteboards, etc. (Jashapara, 2010). Related to socialization, Jafari, Akhavan & Nourizadeh (2013) argue that that individual and group tacit knowledge improve organizational performance.

Externalization captures the shift from tacit to explicit knowledge, via formalizations such as the writing of rules, procedures, instructions and communication (Khandwalla, 1977). Jansen et al. (2005) argued that "in contrast to making established behavior tacit through routinization, codification efforts through formalization enhance a unit's ability to transform and exploit new external knowledge, and to initiate the recombinations necessary for developing new competences and capabilities" (p. 1009). Different tools exist, such as yellow pages, software for collaboration, lessons-learned system, storytelling, etc. (Jashapara, 2010). Shafia, Vanani & Mirzaei (2011) found that tacit knowledge needs to be converted into explicit knowledge to prevent the loss of knowledge due to employee turnover.

Combination is a phenomenon that concerns the transfer of purely explicit knowledge, and is a basic function by which various kinds of documentary knowledge can be combined to create new knowledge. Project managers use this aspect of the SECI model to combine different explicit inputs from various functions (engineering, planning, supply chain, etc.) to produce integrated explicit documents. Combination is what is needed to transmit aggregated explicit knowledge. For instance, a product's nomenclature can be considered as the combination of several explicit descriptions of its

sub-parts. Different tools are available to conduct combination of explicit knowledge: Internet, e-mail, on-line network, wiki, knowledge management platforms, groupware, workflow, data mining, the Balanced Scorecard (Jashapara, 2010), etc.. The use of the Balanced Scorecard (R. S. Kaplan & Norton, 1992) has been very popular in Iranian empirical studies (Ghazinoory & Soofi, 2012; Akhavan et al., 2013; Darvish, Mohammadi, & Afsharpour, 2012).

Internalization is the shift from explicit to tacit knowledge. Individuals use explicit knowledge to acquire tacit knowledge through the process of learning by doing, internalizing explicit knowledge which then modifies their existing tacit knowledge. Internalization occurs when a person reads manufacturing procedures or safety rules, which then impacts their behavior as they absorb explicit knowledge. A few internalization techniques exist, such as case-based reasoning (Jashapara, 2010), which aims to use analogy to solve current problems that resemble past problems. By using past explicit knowledge from a data base, it is possible to proceed to a simple match and cut-and-paste job, allowing a solution (tacit knowledge) to be found faster, better, and more easily than if the process was started from scratch: such processes are used by help desks or call centers(Ranjbarfard, Aghdasi, Albadvi & Hassanzadeh, 2013).Our overall research objectives are to contribute to strengthening the existing body of literature about technology development in Iran by focusing on the challenges of radical innovation and radical technological change. In the context of the construction industry in Iran, we define radical innovation as an innovation: (1) which requires Iranian firms to expend their technological capabilities, (2) which diverges from the existing trajectory of the Iranian construction industry, and (3) which offers something new to the Iranian customers. We define radical technological change as a technological change: (1) which raises the level of Iranian construction workers' qualifications, (2) which closes the existing technological gap between Iran and developed countries, and (3) which significantly improves the design, materials, quality, and resistance of buildings.

Our research aims to study whether local firms develop the ability to learn from foreign partners. We focus on the construction sector because it is economically and socially significant,

because it faces difficulties (design, materials, quality, workforce, etc.) and because it requires radical changes. Our goal is to study how modular innovation develops across stakeholders. We specifically choose to study joint ventures, since this type of strategic alliance encourages reciprocal learning and the absorption of the tacit knowledge embedded within partner organizations. We aim to explore the assimilation of external knowledge via two-way learning within a joint venture, and to see how partner firms' specific absorptive capacities and knowledge natures can affect their knowledge sharing routines. Our final objective is to observe if the development of such joint ventures can have an impact on the construction sector - and eventually on related sectors.

Consequently, our study addresses the following research question: *"What are the challenges of radical innovation, the barriers to technological change, and the difficulties involved in the transfer of tacit and explicit knowledge between two organizations, with different degrees of absorptive capacity, which are involved in a joint venture in the Iranian construction sector?"*

Figure 1 illustrates our theoretical framework. It shows the two-way learning dyad between companies A and B, both involved in a joint venture. There are knowledge transfers of both tacit and explicit knowledge, as referred to in the SECI model, which are influenced by firms' specific knowledge (tacit vs. explicit) and their specific degrees of absorptive capacity (low vs. high). We want to find out if radical innovation can support radical changes in the construction sector in Iran via the collaboration of two partners.

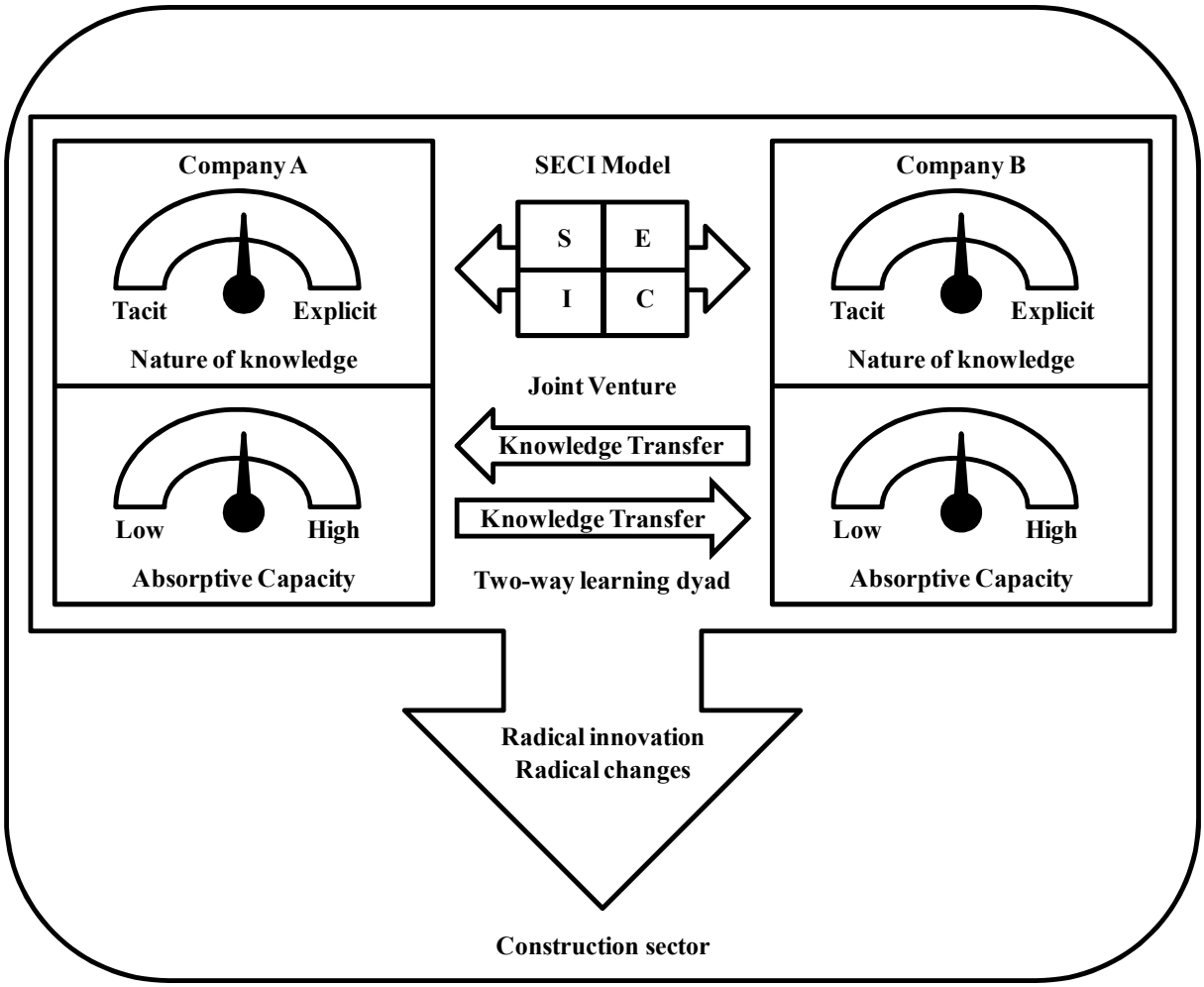


Figure 1: Conceptual framework

3. Methods

To answer our research question, our study investigated the challenges involved in radical innovation, the barriers to technological change, and the difficulties of transferring tacit and explicit knowledge, between Freyssinet and Azaran, firms with different degrees of absorptive capacity, which are involved in a joint venture to construct the roof of the new Imam Reza Stadium in Mashhad, Iran's second largest city (with four million inhabitants).

The Imam Reza Stadium was built 15 years ago. A multi-sports infrastructure, the existing uncovered stadium has a capacity of 25 000 seats. In 2010, Astân-e Ghods-e Razavi, a rich religious institution, was willing to add a roof to the existing stadium, to protect supporters from the snow, the

rain, and the sun, so allowing it to be used in all seasons. Through the intermediation of the Civil and Development Organization of Khorasan acting as a consultant, the contract for the project was awarded to Freyssinet and Azaran, working as a Franco-Iranian joint venture.

The French company Freyssinet is a worldwide leader in the specialist civil engineering sector, with an organizational culture that relies on core values of safety, excellence, and performance. To operate in Iran, Freyssinet was represented by a local Iranian firm E-Man Serve Co (a company specialized in energy management and engineering services). As the leader of the joint venture, Freyssinet was responsible for project management, the design of the roof, erection methods, supply and installation of cables, rods, membrane, and elastomeric bearings. Freyssinet outsourced the design of the roof (design, calculation, sequencing of the erection, etc.) to RFR, a German engineering company specialized in designing roof structures. Azaran is a large Iranian company specialized in manufacturing steel structures and equipment for various industrial projects. Azaran was in charge of manufacturing the steel elements in Tehran and then assembling the entire steel structure in Mashhad. Design studies for the project started in April 2012. The construction then involved up to 51 people from January 2014 to July 2015 (the latest estimated completion date for the project): 8 managers (2 from Freyssinet and 6 from Azaran), 6 supervisors (3 Freyssinet and 3 Azaran), and 30 workers (18 from Azaran, 6 welders, 6 crane drivers) plus 7 others from various subcontractors.

We collected data from various sources, and conducted 41 interviews over a 19 month period (November 2013 – May 2015). We chose this methodology for several reasons. First, conducting research in a real-life environment suited the exploratory nature of our study (Yin, 2003). Second, we wanted to observe both formal and informal processes within a joint venture to investigate technology transfer in Iran. Third, engineers and construction workers were more willing to answer questions during interviews than via online questionnaires. Fourth, the case study methodology allowed us to investigate the effects of decisions taken during the project so as to fully understand the phenomena under study (Golden, 1992; Yin, 2003; Dyer & Wilkins, 1991).

We selected this case study setting because of its richness (Neuman, 1997). We chose the ambitious project of building the Mashhad stadium's roof because it can be considered as a radical innovation of a type that has previously been mostly unexplored in Iran. The joint venture between Freyssinet and Azaran adopted a mixed and complex design using different highly technological materials, which again was something unique in Iran. We wanted to follow how a Franco-Iranian joint venture would handle a great construction project, and how two heterogeneous partners would handle inter-firm knowledge transfer.

The data was collected by the Freyssinet site manager located in Mashhad, who is the second author of this paper. His position gave him unlimited access to any data available, and the opportunity of conducting interviews with all the various stakeholders (members of the joint venture, client, suppliers, subcontractors, and consultants). Our intention was to collect data from all the organizations involved in the project so as to enrich our case study from their various perspectives

We adopted an inductive approach to explore this project, to gain a deep understanding of the issues, stakes, and influences involved (Strauss & Corbin, 1998). To capture the interactions between individuals and organizations, and to identify key dates when major decisions were made, we studied the knowledge transfer between Freyssinet and Azaran and their abilities to absorb transferred knowledge to solve the problems related to radical innovation. We did not need to use any retrospective approach in collecting our data, since the collection process started from the beginning of the construction phase. Collecting interview data and written reports at the time prevented us from distorting the facts of previous events. We used a semi-structured interview guide to explore events and people's involvement according to the time frame of the project as it developed.

We conducted a total of 41 interviews: fourteen with Freyssinet employees (concerning the installation of cables and membrane); twelve with Azaran staff (about manufacturing and assembling the steel structure); three with RFR (design); two with the Civil and Development Organization of Khorasan (consultants); two with E-Man Serve Co (Freyssinet's intermediary firm); two with Fatzer

(the cable supplier); two with Esmery Caron (which manufactured and supplied the membrane), two with ARCHITEXSTEEL (which installed the membrane); and one each with Astân-e Ghods-e Razavi (the client) and Janbaz construction (the local construction company).

We interviewed all the project managers, as well as a few construction workers without managerial functions. This wide selection of respondents from various fields increased the diversity of viewpoints represented and the chance of shedding light on events, networks, dates, places, and policies (Strauss & Corbin, 1998; Wengraf, 2001; Yin, 2003). We selected respondents with different levels of education: 2 with PhDs, 20 with engineering degrees, 7 with bachelor's degrees, 7 with high-school degrees, and 4 without degrees. The data was collected in French, English and Farsi by one researcher (the second author) over a 19 month period (November 2013 – May 2015) in various locations (Mashhad, Tehran, and Paris). The interviews lasted 35 minutes on average, and were recorded with the respondents' permission. (For further details, please see Appendix 9)

To achieve construct and internal validity, the researcher collected observations, documents on the sequencing of the assembly of elements, quality reports, press articles, meeting minutes, communications, e-mail exchanges, and reports to stakeholders, as well as our interviews with key informants. These were cross-checked via triangulation, which was very useful in comparing the perspectives of various stakeholders (Easton, 1995; Miles & Huberman, 1994).

The content analysis unit of the recorded data was single sentences (Insch, Moore, & Murphy, 1997). Coding, clustering, and reduction produced a code scheme, with six major categories (technology development, innovation, individual absorptive capacity, organizational absorptive capacity, multi-organizational absorptive capacity, and knowledge) and 43 codes influenced by literature in the field (Strauss & Corbin, 1998; Araujo, 1995; Coffey & Atkinson, 1996). The coding scheme is provided in Appendix 10. The use of multiple data sources and data coding ensured internal validity (Rosenthal & Rosnow, 1991; Dane, 1990).

4. The case of Imam Reza Stadium

4.1. Challenges of radical innovation

4.1.1. Radical roof design

The design and build of the Imam Reza Stadium roof can be considered a radical innovation project. If the norms of the Iranian construction industry trajectory had been followed, the roof would have been made of a steel structure covered by polycarbonate panels, as had originally been designed by Masoud Ziaee, the consultant architect. However, such design was not satisfactory: it would have been very heavy, used a lot of steel, and only partly covered the stands. This 'mainstream' design was not selected because it did not match the client's requirements, and because the existing concrete structure could not have supported its weight.

As a consequence, the company RFR developed a second, more radical, design - a 'cable-stayed stadium roof'. The design chosen for the roof of the stadium appeared to be radical - in the sense meant by Abernathy & Clark (1985) - in that it clearly diverged from the existing trajectory of the Iranian construction industry. The new roof design was radical in three ways: the newness of the materials used (a light weight high resistant durable and highly protective membrane, with high resistance steel cables), of the design mix (using different materials - steel profiles, cables and membrane), and of the construction methods (using temporary cables for stability and pre-tensioned cables in the roof plane). All three conditions of technological newness were met (Garcia & Calantone, 2002). Although benefitting from past experiences as a subcontractor on the construction of the Millennium stadium in Cardiff and the BC Place Stadium in Vancouver, this is the first time that Freyssinet had been the leader and main contractor on a stadium roof project. Such a cable-stayed stadium roof design was entirely new to the Iranian joint-venture partner Azaran, to the Iranian industry, and to the client Astân-e Ghods-e Razavi who approved the project.

The specific roof design offered a variety of advantages: it would cover all the stadium's seats,

it had a high degree of safety, and involved high-end aesthetic design. Aesthetic is very important in such large projects, because a stadium can become strongly associated with the city's image (famous examples include Barcelona's well-known Camp Nou stadium, the Millennium stadium in Cardiff, the Sydney Opera House, etc.). Figure 2 shows the design model, highlighting the two compression rings, one tension ring, and 18,000 square meters of white membrane: such a radical design had never previously been developed in Iran.

Figure 2: Imam Reza Stadium in May 2015

4.1.2. Initial design

The design is composed of 48 modules, each with a single axis of symmetry. Since the roof is built on top of an existing concrete stadium, it was necessary to assess the ability of the existing structure to support the additional weight of the roof (1500 tons of steel and 200 tons of cables). The roof was designed according to European standards to resist earthquakes: both the existing concrete stadium and the cabled stay roof are designed to withstand earthquakes of a magnitude of 10 on the Richter scale.

> *"To assess the ability of the entire structure to resist to wind, we performed several wind tunnel tests on 1:300 scale model. In our calculations of the resistance of the roof, RFR took into account Iranian data on the various meteorological phenomena such as rainfall, wind speed and snow fall duration and intensity. Last but not least, we took into consideration the difference between the highest and the lowest temperature. Temperature has a direct impact*

on the expansion and the contraction of various materials such as steel." Respondent 2

The use of different materials (steel, cables and membrane) in a mix material design requires that all elements are manufactured perfectly to match the drawings, and that good transverse communication is maintained between all parties concerned. By choosing this specific design, Freyssinet was setting the bar very high in terms of standards from the beginning, demanding special care in terms of safety, quality and planning.

> *"We [Freyssinet] are starting a project at high risk. Quality wise, if we are not able to manufacture the modules within a tolerance of one millimeter, we will not make it. From a planning perspective, if one or several stakeholders do not respect the precise sequencing of our eight-step process, we will not be able to deliver the roof on time. Safety will be extremely important. If a construction worker fell from 50 meters, we would be responsible for that. This aesthetic design requires a lot of work to be done at height, which is always a challenging issue in this kind of country where this is not in the culture."* Respondent 1

This quotation (from the Freyssinet project manager) identifies the challenges related to the radical nature of the design. Later in the project, we observed that Freyssinet and Azaran had different standards, exigencies, references, and habits regarding safety, quality, and planning issues.

4.1.3. Safety issues

Freyssinet faced significant difficulties in making the construction workers respect basic safety rules (wearing helmets, safety shoes, and harnesses when working at heights).

> *"For the first quarter of 2015, the major Projects Department had poor safety performance. Our lagging indicator has been in the red since February with 10 LTI [Lost Time Injuries] and it's increasing. The number of minor injury is exploding 39 since the beginning of the year. Linked to this, most of our projects are in the red concerning the leading indicators (Number of Safety inspections, number of unsafe conditions reported, number of safety training hours, BU manager Site Audit)."* Respondent 20

There were some additional issues that related to the Iranian context. Because of the current restrictions on imported goods in Iran, Freyssinet faced difficulties in accessing some specialized equipment and plant commonly used in the construction sector, without which there was an increased

risk of accidents. As an example, boom lifts aiming at allowing workers to work safely at any height above the ground were impossible to buy or rent in Iran, or even to import. As a consequence, Freyssinet had to use substitute solutions which were less secure and more time consuming.

> *"In my entire career, it's the first time I can't find a boom lift in a country. We have been using a crane as a substitute for a boom lift. Originally, a crane is designed to lift materials only. Now, we use cranes for lifting a man basket with construction workers inside. Although we designed a man basket especially for this application, you never reach the same level of safety as a dedicated boom lift offers many features to increase the safety of the workers, features that are not available on a standard crane. To lift and install a steel beam, the simultaneous coordination of three cranes is required: One for lifting the beam and two for lifting construction workers. What a challenging, unsecured, and time consuming solution!"*
> Respondent 23

4.1.4. Quality issues

Radical innovation is associated with difficulty in setting standards. For instance, the geometrical tolerance specified for all steel elements in the design drawings of a steel structure was +/- 1mm - but the tolerances to which the Azaran factory worked were closer to 1 cm. Consequently, as-built and previously manufactured steel elements often had to be repaired or adjusted as needed on site, when possible. Freyssinet clearly identified the quality of the steelwork that Azaran manufactured as a problem. However, when Freyssinet chose to partner with Azaran, it did not detect that the latter performed poor quality work. When Freyssinet discovered this problem, it took the company a long time to implement the corrective measures required to improve Azaran's work quality. The following points were included in the quality process: the geometry and dimensions, mechanical and chemical characteristics of the steel, welds, the assembly, and the anticorrosion protection. For instance, if the anticorrosion protection of the steel structure was provided by a paint system, several dimensions of the paint involved had to be verified: the number of layers, the coverage, the thickness, etc.

> *"What was the most problematic was the non-respect of the geometry of the elements. Azaran was manufacturing 10 ton steel beams in Tehran, which were then transported by*

trucks to Mashhad. In case of minor problems, on-site repairing was possible. However, sometimes, the geometry was not reparable. For instance, when the flanges were not welded at the correct angle, the beam could not be assembled to the adjacent one. In such cases, the entire 10 ton steel beam had to be returned to the Tehran factory, which implied two week delays and 1800 additional km of transportation." Respondent 18

4.1.5. Planning issues

The sequencing of operations is crucial in construction planning. The modules have to be manufactured in a certain order, as some can only be assembled after the previous modules have been built. The overall sequence was composed of eight steps: (1) Concrete beams and columns, (2) lower compression ring and bearings, (3) columns and upper compression ring, (4) spokes, hangers, tension ring, some arch ties, (5) tension ring closing, (6) plane bracings, (7) arches and remaining arch ties, (8) membrane. The project suffered because the sequencing was not adhered to in the planning and manufacturing. It seemed to be very difficult to get the right modules manufactured and delivered in the right order. This non-adherence to the planned sequence could have affected the stability of the entire structure, or simply stopped progress on the project until the missing element had been finished and installed.

"As a method engineer, I encourage people to care more about the sequencing. I observe that the installation of spokes was stopped a few times because the spokes were not supplied in the right order. There is a constant need for negotiating to get the right module at the right time; which is very tiring. And it is useless to send an e-mail clearly explaining what I need and when I need it. They [Azaran] do not care about sequencing." Respondent 12

4.1.6. Propositions

Quality, safety, and planning are the three prerequisites to meet the European standards associated with modular radical design successfully. The standards were certainly set far above what Iran's current technological development, culture, and habits can match. As Freyssinet and Azaran were involved in a joint venture, Freyssinet had no subordination power over Azaran, so there was little it could do to encourage or constrain Azaran to perform better. If Azaran had been a

subcontractor, Freyssinet could have obliged it to adhere more strictly to materials' specifications, manufacturing sequencing, and safety rules, or would have simply changed its subcontractor. Arrangements for responsibility sharing between Freyssinet and Azaran were clearly defined in the contract, but not adequate in regards to the partners' interests, priorities, involvements, and differences. Consequently, the type of alliance chosen by the partners (e.g. joint venture) - Freyssinet being the leader - was not the most appropriate. We can therefore argue that:

Proposition 1: Firms intending to work on projects in Iran should study the nation's technological development, be aware of the commonly accepted local standards in terms of quality, safety, and planning, and select the appropriate degree of technology radicalness.

Proposition 2: Firms seeking to work on projects in Iran should carefully select the partners they will be working with and the type of strategic alliance that best suits their needs and circumstances. A selection process of this kind requires, among others, a preliminary study on the engineering standards and habits in the host country's industry

Proposition 3: Iranian individuals and organizations were not prepared to handle the newness of the design, the small tolerances, and the precise sequencing, which led to planning, quality and safety issues.

4.2. Difficulties of transferring tacit and explicit knowledge

Facing issues related to safety, quality, and planning, Freyssinet first intended to use socialization, externalization, combination, and internalization to transfer knowledge to Azaran, which had a different knowledge base.

4.2.1. Different knowledge bases

Freyssinet and Azaran relied on different knowledge bases: Freyssinet utilized both tacit and explicit knowledge, but Azaran's knowledge base was mainly tacit. Freyssinet invested heavily in training its employees to internalize know-how related to post-tensioned concrete structures, project management, etc., and had built its competitive advantage on its specific know-how. Expertise is one of Freyssinet's core competences, and it sends supervisors to transfer tacit knowledge by guiding people in the use of the specialist equipment it has designed and manufactured. Freyssinet developed

tacit working solutions to solve daily problems.

Freyssinet makes significant efforts to codify its tacit knowledge. For instance, when finishing a project, the project manager writes a report to share his or her experiences, which is then available on the company's internal data bases. Anyone who is going to work on a similar project, using similar technologies, or operating in a similar country can get access to these reports that outline the problems faced and the solutions found, etc.. An excellent report also brings significant recognition to the author, who would then be considered as a key expert on such matters. In Freyssinet's organizational culture, people are encouraged to contact such key experts to benefit from their rich experiences. Freyssinet also pays great attention to formalizing knowledge in a written form: quality check lists, manuals on the use of Freyssinet equipment, procedures, risk assessments, method statement planning, technical notes, drawings, reports on sequencing, minutes of meetings, letters, monthly cost reports, Health Security Environment reports, etc.

In contrast, Azaran mostly relies on tacit knowledge. Knowledge is rarely written down - rather it is embedded in the organization and in people. Construction workers' habits, job experiences, intuitions, and memories are central. For instance, Azaran benefits from solid experience in welding. People use their own judgment to take decisions - but such decisions may not always be fully justified by facts. Azaran does not take much effort to codify its knowledge - the only explicit documents it uses are welding procedure specifications and manufacturing drawings. Based on the general concept drawings developed by RFR, Azaran's engineering office developed manufacturing drawings to be transferred to the production department. Azaran does not write procedures up systematically, and they are generally neglected, as are risk assessments, follow ups of indicators etc. Even under strong encouragement from Freyssinet, Azaran only wrote three procedures in the entire project, and these were of poor quality.

4.2.2. Socialization difficulties: Use of face-to-face safety training

Freyssinet aimed to transfer tacit knowledge to Azaran. In the contract, Azaran was responsible

for safety on the site, but did not pay much attention to it. As high safety standards were part of its organizational culture, Freyssinet started to get involved in explaining the importance of safety, and instigated the deployment of a life line around the stadium to secure workers working at heights. The original intent was to use socialization to demonstrate the importance of using the life line via face-to-face interactions, and explain risk assessment to all employees verbally. But we observed that Azaran's construction workers did not respect such tacit rules.

> *"Since Azaran workers do not want to learn and do not want to secure themselves, we have to use the reverse method of teaching: Penalties. When a worker is seen breaching the safety rules, the equivalent of one day's pay is deducted from his salary. The second time, the equivalent of two days' pay is deducted. The third time, the worker is excluded from the construction site. But my job did not allow me to spend all my time checking people. Consequently the two Health Safety Environment officers employed by Azaran and all supervisors were in charge of the control of safety rules. It did not work: Those guys never give any tickets to any workers who were at fault, and anyway Azaran would not deduct tickets from their wages… What about giving tickets to the people in charge of giving tickets if they ignore construction workers who do not respect safety rules?"* Respondent 29

4.2.3. Externalization difficulties: Use of lifting plans

Freyssinet faced an important safety issue due to its use of cranes. A crane is characterized by specific capabilities, which are normally formalized in an explicit form. The lift capacity varies according to the distance and the angle involved. Normally, a crane's capacity is explicitly written on the frame, and in its official documentation. However, in Iran, this explicit knowledge is lacking.

A first major incident occurred. As they did not rely on explicit knowledge, Azaran's crane drivers never used load charts (indicating the lift capacity at different distances), nor lifting plans (which covered routine and non-routine lifting activities) - such practices clearly put them at risk. One day, a crane driver tried to lift a heavy load located too far from the center of rotation of the crane, and the overload caused the crane's main boom to break. The construction site was lucky on this occasion - the incident only involved material losses. But as this crane was the only one on site with this

capacity, the project suffered from an additional two week delay, as well as the additional costs of repairing the crane.

On November 2nd 2014, there was a much closer drama. A rented crane that was supposed to be 120 tons started to lift an 8 ton beam. Suddenly, the crane started to tip over. Fortunately, the beam felt back on the ground, and after a few oscillations, the crane stabilized itself. Again, the project was lucky, as no injuries occurred. But the incident required further investigations. The crane - which was rented - had been recently repainted, and there was no longer any indication of its lift capacity: nor was technical documentation provided with the crane. The owner of the rented crane only told the driver that the lift capacity was 120 tons - if that was really true, the incident would have never occurred. The project supervisor searched for the brand of the crane by comparing it to pictures of cranes available on the internet, and finally came to the conclusion that the crane's lift capacity was 80 rather than 120 tons. Thus the crane driver's tacit knowledge was not reliable in this case.

> *"Most of the time, the lift capacity is not written on the machine and the official documentation of the crane is missing. You cannot rely on what the person renting you the crane tells you. You have two options. The first one is to ask an Iranian engineer who is familiar with the use of cranes to estimate its lift capacity, but this option is never actually seriously considered as safety cannot sensibly rely on the opinions of a single person. The second one is to conduct lifting tests and then issue an official Freyssinet certificate documenting the cane's real capacity. The failure of a crane always implies wide scale damage to equipment and potential fatalities."* Respondent 29

4.2.4. Combination difficulties: Use of e-mails

Freyssinet implemented an online platform to upload and download drawings, which was considered as a document repository. Freyssinet intended to use e-mails to transfer explicit knowledge to Azaran. While all Freyssinet employees had an access to their e-mail accounts, the Azaran managers and engineers only used their e-mail accounts for 5 minutes per day, while some others did not have accounts. Physical letters sent from one person to another are the most commonly used method for transferring explicit knowledge in the Iranian construction sector. Freyssinet intended to use e-mails

to send new drawings, procedures, information, schedules, requests to Azaran managers and engineers. In total, 210 e-mails were sent to Azaran - but we only found 70 low quality replies.

> *"I lost hope in using e-mails to communicate with Azaran. They do not read them, or do not take the content into account. I just keep sending e-mails to keep a written proof and traceability."* Respondent 11

4.2.5. Internalization difficulties: Use of case-based reasoning

Freyssinet used internalization to transform explicit knowledge into tacit knowledge to transfer to Azaran. For instance, Freyssinet provided a written procedure for the use of grout, noting the mix ratio (aggregates, water and grout) that should be adopted: the quantity of aggregate depended on the height above ground. However, Azaran employees always used the same quantities of aggregate whatever the use - they were unwilling to turn explicit knowledge properly into successful practice.

Other internalization attempts at Azaran turned out to be counterproductive. Freyssinet wanted to encourage Azaran to use case-based reasoning and to solve problems by analogy. For instance, Freyssinet explicitly wrote down that epoxy resin was approved when properly used to fill gaps between two beams. The problem was that Azaran workers did not apply the proper methods in using the resin, and did not think it was important to follow the recommendations of the epoxy supplier's Technical Datasheet strictly.

> *"I encouraged all supervisors to check if the use of the epoxy resin is relevant or not, and if it was properly used or not. I noticed in a few instances that the use of epoxy resin was relevant but was badly applied. Most of the time, the area of contact between the elements to be linked was insufficient. I also noticed that the use of epoxy resin was incorrect in some cases. Once they have discovered epoxy, Iranian construction workers want to use it to solve any problem. They need to understand that epoxy has a lower compressive strength than steel and its use must be checked and approved on a case-by-case basis depending on the load being transferred in the assembly"* Respondent 15

4.2.6. Freyssinet adapting to Azaran

Facing difficulties in making progress with Azaran, Freyssinet tried to adapt its procedures to

Azaran's through socialization and externalization.

Given the many quality difficulties that arose, on-site reworks were frequently required. Steel work was not part of Freyssinet's core competences, but their engineers were willing to learn how to do it through socialization. They were able to acquire practical techniques about how to modify the geometry of steel structures by heating (location of the area to be heated, duration, temperature, etc.). Thus Freyssinet acquired know-how related to the job of steel manufacturers, and this learning allowed it to better adapt the low quality steel structures that Azaran produced.

Similarly, Freyssinet learnt from commonly faced quality issues. Using the externalization process, such tacit learning enabled Freyssinet to write new quality check lists which took into account the weaknesses identified in the past. In particular, Freyssinet developed some ITP (inspections and test plans) to help Azaran to check the steel elements during the manufacturing process and to reach acceptable quality levels. Based on the experience of working with Azaran, Freyssinet also modified its manufacturing drawings so that the new drawings took Iranian tolerances into account. Additional margins were added to limit the on-site rework - for instance, the size of the holes in the steel structures were sometimes made larger (if structurally acceptable) to make sure it would be easier to assemble them to other elements.

4.2.7. Propositions

Referring to the distinction between explicit and tacit knowledge (Polanyi, 1967; Nonaka & Takeuchi, 1995), Freyssinet maintains a good balance between tacit and explicit knowledge, and benefits from a strong knowledge management culture: in contrast, Azaran mostly relies on tacit knowledge and does not codify its knowledge. These differences acted as a barrier to knowledge transfer, even though Freyssinet and Azaran intended to develop what Noteboom (2000) refers to as a cognitive bridge between the two organizations. Freyssinet attempted to transfer both explicit and tacit knowledge to Azaran. Contrary to the findings of existing literature (Foss, Knudsen, & Montgomery, 1995; Kogut & Zander, 1993; Szulanski, 1996; Zollo & Winter, 2002; Lord & Ranft, 2000), in this

case, the transfer of explicit knowledge did not prove any easier than transferring tacit knowledge.

Given its failure in using these four modes of transferring knowledge to Azaran, Freyssinet made significant efforts to adapt to Azaran. Thus we can say:

Proposition 4: Prior to knowledge transfer, both organizations need to assess that their knowledge bases are similar in term of tacit and explicit knowledge.

Proposition 5: When the firm that receives knowledge does not have a good balance between tacit and explicit knowledge, knowledge transfer may not occur and the learning dyad may fail.

Proposition 6: The lack of the technological capability to integrate tacit knowledge, the intuitive nature and imprecision of tacit knowledge, the lack of attention to written documents, and resistance to internalizing knowledge will hinder knowledge transfer.

Proposition 7: Facing an unsuccessful learning dyad, the teacher should adapt to the student by implementing a reverse learning dyad to best identify the main weaknesses and the common mistakes that need to be addressed.

4.3. Outcomes of radical innovation

Given the original choice of a radical innovation design, both Freyssinet and Azaran faced difficulties related to differences in their safety, planning, and quality standards. Freyssinet developed a system for transferring knowledge to Azaran to cope with such difficulties - but, unfortunately, such knowledge transfers appeared to be unsuccessful in many instances. Facing difficulties related both to innovation radicalness in Iran and to knowledge transfer, the entire project incurred major delays (300% of the initial planned time), additional costs (which involved financial losses for Azaran), and an as-built structure that was beyond the original design tolerances.

4.3.1. Delays

The construction was planned to last 6 months (January– June 2014) but took an additional 12 months - so that July 2015 is the latest forecast date for completing the project, and September 2015 for opening the stadium. There has been a great degree of uncertainty during the whole project. The

need for on-site repair works (quality issues), the non-respect of sequencing (planning issues), the strike by Azaran constructions workers (social issues), and the retention of goods at customs points (political issues) all engendered unexpected delays.

The employees were loyal to the project, although they lacked motivation because of delayed payments from Azaran - at one point, they went on strike when they had not been paid for two months. The economic sanctions against Iran appear to have been a barrier to technological changes: major difficulties in importing goods into Iran hindered the process of radical innovation, as urgently needed materials were blocked at customs.

> *"We [Architexsteel] are not responsible for the delay of the installation of the membrane. We are dependent on the willingness of the Iranian customs and the final client to allow the importation of the membrane produced by Esmery Caron. When I got to know what happened, I went crazy. We had to prove that such a membrane did not exist in Iran and that there was an absolute need for it to be imported. The supply of the membrane was blocked at the customs for a month and a half. Freyssinet even had to send samples of the membrane to be physically tested to demonstrate that it was not comparable to any membrane available on the Iranian market. Only once we proved that this membrane is of a better resistance than any other membranes could we finally get the membrane custom cleared."* Respondent 38

4.3.2. Design as-built

As the structure's original design geometry was compromised by the manufacturing and sequencing problems, the design as built differed significantly from the design as planned. So the entire design had to be checked again after the construction to ensure it could resist the various climatic and seismic conditions as originally planned. A few millimeters can represent a considerable added force and significantly modify the stability of the entire structure. Four surveyors were assigned to verify the structure's geometry. RFR provided inputs before, during, and after the project.

> *"When I [Project manager at RFR] get a call from a phone number starting by +98, I already know that we [RFR] will have to work again and again on the design of the Imam Reza Stadium roof. When I get a call, it means that they [Freyssinet] have a problem. We came up with a great design but I am not too sure it was a relevant choice to develop radical innovation*

in the Iranian context. The quality standards are not met and we constantly have to adapt the design. I am very sorry for Freyssinet, but we will have to charge them additional costs for our extra work all along the project." Respondent 21

4.3.3. Additional costs

Freyssinet had to pay extra fees to RFR due to the extra work needed on the project, and also faced extra costs related to renting equipment and paying salaries over the extra 12 months of the construction period. Freyssinet also faced difficulties in assembling the membrane because the design as built did not match the original plans, so additional modules of membrane were needed and were charged as supplementary costs. Freyssinet faced further difficulties in trying to rent some equipment in Iran, such as chain-blocks or pull-lifts, and so were forced to buy those items themselves.

Azaran also faced extra costs related to paying salaries and renting cranes for an extra 8 months, and also suffered financially from not respecting design quality standards. By April 2014 the Azaran quality manager admitted:

"We [Azaran] are facing difficulties in planning our raw materials needs. In the contract, we were supposed to use a certain amount of steel - but in practice, we are using 50% more. I am not in charge of the business, so let's say, it is not my problem." Respondent 18

In fine, the weight of the entire structure was 50% more than initially planned. This over consumption can be explained by various factors: The client increased the roof's coverage surface, the original structure needed to be strengthened by adding new steel elements, beam sections that were needed were not always available in Iran, which pushed Azaran to use larger diameters, and the weight of connections between the steel beams had been omitted from the original calculations. The extra cost of this 50% over-consumption of steel significantly affected Azaran's profitability so that, by December 2014, it faced financial losses. As a consequence, Azaran stopped fulfilling its initial contract with Freyssinet, and stopped providing equipment and construction workers for project activities.

4.3.4. Propositions

This attempt at conducting radical innovation in the Iranian construction sector suffered from major delays. Quality issues meant that the geometry of the final structure differs from the original design. The development of radical innovation in Iran appeared to be very costly compared to similar projects conducted in developed countries. There is a debate in the literature comparing the costs associated with radical innovation and those associated with modular innovation. The innovation in this case being both radical and modular, the final costs were much higher than those originally estimated. We complement Baldwin & Clark (2000) in arguing that the construction sector in Iran faces the dual challenge of modularity-in-design and modularity-in-production, so that:

Proposition 8: Planning uncertainty, design uncertainty, and profitability uncertainty are likely to be greater in developing countries than in developed countries.

Proposition 9: Radical and modular innovation are likely to be associated with extensive time delays, design modifications, and extra costs due to safety, quality, and planning issues, and because of unsuccessful knowledge transfers.

4.4. Barriers to technological change related to absorptive capacity

To further investigate why Azaran was unable to benefit from tacit and explicit knowledge transfer from Freyssinet, we investigated the inter-organizational absorptive capacity across the two partners, the organizational absorptive capacity of both Freyssinet and Azaran, and the individual absorptive capacities of their employees.

4.4.1. Inter-organizational absorptive capacity

Freyssinet had already worked with Azaran during the construction of the Javadieh stay cable bridge in 2010. In that project, Azaran was the main contractor and Freyssinet was only a subcontractor involved in the stay cable system and supplying bearings, expansion joints and dampers. The project was successful, which offers some evidence of an existing common understanding.

To develop inter-organizational absorptive capacity, effective communication is vital. Although initially frequent, communications between the joint venture partners generally remained weak. Daily meetings were organized at the beginning of the project with the intention of identifying likely problems and developing improvements related to quality, planning, and safety issues. However, Azaran was not committed to attending such meetings, and was unwilling to solve problems by implementing corrective actions, so similar problems were pointed out on a daily basis. Being considered a waste of time, the meetings stopped: when they restarted a month later, they again suffered from similar problems, and finally stopped being organized during the remainder of the project.

4.4.2. Organizational absorptive capacity

Freyssinet benefits from a strong innovative culture. Its founder, Eugène Freyssinet was the inventor of pre-stressed concrete, patented in 1928, which is a method for strengthening concrete structures by introducing steel reinforcement bars or cables into them. This technology is now commonly used in most bridges and large concrete constructions.

With its experience in managing challenging tasks, Freyssinet became specialists in complex civil engineering projects. To maintain its position at the edge of building technologies, it invested heavily in R&D. Freyssinet started operating in Iran via the agent E-Man Serve 10 years ago, and has completed multiple projects successfully. These past successes have strengthened its position in Iran, and it has now opened a local agency to enable it to better identify future Iranian business opportunities.

Azaran's core knowledge relates to manufacturing and assembling steel structures. Its activities mainly concern residential building, in which it chiefly uses basic geometries, with horizontal and vertical structure crossing at 90°, and assembled with large tolerances. Besides manufacturing, Azaran does not benefit from existing knowledge in using cables or membranes. Focused on this very narrow knowledge base, Azaran does not perceive the potential of new technologies that are too far from its

core activities, and so does not see the importance of learning new technologies. Azaran does not carry out any R&D activities, so is not involved in architectural innovation.

To summarize our findings, the radical innovation design that was chosen raised a number of challenges. The construction project faced safety, quality, and planning issues, which Freyssinet intended to address by transferring both explicit and tacit knowledge to Azaran, using socialization, externalization, combination, and internalization transfer modes. Unfortunately, Azaran did not fully benefit from knowledge transfer because of its poor organizational and individual absorptive capacity. Significant delays, a structure as-built that differs from the initial design, and additional costs can be considered as the consequential outcomes of this radical innovation project. Given the failure of its attempts to transfer knowledge to Azaran, Freyssinet effectively had to adapt to Azaran's practices, habits, and routines, using socialization and externalization, based on its high absorptive capacity (see Figure 3).

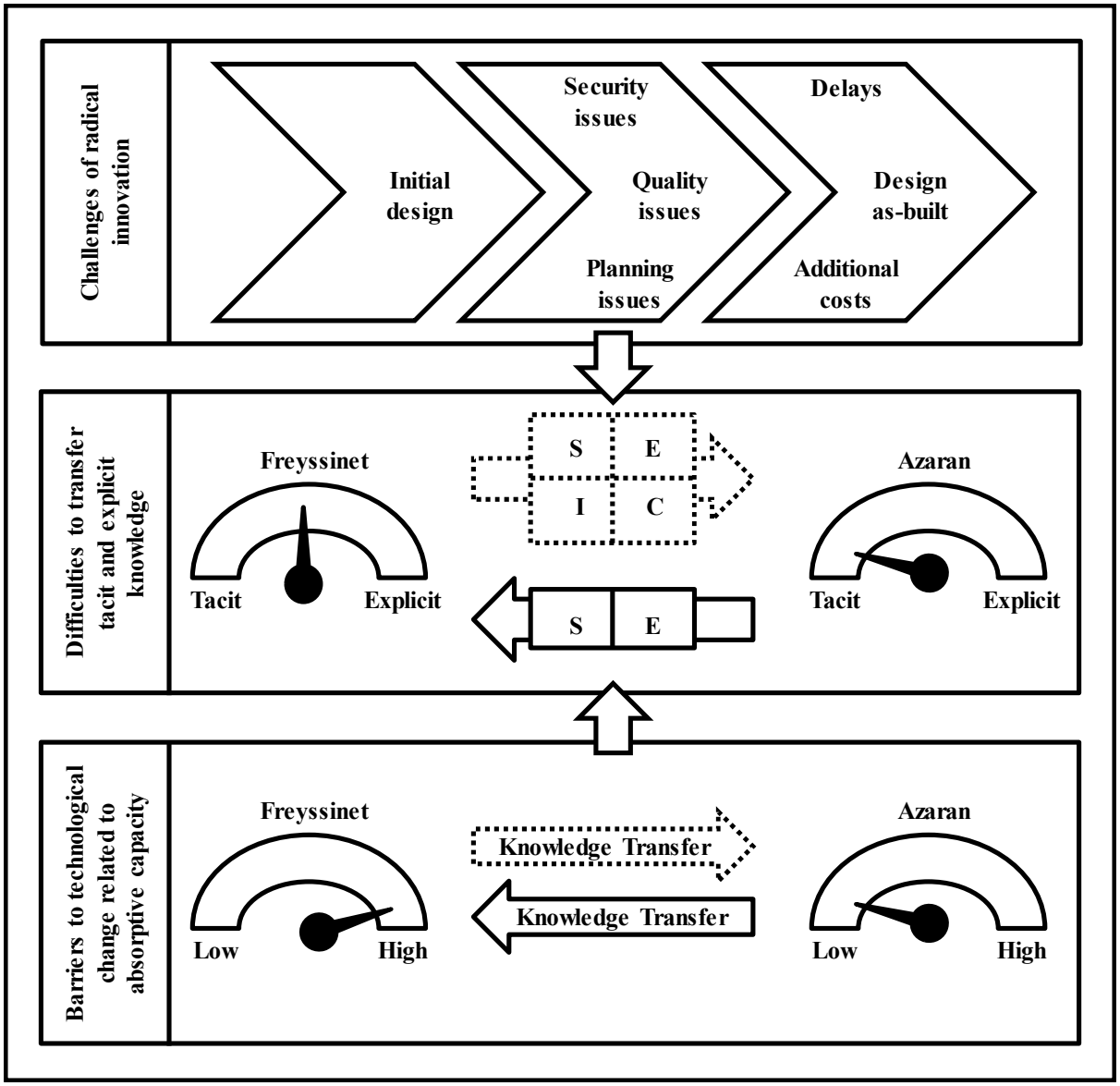


Figure 3: Challenges of radical innovation, difficulties to transfer knowledge, and barriers to technological change

5. Discussion

Kandemir & Hult (2004) argue that joint ventures enable the successful transfer and absorption of tacit knowledge. However, our research studied various knowledge transfers and transfer attempts between Freyssinet and Azaran, and our findings indicate that the transfer of both tacit and explicit knowledge between partners was difficult in this case. Our research contributes to strengthening existing empirical studies in Iranian settings (Madani et al., 2012; Mohammadi et al., 2014; Chu et al.,

2014; Pool et al., 2014; Mehralian et al., 2014; Jafari et al., 2013; Ghazinoory & Soofi, 2012; Akhavan et al., 2013; Darvish et al., 2012; Ranjbarfard et al., 2013). To understand Azaran's inability to integrate tacit and explicit knowledge and Freyssinet's ability to integrate tacit knowledge, we investigated the reasons for these differences in the light of absorptive capacity.

The specific involvement of Freyssinet and Azaran in a joint venture contributes to further investigate this specific type of strategic alliance in the Iranian context, again adding to the existing literature (Madani et al., 2012; Jafari & Love, 2013; Asheghian, 1982; Simiar, 1983). Freyssinet and Azaran had previously collaborated together in a strategic alliance - as recommended Lubatkin, Florin & Lane (2001) - but this partnership did not create much complementarity between the partners as knowledge senders and receivers. Their familiarity in being involved in a past strategic alliance did not encourage Azaran to benefit from knowledge-sharing routines.

We contribute to further investigating the "student-teacher pairing", as developed by Lane & Lubatkin (1998). We argue that a firm's characteristics have a significant impact on its ability to learn from another firm. Specifically, we studied the impact of the nature of knowledge (tacit vs. explicit), the differences between the partners (high vs. low absorptive capacity), and the familiarity between them (based on a shared past project) on Freyssinet's and Azaran's ability to learn from each other to solve problems. We first studied the 'unsuccessful learning dyad' by which Freyssinet attempted to teach Azaran, and then the 'reverse learning dyad' in which the teacher tried to adapt to the student.

Referring to Cohen & Levinthal's (1990) definition of absorptive capacity, Azaran was unable to recognize the value of the knowledge Freyssinet tried to transfer, to assimilate it by learning, and to apply it to its commercial ends. Focusing on assimilation capability, we observe that Azaran did not take advantage of the knowledge available from Freyssinet because of the absence of formal learning routines in its structure and nature. Contrary to the empirical findings in various Iranian sectors - such as health care, manufacturing, petroleum, services, and tourism (Bahadori et al., 2012; Tohidi et al., 2012; Mousaei et al., 2006; Sharifirad, 2011; Ahmadi et al., 2014) - our empirical study highlights

Azaran's difficulties in developing an organizational learning routine.

Azaran had benefitted from strong experience in manufacturing and assembling basic steel structures with basic geometry and loose tolerances for residential and commercial construction work. But beyond this core activity, Azaran did not perceive the importance of learning new technologies, or investing in R&D activities. Azaran neglected to invest in absorptive capacity and was even unable to pay its workers their wages on time. As Cohen & Levinthal (1990), we observe that the continued neglect of technical learning has a negative effect on innovation, and can be considered as a significant barrier to technological change. Suffering from a low absorptive capacity level, Azaran is locked out of new technologies, a finding that reflects those highlighted by Dadfar et al. (2013) in the Iranian pharmaceutical industry. As a follow up to Tabassi & Abu Bakar's (2009) study of the construction sector in Mashhad, our research supports the fact that one of the barriers to technological change is the low level of construction workers' qualifications due to Azaran's lack of organizational effort in investing in training. In our case, on-site training sessions were only provided rarely, and off-site training was clearly non-existent. The workforce was badly managed, had limited existing knowledge and was not encouraged to learn.

Considering absorptive capacity as a dynamic organizational capability (Zahra & George, 2002), Freyssinet benefitted from prior scientific and technical knowledge, and had knowledge-sharing routines in place via which its employees could learn from others easily. Investing heavily in R&D, Freyssinet had developed a certain degree of organizational cognition, learning and memory. It benefitted from a strong innovative culture, and accumulated and renewed its knowledge over time. It had successfully completed multiple complex civil engineering projects in Iran over the previous 10 years. Benefitting from strong path dependency, Freyssinet was able to sense and capture external opportunities abroad and to expend international efforts to support its long term growth and profitability. Such strong organizational absorptive capacity is based on its engineers benefitting from training throughout their careers, and having opportunities to transfer, recombine and create

specialized knowledge in various construction domains. However, Freyssinet was certainly over self-confident due to the experience it had accumulated in Iran and to its previous collaboration with Azaran. As a consequence they neglected to conduct thorough preliminary studies for this unique project and on the partner's specificities and failed to identify the risks inherent to this specific and unusually complex project. Thus:

Proposition 10: The choice of the joint venture as a specific strategic alliance did not ensure the good absorption of technological knowledge.

Proposition 11: The accumulation of experience in Iran and the familiarity between partners should not prevent foreign firms from conducting studies assessing the risks related to the uniqueness and requirements of a project – especially when this project presents technological radicalness - and from carefully examining the partners' knowledge bases and absorptive capacity levels.

Proposition 12: A heterogeneous degree of absorptive capacity between knowledge senders and receivers hinders technological change and does not offer locked out firms the possibility of entering new activities outside their existing knowledge bases.

Proposition 13: Firms' knowledge bases, their absorptive capacity levels, past experiences, and investment in individual training, condition their organizational capabilities to perceive the importance of learning new technologies, developing knowledge-sharing routines, and assimilating new knowledge.

6. Conclusion

Our paper contributes to further expand the body of literature on technology development in Iran. We studied the challenges of radical innovation, the difficulties of transferring tacit and explicit knowledge, and the barriers to technological change related to absorptive capacity.

We have examined the challenges related to radical innovation in a project co-developed by a Franco-Iranian joint venture, the most important of which related to planning, quality and safety. We believe that, before defining the degree of technology radicalness of the design, the local standards need to be characterized more realistically. When they are ignored, and when foreign firms try to

impose design newness, small tolerances, and precise sequencing, they risk facing major safety, quality, and planning issues. When associated with unsuccessful knowledge transfers, conducting radical innovation may lead to extensive time delays, design modifications, and extra costs which can affect the project's overall profitability. Although this project brought radical technology to a construction sector in need of significant change, we believe that the Iranian partners in this case were unable to capture that technology, so the construction of the stadium roof did not benefit the Iranian construction sector.

We studied the difficulties a local Iranian firm had in learning from foreign partners. The two firms had very different knowledge bases, which created additional difficulties for transferring knowledge. We argue that the local firm's neglect of the explicit knowledge that was available to it from its French partner, associated with its use of intuitive and imprecise tacit knowledge, negatively affected the knowledge transfer and success of the learning dyad.

Integrating knowledge requires the implementation of efficient routines. Knowledge appropriation and the capture of technology appear to be very important functions that should be encouraged and supported. However, we observe that being part of a joint venture with a partner willing to share its technology is insufficient to ensure long term knowledge development. When partner firms have different knowledge bases, different degrees of absorptive capacity, and different resources for individual training, technological growth is hindered and locked out firms cannot progress. In such cases - where the learning dyad is unsuccessful - the teacher may need to develop a reverse learning dyad to identify and address the student's main weaknesses and most common mistakes.

This article makes several theoretical and empirical contributions. Our main theoretical contributions concern the concept of absorptive capacity. First, we have been able to combine individual, organizational, and multi-organizational levels of absorptive capacity, which expands our understanding on the interrelation between those different levels. We argue that existing knowledge

plays a significant role in both individual and organizational learning, but not necessarily in learning across organizations when it comes to management of unique projects. We further argue that organizational learning strongly shapes individual learning and plays a key role in learning across organizations.

Second, we have specifically contributed to the relational approach to absorptive capacity (Dyer & Singh, 1998; Lane & Lubatkin, 1998), by considering two-way learning between two organizations involved in a learning dyad. We argue that while complementarity between the sender and receiver teams (e.g. a degree of knowledge overlap between the partners) is needed in a knowledge transfer “from teacher to student”, this complementarity is less important in a knowledge transfer “from student to teacher” because the teacher will be able to absorb the student's knowledge more easily.

Third, we further expend the literature bridging absorptive capacity and knowledge management. When the knowledge to be transferred is too complex, the knowledge transfer fails, not because of a lack of trust, nor because of a lack of familiarity between the partners, but because of the student firm's inability to learn from the teacher firm, which is caused (1) by the different degree of absorptive capacity (e.g. one organization invests strongly in R&D while the other is locked out of new technologies), and (2) by the different knowledge bases (e.g. one organization balances explicit and tacit knowledge while the other relies on tacit knowledge only).

Our main empirical contribution concerns the uniqueness of our case. First, we expand our understanding of the development of radical innovation in the specific case of a joint venture characterized by the challenge of defining common standards. Second, by referring to the dichotomy between tacit and explicit knowledge, we highlight the impact of knowledge transfer in trying to solve issues related to radical innovation. Third, we explore the joint impact of radical innovation and knowledge management issues on project management outcomes in the Iranian context.

The challenging project of developing radical innovation in the Iranian construction sector

holds several implications for practitioners. For foreign firms operating in Iran, we recommend that they: (1) analyze the commonly accepted local standards in term of quality, safety and planning carefully, (2) select the most appropriate design in term of technology radicalness, (3) select adequate partners which have similar knowledge bases in term of tacit and explicit knowledge, (4) choose the specific type of strategic alliance or contractual relationship carefully, (5) adapt to the local partner when facing difficulties in transferring knowledge, and (6) develop and monitor indicators in respect of planning, design, and profitability dimensions.

For Iranian firms, we recommend that they: (1) increase the codification of their knowledge, (2) reward people engaged in knowledge-sharing routines, (3) balance their tacit and explicit knowledge more carefully, (4) make efforts to benefit from successful learning dyads, (5) pay greater attention to quality, safety, and planning issues (because control of these three dimensions will increase the profitability of the final project, a concept that they have not yet understood) (6) endeavor to meet the standards conjointly developed with foreign partners, (7) carry out new activities beyond their existing ones, and (8) invest in R&D and workforce training.

As a single in-depth case study, our article has limitations in terms of generalization. However, our analysis identifies some important phenomena of the management of knowledge and innovation in the specific case of a Franco-Iranian joint venture and suggests paths for further research. First, we encourage future research to study radical innovation in the specific case of Iran, in different industries, and in different types of strategic alliance. Second, the management of both tacit and explicit knowledge in Iran requires further study to better understand people's resistance to explicit knowledge and the difficulties of knowledge transfer. Third, there is a need for empirical study to measure the impact of radical innovation on the key performance indicators of project management in emerging countries such as Iran. Fourth, the concept of the learning dyad is worth further exploration across different partnerships in specific strategic alliances.

Part 3: Customers Involvement and Firm Absorptive Capacity in Radical Innovation: The Case of Technological Spin-Offs

Abstract

This study investigates how the absorptive capacity of scientific spin-offs affects the benefits and challenges of customer involvement in the development of radical innovations. We conducted 36 interviews in 3 spin-offs over 4 years to collect data regarding customer involvement in the development of radical innovations. The findings show the importance of spin-offs developing both potential and realized absorptive capacities to internalize customer knowledge and technology emergence awareness and to simultaneously offset customers' lack of technical knowledge in formulating their needs. Both market and technical knowledge appeared to be important for spin-offs, and these were available from both customers and the parent research center. The findings' main implication is spin-offs need a blending capability to balance between (1) market and technical knowledge, (2) market-pull and technology-push approaches, (3) the involvement of customers and parent research centers, and (4) potential and realized absorptive capacities. This study contributes a conceptual framework on the blending capability of customer involvement in the development of radical innovations and a set of propositions for future research.

1. Introduction

The role of customers in new product development (NPD) is well documented in the innovation literature. Firms can gain from knowledge exchanges with customers (Fang, 2008; Noordhoff, Kyriakopoulos, Moorman, Pauwels, & Dellaert, 2011; Truong, Simmons, & Palmer, 2012), and these exchanges improve their capacity to research and develop new products that fit market needs (Coviello & Joseph, 2012) and increase the probability of financial returns (Danneels, 2007; Levinthal & March, 1993). This logic posits that firms should do their best to serve their customers (Govindarajan, Kopalle, & Danneels, 2011; O'Cass & Ngo, 2011).

Although customers may help companies bring incremental innovation in NPD, researchers have contended that involving customers may be ineffective or even detrimental to radical innovation, which is defined as a product that is new to both customers and the focal firm (Markides, 2006) and follows a substantially different technological trajectory than existing products in the same category (Abernathy, 1978; Anderson & Tushman, 1990).When a firm overemphasizes its focus on existing customers, it may not recognize opportunities that arise in emerging markets (Day, 1999). Similarly, some innovative firms limit their attention to their best customers, who tend to drive innovation along the path that best serves their own needs (Christensen, 1997; Christensen & Bower, 1996). Indeed, given the degree of newness and different technological trajectory, radical innovation is rarely driven by demand, and it may be counterintuitive to involve mainstream customers in the development of this type of innovation. On the basis of this assumption, Markides and Geroski (2005) posited that radical innovation often results from a supply-push process rather than a market-pull process for new technologies. Such an assumption is more relevant to Business to Consumers (B2C) rather than Business to Business (B2B) or Business to Research Centers (B2RC) markets, as these latter tend to embrace newness and possess sufficient advanced technical capabilities to co-innovate with suppliers.

However, several recent studies have suggested that under certain conditions, customer orientation can play an important role in the radical innovation process. Customers can foster the

innovation process if (a) the customer portfolio is diverse; (b) customers are willing to commit financial and technological resources; and (c) customers are involved early in the creation stage (Coviello & Joseph, 2012). The success of radical innovation may be more closely related to customer orientation in mainstream markets than in emerging markets (Govindarajan et al., 2011), in which the high risk of investing in radical innovation may satisfy mainstream customers offering immediate market opportunities, even though emerging customers constitute a smaller market that offers long-term opportunities. This current debate encourages us to investigate the conditions under which customer involvement can help firms develop or stall radical innovations.

We argue that, in the absence of organizational learning, customer involvement is not efficient at helping the firm develop radical innovations. In our study, successful customer involvement in the development of radical innovations is related not only to a firm's intrinsic qualities but also to its ability to develop an absorptive capacity to exploit new knowledge and increase the likelihood of commercialization success. Consequently, we use Zahra and George's (2002) notion of both potential and realized absorptive capacity to investigate how acquiring knowledge from customers can either facilitate or hinder a firm's quest for radical innovation.

This research's contribution to the area of customer involvement in the radical innovation process is twofold. First, our study provides further insight into the dynamics of customer participation in the NPD process and the marketing capabilities of young firms seeking to manage customer involvement, both identified as major gaps in the literature (Coviello & Joseph, 2012), by examining how the level of customer involvement at different stages has improved or impeded the process of developing radical innovations within young technological firms. Specifically, we examine the firm's role of absorptive capacity in internalizing the knowledge gained from customers. Past studies show that customers can bring valuable insights for product creation and development, but few have addressed the challenge of a firm's capacity to internalize these insights from the perspective of absorptive capacity.

Second, we focus on a particular type of new ventures which has received limited attention in the past, namely scientific spin-offs. Spin-offs are relatively common in science-based high-technology industries (e.g., biotechnologies, Arts, Appio, & Van Looy, 2013; c.f. Capaldo Lavie, & Messeni Petruzzelli, 2014), and a growing number of public institutions, including universities and scientific institutions, establish spin-offs to market their scientific knowledge (Fini, Fu, Mathisen, Rasmussen, & Wright, 2016). Spin-offs' salient impacts make them a relevant study subject because of their strong influence on the economy (Bolzani et al., 2015; O'Shea, Chugh, & Allen, 2008; Scaringella & Chanaron, 2016; Vincett, 2010), society (O'Shea et al., 2008; Scaringella & Chanaron, 2016), and future entrepreneurial initiatives (Ciuchta, Gong, Miner, Letwin, & Sadler, 2016).

Scientific spin-offs are also different from regular start-ups or SMEs. Spin-offs rely on different knowledge bases (Colombo & Piva, 2012), have access to unique capabilities from parent institutions (Basu, Sahaym, Howard, & Boeker, 2015; Chatterji, 2009; Klepper, 2001), benefit from learning in dyadic relationships (Agarwal, Echambadi, Franco, & Sarkar, 2004; Chatterji, 2009; Phillips, 2002), enjoy privileged access to "local searches" (Rosenkopf & Almeida, 2003), benefit from parental heritage (Agarwal et al., 2004; Basu et al., 2015; Klepper & Sleeper, 2005), achieve superior potential absorptive capacity (Colombo & Piva, 2012), may suffer from transmitted inertia (Ferriani, , Garnsey, & Lorenzoni, 2012), are rather long-term oriented (Fini et al., 2016), do not necessarily rely on customer involvement (Fini et al., 2016), have a better survival rate (Agarwal et al., 2004; Basu et al., 2015; Bolzani, Fini, Grimaldi, & Sobrero, 2015; Fackler, Schnabel, & Schmucker, 2016; Phillips, 2002; Smith & Ho, 2006; Stinchcombe, 1965), and achieve superior performance (Chatterji, 2009). Given these major differences, studying potential and realized absorptive capacities in the specific case of spin-offs would be a valuable contribution to the existing literature.

Among scientific spin-offs, there are major differences between spin-offs that may emerge from: research centers, universities, and corporations. Each category of spinoff is differently able to use technology and to identify and exploit opportunities. The commercialization of technologies, the

trajectories of growth, and the performance are category specific, and Fini and Toschi (2015) emphasized the differences between academic and private start-ups in term of organizational blueprints and cognitive abilities.

Despite new ventures' importance in these high-technology industries, our literature review has identified little existing research concerning them emerging from research centers; however, they deserve more attention from scholars because of their specificities. Scientific institutions' technological spin-offs are distinctive from other types of spin-offs because they often spring from the parent institution's intention to market an advanced technology. Thus, these spin-offs primarily focus on technology-push processes and are less inclined to possess and develop customer management skills. Our findings focus on science-based spin-offs emerging from research centers and are not generalizable to university spin-offs or corporate spin-offs.

In the following sections, we first introduce the theoretical background and then describe the qualitative method used to investigate three spin-offs created from a research center in the Grenoble area. Finally, we analyze and discuss the benefits and challenges of customer involvement in radical innovation and the duality of market and technology absorptive capacity for spin-offs.

2. Theoretical Background

We study customer involvement in a spin-off's pursuit of radical innovation from the lens of absorptive capacity by first discussing the distinction between potential and realized absorptive capacity according to Zahra and George (2002) in section 2.1, followed by a review of customer involvement's benefits and challenges in the development of radical innovation across acquisition in section 2.2, assimilation in section 2.3, transformation in section 2.4, and exploitation in section 2.5 in line with the four dimensions of absorptive capacity. Finally, we consider absorptive capacity in the particular case of technological spin-offs (see section 2.6) using existing works solely related to

university spin-offs, which are far more abundant than existing researches conducted in research centers (section 2.7).

2.1. Potential and realized absorptive capacity

Zahra and George (2002) argued that it is important to distinguish potential from realized absorptive capacity. Potential absorptive capacity characterizes the effort made by a firm to identify and assimilate external knowledge; realized absorptive capacity characterizes how knowledge is transformed and exploited.

Potential absorptive capacity, which consists of knowledge recognition and assimilation, appears as a popular possibility for firms to explore new sources of knowledge (Lau & Lo, 2015) and depends on prior knowledge, specific decision process, availability of slack resources, and openness to the external environment (Burcharth, Lettl, & Ulhøi, 2015). Conversely, realized absorptive capacity has attracted limited attention from scholars, although it can make newly acquired knowledge valuable for enhancing commercial ends (Lau & Lo, 2015). External openness and prior knowledge are important antecedents to realized absorptive capacity (Burcharth et al., 2015), and therefore, according to Volberda, Foss, & Lyles (2010), commercialization requires further attention.

Potential and realized absorptive capacity have been considered as complementary (Ebers & Maurer, 2014; Xia 2013), distinct (Cepeda-Carrion et al., 2012; Ebers & Maurer, 2014), and even as opposites (Jansen, Van Den Bosch, & Volberda, 2005; Martini, Neirotti, & Appio, 2015).

Yet, *the complementary view* contradicts the *distinctive view*. Cepeda-Carrion et al. (2012) distinguished potential from realized absorptive capacity and in studying the positive effect of absorptive capacity on innovativeness in information systems in 286 large Spanish firms, they argued that both concepts are distinct and cannot be taken together. They further argued that "while potential absorptive capacity requires change, flexibility and creativity, realized absorptive capacity requires

order, control and stability" (p. 111) and suggested potential and realized absorptive capacity should be balanced to benefit from innovation.

Further contradicting the complementary view and the distinctive view, Jansen et al. (2005) argued a negative link exists between potential and realized absorptive capacities. They found that focusing on potential absorptive capacity by acquiring and assimilating external knowledge may be counterproductive to firms because the costs incurred would prevent fully capturing value during the exploitation stage.

This debate begs for further investigation of the complementarity, the distinction, and/or the opposition between potential and realized absorptive capacities, and Martini et al. (2015) have encouraged further studies using a qualitative lens to better understand how external knowledge dynamics affect firms. Filippini, Güttel, Neirotti, and Nosella (2012) also supported further qualitative research to better understand "how firms absorb knowledge from their environment" (p. 64).

Firms' available external knowledge can either be market knowledge, technological knowledge, or both. Rakthin, Calantone, and Wang (2015) compared the role of market orientation to absorptive capacity in line with Zahra and George's (2002) distinction between potential and realized absorptive capacities. Rakthin et al. argued there are a limited number of studies considering market-related knowledge, as compared to technological knowledge, in absorptive capacity. Considering this, we focus on both market and technological customer involvement knowledge that help firms either develop or stall radical innovations from the lens of potential and realized absorptive capacities.

The literature contains extensive discussions of the customer's role in NPD (Brockhoff, 1998; von Hippel, 1986; von Hippel, 1988a). In earlier literature, users provided input only to qualify their needs (Burns & Stalker, 1961; Myers & Marquis, 1969; Rothwell, 1977), but recently, involvement of customers in NPD has become an important area of research (Alam, 2002; Martin & Horne, 1995; Simmons, Palmer, & Truong, 2013) focusing on this involvement's advantages and disadvantages. In the context of radical innovation, strong potential and realized absorptive capacity can leverage these

benefits (Jansen et al., 2005; Zahra & George, 2002). Only few studies distinguish potential from realized absorptive capacities from a customer involvement perspective.

2.2. The acquisition of customers' knowledge

Zahra and George (2002) argued the acquisition of external knowledge influences a firm's potential absorptive capacity in intensity, speed, and direction. New external knowledge acquisition contributes to strengthening potential absorptive capacity and knowledge stock renewal (Jansen et al., 2005), and it has been demonstrated that firms with greater absorptive capacity are more likely to be proactive and able to sense and capture external knowledge (Filippini et al., 2012; Koza & Lewin, 1998; Lane, Koka, & Pathak, 2006) because external knowledge tends to be easier to integrate than internal knowledge (Denicolai, Ramirez, & Tidd, 2016).

External knowledge can be technological or market based. However, a view that opposes the technology-push perspective suggests "the firm should be 'market oriented' and the satisfaction of customer needs is key to corporate profits" (Bennett & Cooper, 1981, p. 52). From this perspective, a firm must acquire market knowledge to innovate and develop successful products. The importance of end users has been supported by McAdam, Miller, and McAdam (2016), and user-driven innovation models support has come from K. Miller, McAdam, Moffett, Alexander, and Puthusserry (2016).

New external knowledge can come from specific customers, named lead users, who are involved during the idea-generation stage (von Hippel, 1978). Consequently, lead users involved from the beginning of the development process may increase the likelihood of success (von Hippel, 2001). Because they anticipate the market's future needs by seeking a solution to its current needs (von Hippel, 1986). This allows the firm to identify the need of a small group before it becomes a need for the mainstream market and to benefit from having their needs satisfied (von Hippel, 1988b; von Hippel, 1989).

User insights may also differ among users who are categorized as ordinary, advanced, or professional (Kristensson, Gustafsson, & Archer, 2004). These *technology lead users* foresee technological opportunities based on their experience (Lettl, Herstatt, & Gemuenden, 2006). Consequently, customer involvement can lead to the development of successful new products because it allows the identification of the right direction to follow (Alam, 2006; Cooper, 2001; Gruner & Homburg, 2000; Lilien, Morrison, Searls, Sonnack, & von Hippel, 2002) and increases the firm's internal innovation capabilities (Cooper, 1980; Murphy & Kumar, 1997; Voss, 1985).

Specifically, because lead users have needs beyond what the current best version of a particular product can satisfy, they can help firms identify opportunities for breakthrough innovations (Condit, 1994; Coyne, 2000; Herstatt & von Hippel, 1993; Lilien et al., 2002; Lüthje & Herstatt, 2005; von Hippel, 1986; von Hippel, Thomke, & Sonnack, 2000), and involving advanced customers in NPD reduces the risk of market mismatch for a radical innovation (Cooper, 1980; Murphy & Kumar, 1997; Voss, 1985).

Although customers are able to design their own products (von Hippel, 1988), they may not be fully aware of a new technology's capabilities (Lynn, Morone, & Paulson, 1996). Additionally, user-inventors may lack some competencies to guide product development to the market (Lettl et al., 2006). As a consequence, the lack of knowledge and competencies may lead to an unduly specific design and excessive consumption of time. More specifically, integrating customer needs into the process of NPD is time consuming (Cusumano & Selby, 1995; Dahan & Hauser, 2002) and thus represents a major challenge for firms (Tidd, Bessant, & Pavitt, 2001).

2.3. The assimilation of customers' knowledge

In light of Zahra and George's (2002) potential absorptive capacity, we consider the assimilation of customer knowledge and propose the shift from external knowledge acquisition to assimilation requires organizations to be able to learn.

Levinthal and March (1993) argued that organizations learn through simplification and specialization. Therefore, firms should avoid three types of myopia: the tendency to overlook distant times, distant places, and failures that strongly matter in the assimilation of external knowledge. However, it is extremely challenging for firms to look at the long run and to focus on short-term benefits while assimilating customers' knowledge. Levinthal and March presented organizational learning's limitations and challenges, such as the balance of exploration and exploitation, which matter particularly in our research in radical innovation.

Furthermore, knowledge assimilation may vary across the different relationship forms between sellers and buyers in NPD. There are three possible forms: a bilateral approach (i.e., the mutual exchange of information), a buyer-guided approach, or a seller-guided approach (in which no mutual exchange occurs). Companies may benefit from cultivating portfolios that include different types of relationships (Athaide & Klink, 2009) in which organizations assimilate knowledge and learn from others in "student-teacher pairing" (cf. learning dyad of Lane & Lubatkin, 1998).

Knowledge transfer and learning and knowledge assimilation have been studied in the context of clusters (Phene & Tallman, 2002) and regional innovation systems (Lau & Lo, 2015). Phene, Fladmoe-Lindquist, and Marsh (2006) argued that the exploration of technologically and geographically distant knowledge together do not lead to breakthrough innovations. Scaringella and Burtschell (2015) reasoned this is related to the concept of absorptive capacity because getting access to distant knowledge that differs from the firm's own knowledge base does not guarantee the acquisition, absorption, and use needed to conduct breakthrough innovations.

In the assimilation of knowledge, the impact of not only geographical but also cognitive, organizational, social, and institutional proximity on learning and innovation matters (Boschma, 2005). Geographical proximity may not be sufficient to ensure learning; therefore, Boschma (2005) encouraged firms to consider the cognitive proximity as it is related to absorptive capacity because the cognitive base of people and organizations has an impact on learning ability.

Additionally, firms must be aware when assimilating customer needs that customers may have a restrictive vision of needs outside their personal scope and be unable to articulate them, especially in terms of technological feasibility and changes that occur during NPD; this creates a mismatch between the product and the actual needs (Bennett & Cooper, 1981). Users may have difficulties explicitly communicating their needs and wants because of knowledge stickiness (Franke & Piller, 2004) "the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker" (von Hippel, 1994, p. 430).

Finally, the development of an efficient knowledge transfer process is needed to assimilate knowledge from customers. Corso, Martini, and Paolucci (2001) conducted an interpretative review of the importance of knowledge sharing and transfer across organizational boundaries and encouraged further studies on the process of assimilation, creation, transfer, and storage, and retrieval of knowledge. As mentioned, customer knowledge assimilation can take place by direct contact with customers; however, it can also be vicarious (Baum, Li, and Usher, 2000).

2.4. The transformation of customer's knowledge

Shifting from the potential to the realized absorptive capacity, Zahra and George (2002) argued that transformation is the capacity to handle compositeness between existing knowledge and new knowledge.

The complementarity between external search and internal knowledge have been studied by Martini et al. (2015), who stressed the importance of the recombination process in which external knowledge is effectively integrated into internal knowledge by breaking down functional silos. However, Capaldo et al. (2014) discussed the potential mismatch between external knowledge and internal knowledge bases and maintained that "Even if external knowledge is well established in the market, its absorption remains challenging if the inventors lack a related knowledge base." (p. 25)

Overall, the findings regarding the transformation of knowledge—the integration of new knowledge into an existing knowledge base may be contradictory and need further study. Ardito, Messeni Petruzzelli, and Albino (2015) posited there is a need to study "how firms should balance the use of new and old knowledge on introducing innovative products" (p. 128).

2.5. The exploitation of customer's knowledge

Exploitation, applying knowledge to commercial ends, is the second aspect of realized absorptive capacity (Zahra & George, 2002).

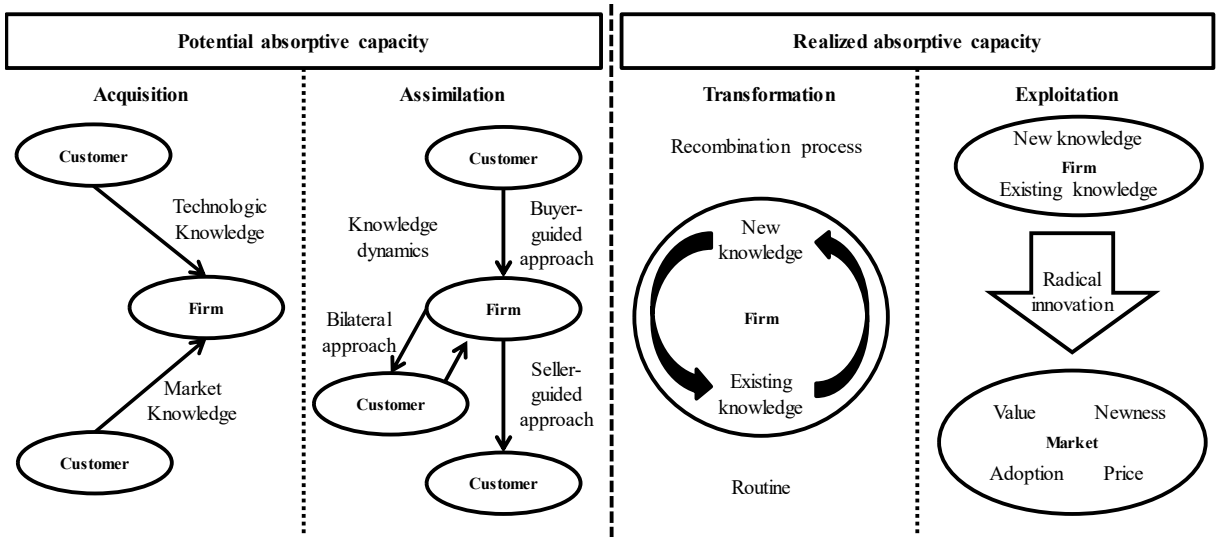
In the commercialization stage, uniqueness matters: a product must have both newness and value (Ekvall, 1997). Bennett and Cooper (1981) defined product value as the following, "A business orientation that recognizes that product value is key to profits. It stresses competing on the basis of customer need satisfaction with superior, higher value products" (p. 59). The notion of *value* is related to geographical distance, according to Capaldo, Lavie, and Messeni Petruzzelli (2014). They found that "the more distant the knowledge from the current domain of expertise in the industry, the more difficult it is to generate value from maturing knowledge. An inventor's unfamiliarity with distant knowledge and increasing difficulties in searching, internalizing, and leveraging that knowledge can limit its recombination opportunities and depreciate the value of innovations." (p. 24).

During the process of exploitation, firms may intend to develop radical innovation and/or ensure continuous innovation (Magnusson & Martini, 2008). We consider the dichotomy between incremental and radical innovation as the distance between a technological trajectory and a product (Abernathy & Clark, 1985). Generally, radical innovation can be defined as a new-to-the-world product (i.e., new to both users and firms); however, incremental innovation builds on familiar-to-the-market existing products (Markides, 2006). Similarly, truly new products are so radical that they may create a new product category (Gregan-Paxton & John, 1997).

Given the substantial difference between both types of innovation, radical innovation commercialization requires scholars to focus on the question of customer adoption (Wejnert, 2002). Bennett and Cooper (1979) commented on product acceptance, finding "because the potential user is familiar with the product class, he can make constructive comments about desired features and may even indicate an intent to purchase" (p. 78). User adoption of new products studies have shown that some users adopt innovations earlier and more completely than other users (Rogers, 1995; Rogers & Shoemaker, 1971; Schreier & Prügl, 2008).

The acquisition, assimilation, transformation, and exploitation of customer knowledge can play a significant role in both potential and realized absorptive capacities of firms. Based on sections 2.1 through 2.5, Figure 1 presents the knowledge used and processed across the four steps.

Figure 1: Knowledge dynamics related to potential and realized absorptive capacity



Savino, Messeni Petruzzelli, & Albino (2015) have called for further research on how recombination and search dynamics occur in SMEs. Therefore, our focus on the context of SMEs is both relevant and timely, and we expect the implementation of absorptive capacity to greatly differ between large companies and SMEs. In contrast to large companies where organizational functions may be separately managed by different individuals or teams, SMEs tend to consolidate these functions among one or a few individuals. We focus on a specific type of SMEs: technological spin-offs.

2.6. The particular case of spin-offs

At the end of the 1950s, various young organizations benefited from an interventionist process and top-down knowledge spillover from new scientific discoveries with new technological applications. Start-ups were poorly recognized compared with large firms that dominated the organizational paradigm. Gradually, start-ups became the key to using research activities and knowledge to develop innovation (Lundvall & Johnson, 1994). Because these start-ups were closer to the market, they began to capture increasing portions of the value chain by accumulating competences, technologies, and R&D activities that were originally under the control of public research centers. However, there is scarce empirical research on the involvement of customers in NPD, particularly for start-ups (Alam, 2002).

In contrast to the neo-liberal competition-based free-market model, several voluntary policy instruments offer governance at the national level. One form of business knowledge governance involves the creation of a particular type of start-up, generally called a spin-off or a spin-out (Agarwal et al., 2004). Spin-offs are defined as new ventures created from universities, research institutions, or an existing firm and aim to transform technical knowledge into wealth through commercialization (Callan, 2001; Siegel, Waldman, & Link, 2003). Spin-offs significantly differ from conventional start-ups and large well-established companies. For instance, academic spin-offs have a greater focus on technological and scientific competencies (based on technical and scientific education), but they may lack investment in commercial functions (Colombo & Piva, 2012).

Entrepreneurs benefit from knowledge acquired in their past institutions (e.g., social capital, skills, technical expertise, routines, learning trajectory, and capabilities of identifying relevant opportunities) (Basu et al., 2015; Chatterji, 2009; Klepper, 2001). The link can be considered as a dyad between the parent firm and the spin-off (Agarwal et al., 2004; Chatterji, 2009; Phillips, 2002), and

within it, a new venture conducts a "local search" in the parent firm to consider existing knowledge domains (Rosenkopf & Almeida, 2003).

Several scholars (Agarwal et al., 2004, Basu et al., 2015, & Klepper & Sleeper, 2005) have noted the notion of parental heritage of a spin-off. Agarwal et al. (2004) conducted a study in the disk drive sector and found the impact of this kind of initial trajectory with the transfer of knowledge related to both technological and marketing aspects is long lasting (i.e., spin-offs will hardly be able to decide on their own destinies).

Agarwal et al. (2004) contended that the notion of heritage is clearly linked to absorptive capacity. Colombo and Piva (2012) compared 64 new technology-based firms (NTBFs) to non-academic high-tech start-ups and referred to absorptive capacity by distinguishing potential from realized absorptive capacity. They argued that "because of their [academic NTBFs'] superior potential absorptive capacity, the benefits they can reap from technological collaborations with public research organizations are greater than those that can be obtained by non-academic NTBFs" (p. 83). Nonetheless, Ferrianiet al. (2012) also argued that the parent company transmits certain inertia to the start-up. The start-up may need to unlearn these inappropriate practices, and therefore, the search for novelty and the inheritance are opposing forces (Ferriani et al., 2012). For example, spin-offs can access their parent organization's large technological knowledge base, they may be less motivated to search for and integrate new knowledge from customers.

Overall, spin-offs benefit from a better survival rate than independent new ventures (Agarwal et al., 2004; Basu et al., 2015; Fackler et al., 2016; Phillips, 2002; Stinchcombe, 1965), but inherited knowledge has an impact on a spin-off's long-term survival (Stinchcombe, 1965). For instance, based on a study of 935 university spin-offs since 2000 from 95 Italian public universities, Bolzani et al. (2015) found that 813 were still running (86.95%), 108 failed (11.55%), and 14 either had been acquired, had merged, or had changed into another company (1.50%). Their findings suggest that spin-offs have a lower failure rate than regular Italian companies.

Agarwal et al. (2004) argued that the capabilities of incumbents have a positive impact on a spin-off's knowledge capabilities and increases its probability of survival in comparison with a regular new firm entering the market. Similarly, Phillips (2002) argued that routines and the processes with customers enable spin-offs to overcome the liabilities of newness.

Klepper and Sleeper (2005) found that the parent firm transmits a heritage to spin-offs that determines the new venture's organization, strategy, and performance. Chatterji (2009) noted that spin-offs from incumbent firms perform better than regular start-ups entering in the market. However, Chatterji's study did not show the superior performance of spin-offs was due to technical knowledge spillovers from parent firms; rather, it supported the idea it came from nontechnical knowledge, such as marketing and did not support the premise that spin-offs perform better than regular start-ups in the commercialization of a product. Based on these studies' reviews, Appendix 11 summarizes the differences between spin-offs and start-ups.

2.7. Highlights from university spin-offs

University spin-offs appeared as a necessity in the technological commercialization of universities and constitute a significant part of national wealth creation (Shane, 2004). K. Miller, McAdam, and McAdam (2014) argued that universities are currently going through an important change in their business model and are developing new relationships with stakeholders in a regional context.

Using the theoretical background of absorptive capacity, K. Miller et al. (2016) studied knowledge transfer between universities and stakeholders through a longitudinal data collection and used the four dimensions of absorptive capacity (Zahra & George, 2002) to argue that it refers to a knowledge-based dynamic capability. Absorptive capacity is relevant to better understand the difference in success between firms when it comes to the development of innovative products and the success of innovation activities (McAdam, McAdam, Galbraith, & Miller, 2010).

Díez-Vial and Montoro-Sánchez (2016) also studied the flow of technological knowledge in light of absorptive capacity from universities to research parks. They argued that university knowledge has a positive impact on innovation of co-located firms. However, they challenged the positive impact of university knowledge on the potential absorptive capacity of spin-offs and argued that "spin-offs do not significantly increase the knowledge received from the university" (p. 49).

2.8. Research focus

Surprisingly, research centers' entrepreneurial activities have not been studied as energetically as universities' pursuits; however, research centers are as important as universities when it comes to entrepreneurial activities. Van Looy, Debackere, and Andries (2003) argued that "the local knowledge centers in particular universities and research institutes—can play a major role in this process [to stimulate a region's economic growth based on knowledge-intensive entrepreneurship]" (p. 225) and noted that those institutions are embedded in the supra-regional context that offer a solid ground for young start-ups. In turn, Van Looy et al. (2003) found that research institutes and knowledge-intensive start-ups linked to larger firms support regional innovation and economic success.

Spin-offs' organizational structures appear to be promising and have drawn increasing interest from both academics and practitioners. Studies have investigated the motivations behind the creation of spin-offs (Mustar, 1995; Smiler, Gibson, & Dietrich, 1990), university spin-off companies' formations (Shane, 2004), the regional creation of spin-offs (Roberts & Malone, 1996), and governance models (Clarysse et al., 2005). Thus far, however, little research has examined customer involvement in radical innovation in spin-offs.

To link the particular case of spin-offs with the theoretical foundation of absorptive capacity, we identified two main components: benefits from pre-existing knowledge and from foreseeing the future. These components are consistent with the work of Cohen and Levinthal (1994) who argued

that absorptive capacity guides the exploitation of external knowledge and allows a more accurate prediction of future technological advances.

Spin-offs may consider prior related knowledge, partner-specific absorptive capacity, knowledge similarities, routine interactions, and frequency (Dyer & Singh, 1998). We suggest that spin-offs benefit from the pre-existing knowledge of their universities, research centers, or parent companies and associated knowledge from customers, and this gives them an advantage over other start-ups in the context of radical innovation.

In the theoretical background, we characterized the distinction between potential and realized absorptive capacity, which requires further studies using a qualitative lens to better understand how: (1) firms may benefit or suffer from external knowledge dynamics; (2) firms assimilate knowledge from their customers; (3) to recombine new knowledge with existing knowledge; and (4) to successfully create value in radical innovation.

Our specific interest is investigating those questions in the case of spin-offs created by research centers. Our empirical qualitative study consequently studies how the absorptive capacity of scientific spin-offs determines the benefits and challenges of customer involvement in the pursuit of radical innovation.

3. Methods

3.1. Case and sample selection

Our study consists of three cases of spin-offs from CEA–LETI.[1] CEA was created in 1941 and develops both military and civilian applications of nuclear technology and is comprised of one military

[1] CEA–LETI is unique in its focus on micro- and nano-technologies and is designed to transfer technical knowledge to business for a fee and through agency-created start-ups. Its activities with firms range from microelectronics

division and four civilian divisions. A unique civilian division, the Technological Research Division, specializes in micro- and nano-technologies, nano-material, software, and new technologies that can be used in energy production. This division was selected for analysis because of its market orientation. The division is composed of three research centers: the Laboratory for Electronic and Instrument Technologies (LETI), the Laboratory for the Integration of Systems and Technology (LIST), and the Laboratory for Innovation in the Technologies of New Energies and Nano Materials (LITEN). In 1967, CEA-Grenoble created a subsidiary, LETI, which focuses on micro- and nano-technologies. CEA–LETI has expanded over the years, and currently has 1,500 employees and 250 interns.

Our sample selection was conducted in four steps: overall sample consideration and categorization, identification of several cases per category, final choice of cases, and consideration of post-data collection categorization.

First, we considered the entire set of 42 spin-offs created by CEA-LETI. Based on our survey, we observed those spin-offs fell into three categories: (1) those currently running and continue to operate individually; (2) those that failed and were bankrupted; and (3) those purchased by another company or became a joint venture. At the beginning of our study, we focused on categories 1 and 3 because we could not foresee the failure of successful spin-offs a few years before.

Second, we identified six spin-offs from the first category (Sofradir, ELDIM, Soitec, CORYS, Tronics, and Beamind, c.f. Appendix 12) and five spin-offs from the third category (Crismatec, ICAP, CSO, Apibio, and STMicroelectronics, c.f. Appendix 14). Based on our early desk research and phone calls, we considered the possibility of conducting research on those 11 spin-offs.

Third, we wanted to have a representative sample; thus, our early intention was to select two spin-offs from the first category (Tronics and Beamind) and one spin-off from the third category

and microsystems on silicon (60%) to systems for biology, health, and telecommunications (20%), and optoelectronics components (20%).

(STMicroelectronics). The cases were chosen because their detailed descriptions and analyses illustrate common patterns of technical knowledge use and misuse, not only across the Grenoble cluster but also among external firms.

Fourth, based on post-data collection conducted in Tronics, Beamind, and STMicroelectronics, we concluded that Beamind was not as successful as it was at the beginning. Because Beamind was in the second category, we decided to conduct desk research on spin-off failures and considered four other cases (Silmag, Pixtech, PHS MEMS, and Alditech, c.f. Appendix 13).

Overall, our sample consisted of one case per category: Tronics in the first category, Beamind in the second category, and STMicroelectronics in the third category.

We conducted 36 interviews with nine researchers from CEA–LETI and research centers, two founders of spin-offs, two CEOs, three project managers, 17 engineers/managers, one supplier, one individual from knowledge-intensive business services, and one consultant (Appendix 15). On average, the interviews lasted one hour and 20 minutes (ranging from 45 minutes to 2.5 hours). The interviews were recorded with the participants' permissions. To avoid observer bias, a transcript of each interview was sent to each interviewee for approval and modification (Lincoln & Guba, 1985). All three case studies were conducted during the same period to facilitate comparisons.

3.2. Method and procedure

We adopted an inductive approach to obtain an in-depth understanding of the issues, stakes, and influences that were at play within three spin-offs from CEA-LETI. We used this methodology for four reasons: (a) the exploratory nature of our research, (b) the potential to conduct research in real-life contexts, (c) the need to observe formal and informal processes within organizations, and (d) the overall acceptance of case-study research by R&D managers (Eisenhardt, 1989; Gassmann, 1999; Hartley, 1994; Yin, 1994). The literature primarily consists of cases developed in a narrative process that is relevant to the field (Franke & Piller, 2004; Lettl et al., 2006; McDermott & O'Connor, 2002; O'Connor, 1998; Perry, 1998; Shane, 2000; Van den Bosch, Volberda, & De Boer, 1999).

We assessed the richness of the cases by examining customer involvement in radical innovation (Eisenhardt, 1989; Hedges, 1985; Merriam, 1988; Minichiello, Aroni, Timewell, & Alexander, 1995; Neuman, 1997; Patton, 1990; Perry, 1998). We employed a literal replication logic by conducting a comparable case selection with a focus on high-technology products developed by a spin-off from CEA–LETI (Goetz & LeCompte, 1984; Yin, 2003).

We followed a research procedure that increased the study's reliability and success rate. The identification of a potential case involving a firm (step 1) was followed by an intensive screening that included several exploratory interviews to assess feasibility and information access. The aim was to obtain agreement from a top manager to act as a first contact (step 2) and to establish trust and a collaborative framework for further interviews. The case should be sufficiently detailed to have contacts of key people involved before conducting the initial narrative interviews involving top managers and founders of the start-ups involved (step 3). Information on event timing, stakeholders, and locations was carefully recorded, written, and analyzed to ensure the study's accuracy. Further interviews inside the firm were then conducted (step 4) to obtain different perspectives. The selection of people from various fields increased the variety of perspectives and yielded insight into different events, networks, dates, places, and policies (Strauss & Corbin, 1990; Wengraf, 2001; Yin, 2003). Contradiction and opposition offer deeper insights and a richer perspective than would be possible with a more uniform sample of interviewees. Completion of the internal interviews was followed by interviews with a limited number of external stakeholders (step 5) such as customers, suppliers, public bodies, universities, research centers, and firms to enrich the case study from another perspective. The subsequent evaluation and analysis provided the case study's conclusions (step 6) and resulted in three case studies of Tronics, Beamind, and STMicroelectronics.

We conducted longitudinal case studies to investigate the effect of decisions on the innovation process. In examining the failure of Beamind, we began at the point at which the spin-off was growing and had a good outlook (Dyer & Wilkins, 1991; Golden, 1992; Yin, 1994). The data were collected in

France by two researchers over a four-year period (2007 to 2010). We conducted semi-structured interviews that allowed the researcher to conduct both retrospective and real-time accounts (Gioia, Corley, & Hamilton, 2012). Initially, we used a retrospective approach to become familiar with projects that had begun prior to our investigation (C. C. Miller, Cardinal, & Glick, 1997).

The interviews were structured in five parts:

(1) information about the interview setting (date, interviewee name, location, duration, curriculum vitae, current job description , academic and professional background, the role in the firm, the reasons for doing the job, the influencers during the career, and the key moments in the career);

(2) the timing of the period 1, 2, 3, and 4 (the preconditions, the implementation and the development, the subsequent performance, and the lessons learned);

(3) knowledge, learning, and innovation perspective, including the decisions taken and the timing, the degree of formality in decision making, the reasons for making changes, the influence of experiences in decision making, the type of knowledge involved, the type of learning (training/ book, observational, trial-and-error);

(4) the stakeholders involved in the case (customers, competitors, universities/research institutions, financial institutions, employees/contractors/consultants, politicians, regional bodies, and friends/peers), the interactions and space, the reasons for mobilizing stakeholders, the role played by stakeholders, the added value and the drawbacks of such involvement, and the agreements and the disputes; and

(5) territorial perspectives including the geographical, cognitive distances/proximity, and the regional anchoring. Interviews and written reports helped us avoid the distortion of past facts.

We conducted periodic interviews to collect longitudinal data in real time to explore events (Pettigrew, 1990), stakeholders, and time issues. Pettigrew (1990) provided recommendations on various practical problems researchers can encounter while conducting longitudinal comparative case studies. Longitudinal data enables data collection to explore the past, the present, and the emerging

future (Pettigrew, 1990). Our objective was to select cases that matched the four capabilities across the two absorptive capacities and provided sufficient variation in the contextual factors, thus representing polar cases.

3.3. Construct operationalization and data analysis

To ensure construct and internal validity, observations, documents, press articles, meeting minutes, communications, letters, memoranda, shareholder reports, chief executive officer speeches, and interview data were collected and cross-checked through triangulation (Easton, 1995; Miles & Huberman, 1994). We followed the advice from Gioia et al. (2012) to not play the role of "glorified reporters." By multiplying the data sources and by focusing on obtaining high-quality data coding, the researchers sought to enhance the study's internal validity (Dane, 1990; Rosenthal & Rosnow, 1991).

We used open coding to allow the use of a large number of terms, codes, and categories (Strauss & Corbin, 1998), and this resulted in 81 codes. Then, we conducted axial coding by reducing the numbers of codes to 25 to 30 codes by seeking for similarities (Strauss & Corbin, 1998). We finally considered 38 codes.

The operationalization of absorptive capacity has been discussed and debated in the following existing studies: Dyer and Singh (1998), Jansen et al. (2005), Jaworski and Kohli (1993), Lane et al. (2006), Lane and Lubatkin (1998), Szulanski (1996), Van den Bosch et al. (1999), and Zahra and George (2002). Consistent with the work of Lane et al. (2006), our intent was to optimally capture the holistic concept of absorptive capacity. From the literature, we identified nine factors that characterize absorptive capacity, which we sought to explore: (1) external sources of knowledge, including from (2) distant stakeholders, particularly from (3) customers and (4) research centers offering (5) learning alliances through (6) sequential steps toward (7) innovation, in particular (8) radical innovation, and toward (9) commercial ends. All nine factors have been integrated into the data collection design and data analysis design.

We investigated external knowledge (1) because the ability to capture and utilize external knowledge spillovers from the external environment is strongly linked to absorptive capacity (Cohen & Levinthal, 1989; Koza & Lewin, 1998; Lane et al., 2006), including from distant Phene et al. (2006) (2). From the "learning dyad" of Lane and Lubatkin (1998), we considered particular learning with customers (3) and research centers (4).

Learning in alliances (Grant & Baden-Fuller, 1995; Hamel, 1991; Huber, 1991) is increasingly important and is clearly linked to absorptive capacity (Lane et al., 2006) (5) in terms of exploratory, transformative, and exploitative learning. Such learning occurs in sequential steps (6). Initially, Cohen and Levinthal (1990) identified three of these steps: identification, assimilation, and exploitation (recognition, assimilation and use, cf. Lane et al., 2006). By contrast, Zahra and George (2002) and Jansen et al. (2005) considered four steps: acquire, assimilate, transform, and exploit knowledge to balance potential and realized absorptive capacity.

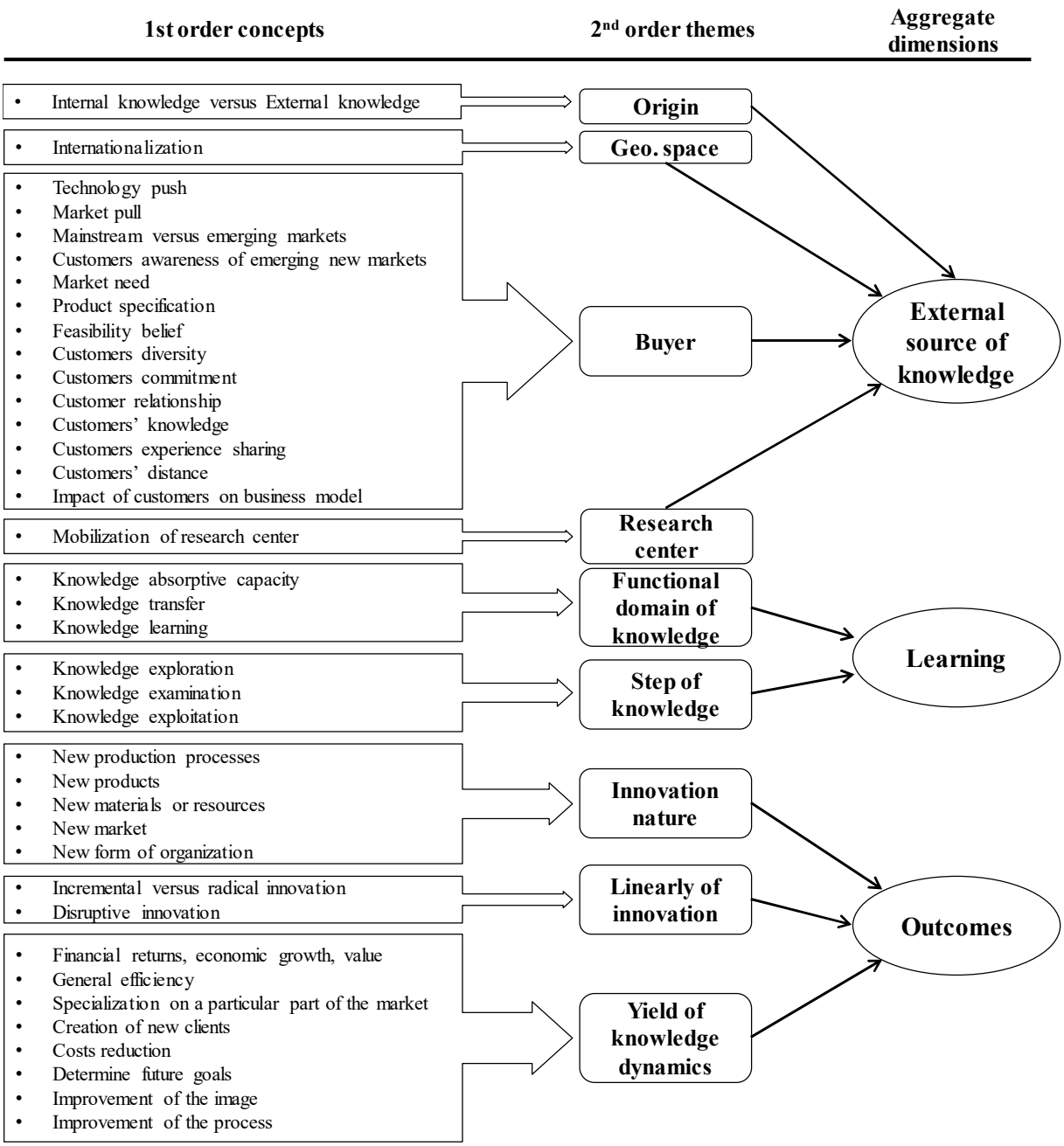
The outcomes of absorptive capacity in term of innovation (Tsai, 2001) (7) appeared to be important to our study exploring the particular case of radical innovation (Lane et al., 2006) (8). Final outcomes, such as commercial ends (Cohen & Levinthal, 1990) and predictions of future technological advances, are important (Cohen & Levinthal, 1994) (9).

Using the results of this data collection process, we conducted a content analysis. The sentence was the unit of analysis used for the recorded data. We determined whether the categories were mutually exclusive or were overlapping on the basis of the theoretical background in previous studies (Dunphy, Bullard, & Crossing, 1974; Insch, Moore, & Murphy, 1997; Namenwirth & Weber, 1987; Weber, 1990). From the interviews, we developed a detailed coding scheme with multiple categories. The data were collected in the context of the EU-funded project EURODITE with the objective of answering a number of additional research questions that are beyond the scope of this article. Researchers must conduct their interviews based on an existing research question (Gioia et al., 2012).

Coding, clustering, and reduction were performed to obtain a coding scheme in accordance with the literature (Araujo, 1995; Coffey & Atkinson, 1996; Strauss & Corbin, 1990). Gioia et al. (2012) recommend the use of first-order and second-order analysis to analyze data in a systematic manner. The second-order analysis should present theoretical concepts and emerging themes from an observed phenomena (Gioia et al., 2012). Once the theoretical saturation has been reached (Glaser & Strauss, 1967), it is possible to develop aggregate dimensions based on the second-order themes. The first-order concepts, second-order themes, and aggregate dimensions are presented in Figure 2.

From our data coding, we did not use 17 categories because those codings were not relevant to answer the present article's research question. Consequently, we used only nine categories out of 26 and a total of 38 elements. We focused on the following categories and elements: buyers (14 elements), the functional domain of knowledge (three elements), geographical space (one element), the nature of innovation (five elements), the linearity of innovation (two elements), the origin of knowledge (one element), the research center (one element), the steps of knowledge (three elements), and the yield of knowledge dynamics (eight elements). The coding was performed by the two researchers who conducted the interviews. To check intercoder reliability, we randomly selected 20% of the contents and asked two other researchers to code them following the same scheme. Agreement in coding was reached in 85% of the cases. As recommended by Gioia et al. (2012), we provide the concepts and themes in Figure 2, which presents the first-order concepts, second-order themes, and aggregate dimensions. The three aggregate dimensions, namely external source of knowledge, learning, and outcomes, echo the three components highlighted by Cohen and Levinthal (1990) in their seminal definition of absorptive capacity: "the ability to recognize the value of new external information, assimilate it and apply it to commercial ends" (p. 128).

Figure 2: First-order concepts, second-order themes, and aggregate dimensions



Each case study was developed as a separate narrative biography to obtain a global picture (Kwan, 2004; Strauss & Corbin, 1990; Wengraf, 2001; Yin, 2003). From the set of three narrative biographies, we conducted a cross-case analysis to determine the similarities and differences.

We intended to provide verbatim quotations from our field work to report qualitative research insights. We used an exclusive approach in reporting verbatim quotation (1) to provide evidence, (2) to give a voice to the participants, (3) to balance verbatim quotations and narrative text, (4) to ensure

good readability (not too technical), (5) to avoid problems of confidentiality, and (6) to keep our manuscript concise.

We selected quotations that were the most representative of the research participants and avoided quotations that only reflected the point of view of a single respondent unless it would introduce a valuable debate to the case. The choice of verbatim was influenced by the authors' readings and careers in qualitative research. After a discussion among the authors, only the verbatim quotations that were accepted by consensus were selected.

4. Analysis of the Results

In the analysis, we present the cases of Tronics, Beamind, and STMicroelectronics.

4.1. Tronics: Customers guiding radical innovation

In 1997, CEA–LETI created a spin-off called Tronics Microsystems, which specialized in micro-electronic mechanical systems (MEMS) for the oil exploration market; Sercel took a 10% equity stake. In the process of NPD of a radical innovation, Tronics was able to capture the value of both market and technical knowledge from Sercel and CEA–LETI.

The origin of Tronics lies in the context of the 1990s, when the traditional captor (gyro-meter) industry was producing mechanical measurement instruments based on incremental innovation. Sercel, a leading supplier of captors used in the undersea oil exploration industry, saw its market moving toward a demand for more advanced technologies and anticipated radical innovation based on the shift toward microelectronic-based instruments. This competitive threat pushed Sercel to approach CEA–LETI and evaluate the possible contributions of radical innovations in its industry.

In 1994, Sercel and CEA–LETI shared market information about the captor industry and discussed their current and potential technological options. In that sense, CEA–LETI was aware of technology emergence through the integration and absorption of customers' specific knowledge. Over

the next year, CEA–LETI combined focused research and existing technical knowledge from pre-existing knowledge structures to develop a new product design. By 1995, CEA–LETI had created a prototype that combined micro-electro-mechanical system (MEMS) components within a ceramic housing that included a pump that allowed the sensing instrument to operate within a vacuum.

Tronics could benefit from Sercel's market knowledge of the oil prospecting business. However, Sercel lacked technical knowledge regarding the core technologies of Tronics, such as the MEMS, the chemical pump, and the packaging. Consequently, Sercel could not clearly express its needs in technical terms. In the face of this challenge, Tronics spent a considerable amount of time and effort attempting to translate the business needs of its customer into technical needs. This effort yielded a clear specification of the future product and was evidence of Tronics' willingness to internalize its customers' business insights. Participant 2 relates the situation in the following quotation:

> *The customers are looking for the same thing as before. The only change is the need for more accurate and more precise device. […] After several meetings with the customer and internal discussions, the product specification of Sercel was very simple and precise: Measure 0.1 G with an error of 1/1.000.000 (Captor 120 DB). To give you a comparison, the precision of a car air-bag is 1/1.000.* (Participant 2)

The outcome of this exchange was beneficial beyond the mere translation of the customer's need into technical specifications because Tronics also had access to the "sensing" skill of Sercel concerning future market developments and the associated technological evolutions. Participant 3 relates that

> *Sercel didn't know exactly what name to put on the next stage of technological progress, but they could sense it.* (Participant 3)

Tronics integrated the constructive feedback from Sercel to increase the value of its new products. Once prototypes had been developed, the firms engaged in intensive and complementary

collaborative work to resolve the engineering issues faced by the customer (Sercel) and Tronics. In the development process, Tronics contacted Sercel to ensure the match between product value from the customer's perspective and Tronics's R&D costs. Participant 36 recalled,

> *We had to innovate by using new materials to decrease the cost of replacement materials. Consequently, we have experienced a series of changes: aluminum-gold (expensive), silicon (abrasive), and then silver.* (Participant 36)

In addition to the insights brought by customers, the company also benefited from the knowledge of CEA–LETI. Because most people from the spin-off were originally from this research center, they had not only rich technical knowledge but also a long history of strategic know-how in terms of developing alliances with international partners. With guidance from CEA–LETI, Tronics created formal supply agreements with other partners to gather the necessary technical and production knowledge to develop the captor and to explore its possible uses in other industries. Tronics was immediately involved in international strategic alliances: technology transfer that potentially could lead to new types of bolometers (measurement by night, night vision, and infrared) with external partners, cross-technology transfer associated with an exclusive licensing agreement between Sercel and LETI, the role of original equipment manufacturer with Williams and NTK, and a multiple-cooperation agreement and equity stake purchase of Tronics by Williams. The ability to develop alliances appeared to be a major mechanism through which the firm acquired new competences far beyond its core competences.

The oil prospecting sensor's technical specifications were highly sophisticated, and the technology would likely have uses in various industries, especially the oil exploration business model directed toward multiple market innovations. Tronics's current market focus includes aerospace/defense (night measurements, night vision, video projector improvements, and infrared technologies), telecom networks, measurement instruments (earthquake forecasting captors), life science biomedical products (healthcare), and building automation. Participant 1 recounted that

Yesterday, we were able to capitalize on CEA's own knowledge, and today we are able to capitalize on the knowledge we acquired in the MEMS seismic captor to expend in other businesses. Those days, you can see a captor in any device you have at home, in your car, at work. The range of products available is just huge. (Participant 1)

Additionally, in 2009, Tronics signed a strategic supply agreement in the field of navigation systems with Thales (a global technology leader in the aerospace, space, defense, security, and transportation markets). Tronics would produce high-performance, vacuum-packaged inertial MEMS-sensing elements for aircraft navigation. According to Thales, MEMS technology represents a radical innovation because it features reduced volume, weight, power consumption, and cost along with increased instrument and measurement reliability. In such strategic alliances, absorptive capacity has been based on a bilateral approach because there is a mutual exchange of information between buyer and seller. These applications were developed by Tronics with the assistance of new spin-offs from CEA–LETI and other external partners. In that sense, new spin-offs benefit from the success of existing spin-offs.

Tronics achieved a growth rate of 542.78% during the five-year period from 2003 to 2007. Its next markets were the markets for automotive, IT, mobile, and customer products (the gaming industry). In summary, Tronics's growing success is a clear example of advanced radical innovation that has been used to create wealth across a series of related applications based on a clear understanding of market needs and opportunities.

4.2. Beamind: Customer over-involvement

In 1999, quality control equipment for printed circuit boards (PCBs) was under-developed. A CEA–LETI researcher began to develop a testing device that would be equipped to monitor PCB production. After obtaining an initial patent, the inventor shared his radical discovery within the scientific community through CEA–LETI, and this led in 2002 to the creation of a spin-off, Beamind. Within Beamind, the pursuit of radical innovation involved several disciplines, including physics,

optical materials, and electronics, and this cross-disciplinary work required the convergence of internal technical knowledge and external operating and technical knowledge from different organizations. Participant 6 shared that

> *We want to get rid of the manual way of testing integrated circuits […] we will not keep those needles forever. The use of our machine will change the way this job is currently performed. In fact, Beamind customers could not believe that it was possible. Our relationship was based on convincing them that we can make it.* (Participant 6)

Consequently, Beamind sent technical personnel to explore market opportunities in Japan, where potential customers provided production samples for PCBs to be tested and helped to redefine and improve the device. In the beginning, potential customers fostered Beamind's pursuit of radical innovation; however, in 2005, Beamind completed the first prototypes, but tests revealed technical problems. The search for technical and production knowledge added to the prototype's complexity and required expanded resources, which were obtained in 2005, for development. Beamind reinforced its relationships with potential customers in Taiwan, Japan, and the United States to generate possible operating uses as soon as advanced prototypes were ready. Beamind wanted to internalize customer knowledge in terms of sharing its experience. Participant 8 remembered thinking that

> *Within a few months, our first machine will be with our customers. The first customer is the most important. Through the first interaction, we will take our marks to solve real issues. The first customers are happy at the same level as us when the machine is functioning well. They will become development partners. It became a common project.* (Participant 8)

Subsequently, however, potential customers hindered the process of radical NPD because they did not have sufficient technical knowledge. Rather than attempting to engage in a process of understanding and internalizing the insights from its potential customers' business needs, the company attempted to resolve all issues individually in a sequential but time-consuming manner. The customer was involved on an almost daily basis and provided frequent but sometimes contradictory feedback on

the future product's specifications; this excessive intervening led to increased frustration among the company's R&D employees. Participant 8 realized

> *The customer is not willing to make the machine functional, does not want to invest resources. In such a case, it's terrible because Beamind will get tired of solving unimportant problems.* (Participant 8)

Because Beamind was considering all of its customers' requirements, its managers eventually realized that the prototype quality control product was more sophisticated than the average customer required and its complex design and advanced capabilities made it too expensive for the target market. Thus, in this process, Beamind developed a radical product that was never sold, and the company declared bankruptcy on February 2, 2010.

4.3. STMicroelectronics: Limited but guided customer involvement

STMicroelectronics (ST) evolved from an early (1972) CEA–LETI spin-off, EFCIS (Specific Integrated Circuit Manufacturing), which was aimed at the market for metal oxide semiconductor integrated circuits. EFCIS was later acquired by Thomson Semiconductors. Thomson integrated with an Italian firm, SGS, and in 1998, the new firm became STMicroelectronics. The firm has operated as a major worldwide semi-conductor firm for the past two decades (typically in the top seven firms in total sales). Since 1980, the European Nano-electronics Initiative Advisory Council (ENIAC) has followed its version of what is called Moore's Law in the United States, and it predicted that the number of transistors on a micro-chip will be multiplied by two every 18 months and will exhibit linear innovation for the next 10 years; therefore, such a progression would require new technology development every two to three years.

Some firms in the semi-conductor industry appear to have limited their exploration of new technologies, radical innovation, and potential market shifts. For example, in January 2005, Nokia contacted ST to develop an integrated circuit (IC) as part of a customized platform combining hardware

and software; this was a way for the firm to be aware of technology emergence. However, ST had great difficulty internalizing customer knowledge and gaining experience. Participant 11 observed that

> *Nokia prevents direct contact with mobile phone end users. So, ST is very dependent and needs to rely on Nokia's expectations without the possibility to stand back.* (Participant 11)

ST defined Nokia's needs on the basis of a feasibility study conducted in Grenoble, France, which benefited from efficient NPD routines that incorporated 80% of the technical knowledge employed by previous complementary NPD processes. In that sense, the role of customers is clearly not to foster the pursuit of radical innovation. By July 2006, ST was handling prototype development using technical and marketing tests based on its extensive technical knowledge and production expertise.

ST is a customized designer–producer that relies on a set of sub-contractors to provide integrated circuit products for major customers. Rather than exploring innovation within external sources, ST relied on internal knowledge pulled from previous NPD to create the new IC platform for Nokia. Each ST production entity (in France, Italy, India, and the Czech Republic) developed knowledge modules by complying with product specifications and architectures, but without conducting real knowledge sharing. Participant 15 explained that

> *Blocks of knowledge from one team are then transferred at the platform level.* (Participant 15)

Thus, only a fraction of ST's technical knowledge has been developed in cooperation with external partners, and all of ST's products are based on its linear progress and production expertise, which suggests that the firm may have been concerned with unintended knowledge spillover with possible partner firms and research agencies.

In particular, ST has not benefitted further from market or technical knowledge from CEA–LETI. Relying primarily on its own pre-existing knowledge structure, ST does not benefit from the research center's network. As a consequence, ST tends to limit the number of strategic alliances involved in this particular NPD: a few R&D agreement subcontractors from CERMA, three

subcontractors, and limited cooperation with Teradyne to develop test software. However, ST enjoys vast but underexplored potential for alliances with Bosch and Marelli, Hewlett Packard, Seagate, Western Digital, or Thomson Multimedia. Meanwhile, ST has slipped in recent years from being the fifth-ranked global supplier of microelectronics to being the seventh-ranked supplier.

5. Discussion

Although previous research has suggested that customer knowledge can help firms create and develop valuable new products, few studies have investigated the question of how firms internalize such knowledge; consequently, we know little about the processes that are involved in the acquisition, assimilation, transformation, and exploitation of knowledge from customers. Furthermore, this gap is even greater when it comes to the development of radical innovation from spin-offs, a largely underresearched category of new ventures. Therefore, we believe that more scholarly attention should be dedicated to how this type of firm internalizes customer knowledge in their pursuit of radical innovation.

This section discusses our study's findings in three sections: the benefits and challenges of customer involvement in radical innovation, the duality of market and technology absorptive capacity for spin-offs, and the novel concept of blending capability.

5.1. *Benefits and challenges of customer involvement*

Customers such as Sercel and Nokia helped develop new products at Tronics and STMicroelectronics. In the case of Beamind, the technology-push toward semi-conductor firms failed although the prototypes were highly customized to the technical requirements of customers. Sercel-Tronics clearly adopted a bilateral approach involving the mutual exchange of information. Nokia-STMicroelectronics implemented a buyer-guided approach with a limited number of exchanges at the beginning of the NPD process. As a multiple semi-conductor firm, Beamind suffered from a seller-

guided approach in which the mutual exchange overwhelmingly occurred toward the end of the NPD process.

In all three cases, the spin-offs involved customers and potential customers at different NPD process stages. Drawing on our results, we divided this process for the three companies into four stages to identify the various events and customers involved through the lens of potential and realized absorptive capacity (Table 1). The number of stages emerged from the knowledge biographies, and the stages differ in length, content, and nature.

Table 1: Involvement of customers along NPD stages and absorptive capacity

	Potential Absorptive Capacity		**Realized Absorptive Capacity**	
	Acquisition	**Assimilation**	**Transformation**	**Exploitation**
Tronics	**Strong** involvement of Sercel Partial funding of R&D at LETI No end-users	**Moderate** involvement Sercel and LETI seeking MEMS manufacturer Market study Chose Tronics	**Lower** involvement of Sercel after specification step	**Lower** involvement Delivery of the final product fulfilling the necessary specifications
Beamind	**Low** customer involvement Only a market study Some market forecasting	**Strong** involvement of end users of the machine Real sample chip tested Concrete questions	**Strong** customer involvement Continuous adaptation Time to market Cultural and physical distance	**Strong** customer negotiation with potential customers Sharing learning Back loops Modification Customer satisfaction
ST	**Moderate** involvement Custom product Nokia specifications Value of platform development No end users	**Strong** involvement by Nokia "Change requests" Influence on NPD	**Low** customer involvement during the combination of hardware and software	**Moderate** involvement Feedback from Nokia Outsourcing manufacturing: "Fabless"

An analysis of Table 1 shows two important benefits of customer involvement: (a) the sharing of experience and (b) awareness of technology emergence. These benefits appear to be connected to

the type of relationship between the spin-offs and customers (bilateral, buyer-guided, or seller-guided relationships). Surprisingly, the sharing of experience was low in the buyer-guided approach at ST, overintensive in the seller-guided approach at Beamind, and moderate in the bilateral approach at Tronics. Normally, in a buyer-guided approach, the experience sharing should be high, and in a seller-guided approach, the experience sharing should be low. In our empirical study, it was not the case because although Beamind was strongly pushing its product to the market, the company was collecting a large amount of feedback on the machine. At Beamind, customers continuously noted technical problems, and this forced the company to revise its prototype after every meeting. Furthermore, although very dependent on the contract with Nokia, STMicroelectronics was not mobilizing Nokia to get any feedback. At ST, Nokia only shared product specifications and requested changes.

Another effect of customer involvement is the potential awareness of new technology emergence. In relation to absorptive capacity, the degree of interaction between two parties influences the intensity of the predictions regarding an industry's technological change. ST only reacted to the changes imposed by Nokia, which shows that the non-investment in learning led to being locked out of new technology (low absorptive capacity). By contrast, Beamind considered every future technical change from its customers.

By incorporating a well-balanced amount of technological change into its new products, Tronics was able to successfully conduct its initial NPD process as a result of customer contributions and was then able to move to other application fields. Customer involvement may sometimes be counterproductive if it is overintensive, especially in stages related to realize absorptive capacity. The challenges of customer involvement include the customers' lack of technical knowledge (which differs from use experience) and the difficulty of expressing needs because of knowledge stickiness (potential absorptive capacity). For example, Nokia had a clear idea but did not interact with ST in terms of knowledge or use experience in the process. Although Sercel was motivated, it did not have the technical knowledge and skills to co-design the product with Tronics. Semi-conductors' potential

customers also suffered from insufficient technical knowledge and only provided use experience to Beamind. Beamind implemented a rich knowledge-sharing process by seeking a means of improving the quality of PCB tests. Overall, beyond the use experience, customers lacked the requisite knowledge to co-design a radically new product. However, we were not able to identify the potential community assistance to cope with this lack of knowledge and competencies that had an effect on the expression of needs necessary to guide the product development to the market.

Moreover, we found that customers have difficulties expressing needs and wants linked to technological feasibility in both potential and realized absorptive capacity. With an unclear idea of technological feasibility, customers' needs may change more rapidly than the development process is able to respond. Beamind could not develop specifications as precise as those that Nokia developed with ST or those that Sercel developed with Tronics. This lack of specification created an extensive trial-and-error process that wasted time and resulted in solutions to nonessential problems. A sound understanding of the use of functions leading to extended use is important, but it does not ensure the match between product value and customers' willingness to pay. Involving users can be limited (passive involvement) and even harmful if users are regarded as "prototype lead users." In this sense, the organizational cognition aimed at establishing an absorption process routine should focus on the progress of technical knowledge guided by market knowledge.

In exploring the issue of the expression of needs, we found that knowledge stickiness represents a major challenge in the communication between customers and spin-offs in the particular case of radical innovation because it increases the overall time to market through an extension of the timeframe dedicated to the acquisition, assimilation, transformation, and exploitation of knowledge. To overcome this challenge, spin-offs should combine the benefits from customer insights and, at the same time, reduce the potential noise of non-sticky and superfluous information. In addition to the argument of a distinction between obtaining access to skills and internalizing them (Hamel, 1991), we propose a

distinction between internalizing these skills and properly filtering them to optimize absorptive capacity. As a result, we propose the following:

P_1: The type of relationship between spin-offs and customers (bilateral, buyer-guided, or seller-guided relationships) determines the stages of customer involvement in radical innovation, which has an influence on potential absorptive capacity (sharing of experience) and realized absorptive capacity (awareness of technology emergence).

P_2: Customers forestall the development of radical innovation in spin-offs when they lack the technical knowledge needed to articulate their actual sticky needs unless organizations deploy an appropriate level of both potential and realized absorptive capacity to benefit from their valuable insights.

5.2. Duality of market and technological absorptive capacity

Our findings reveal that consistent with the original definition of absorptive capacity (Cohen & Levinthal, 1990), spin-offs have been able to identify, capture, and apply external valuable knowledge from both customers and research centers to develop radical innovation. Our results indicate that the organizational routine of absorptive capacity has two parts for spin-offs, which benefit from both their customers and their parent research centers.

Spin-offs that work with both actors achieve superior outcomes in terms of radical innovation performance. By contrast, focusing exclusively on its customers was detrimental to Beamind. Similarly, the NPD process at STMicroelectronics was limited by the lack of interaction with CEA. With this initial outlook, we could easily argue that customers provide important market knowledge and that parent research centers can help firms mobilize technical knowledge.

Research centers are more likely to guide technical knowledge, and customers are more likely to guide market knowledge; therefore, we observed that technical knowledge can also come from the

customer side as a “technical knowledge market-pull” and that market knowledge can come from the research center side as a “market knowledge technology-push.” This finding encouraged us to distinguish market-pull from market knowledge and to distinguish technology-push from technology knowledge. The literature shows that both technology and market knowledge are necessary to achieve successful radical innovation in the marketplace (Leonard-Barton & Doyle, 1996; McDermott, 1999; O’Connor, 1998; O’Connor & Veryzer, 2001).

Spin-offs consider prior related market and technical knowledge, partner-specific absorptive capacity, knowledge similarities, routine interactions, and frequency. In consideration of the pre-existing knowledge structure’s richness, we further discuss the central function of absorptive capacity in the management of both market and technical knowledge, which are identified, captured, and applied from both customers and research centers.

We propose that customers can provide technical knowledge, market knowledge, or both, with varying levels of intensity affecting both potential and realized absorptive capacity. When a firm employs knowledge from its customers, transformation and exploitation are essential to absorptive capacity, but firms must access skills and identify an adequate level of internalization. At a lower but sufficient level, ST was able to meet market needs. At a higher and overwhelming level, Beamind was selective with its customers in the idea-generation phase. At a moderate level and during a well-timed process, only Tronics was able to obtain greater opportunities for innovation. In this case, we also observed that successful absorptive capacity can occur in both directions and can be characterized as “bilateral absorptive capacity.” Sercel benefited from CEA–LETI’s knowledge in determining whether new technology improved its product, and Tronics benefited from Sercel’s business knowledge. On the basis of this mutual sharing, the organization could generate more industrial applications for its technology).

Similarly, research centers also provide technical knowledge, market knowledge, or both types of knowledge. First, we argue that spin-offs benefit from the CEA–LETI’s technical knowledge base

and from the cumulative learning that is possible for them as a result. Consequently, spin-offs succeed in transforming technical knowledge into wealth creation through commercialization.

Second, spin-offs also benefit from CEA–LETI's market knowledge. Indeed, CEA–LETI provides spin-offs with strategic alliances in the market and internationalization capabilities, which can be associated with path-dependent market-related capabilities. CEA–LETI encouraged ST, Beamind, and Tronics to develop knowledge-sharing routines through strategic alliances. Existing knowledge at CEA–LETI facilitated understanding and the building of alliances from which both market and technical knowledge could be obtained. Additionally, the ability to develop products internationally has been strongly influenced by market knowledge from LETI as a cumulative, experience-based, and path-dependent capability.

Finally, Beamind suffered from a significant gap between its potential and actual capacity because of its overdeveloped absorptive capacity with regard to both market and technical knowledge. ST also suffered from its single focus on technical knowledge. Both technical and market knowledge can be acquired externally from research centers and customers. In this process, as our study showed, the capacity to absorb both market and technical knowledge combined to guide the three spin-offs in reconfiguring resources, such as technical knowledge, and in considering the constraints of the current market.

On the basis of the previous discussion, we propose the following:

P_3: Spin-offs benefit from customer knowledge and skills when they can access and adequately internalize these skills through improved absorptive capacity.

P_4: Spin-offs benefit from parent research centers' path dependency when they access cumulative technical knowledge and acquire alliance and internationalization capabilities from a pre-existing knowledge base and structure.

5.3. Blending capability

From our discussion, we introduce the concept of *blending capability* to refer to a firm's capability to integrate and balance different types of knowledge, forces, and stakeholders. First, the balance between market and technical knowledge is important; we argue that spin-offs benefit from scientific/technical knowledge from their parent research centers to pursue commercialization and wealth creation guided by sound market knowledge. The joint benefit of both technical and market knowledge requires the configuration of knowledge components, and this process relies on combinative capabilities that are linked to absorptive capacity (Kogut & Zander, 1992; Teece, Pisano, & Shuen, 1997; Van den Bosch et al., 1999).

Second, in the discussion of technology-push versus market-pull (Bennett & Cooper, 1981), we argue that the two forces are complementary and necessary. Technology-push offers vast areas of development and expands the frontier of what is feasible, and market-pull orientation focuses on the satisfaction of customer needs. The mutual exchange of information between sellers and buyers in a bilateral approach offers the benefit of both the buyer-guided and seller-guided approaches.

Third, we explore beyond the "learning dyad" of Lane and Lubatkin (1998) or the one-way learning perspectives of Lane and Lubatkin (1998) and Dyer and Singh (1998) by considering research centers, customers, and spin-offs as playing the roles of both teacher and student. Both reciprocal learning and limited overlapping knowledge exist (Lubatkin, Florin, & Lane, 2001). We observed that strong ties among stakeholders offer a certain ease of learning and impart a positive influence on external knowledge's relevance.

Fourth, the balance between potential and realized absorptive capacity is linked to the opportunities and challenges of customer involvement in radical innovation and to parent research centers' opportunities. We identified the key positive and negative aspects of customer contributions, such as involvement, idea creation, knowledge/lack of knowledge/lack of competencies, and the

difficulties in expressing sticky needs, in terms of potential absorptive capacity as characterized by spin-offs' efforts to identify and assimilate external knowledge.

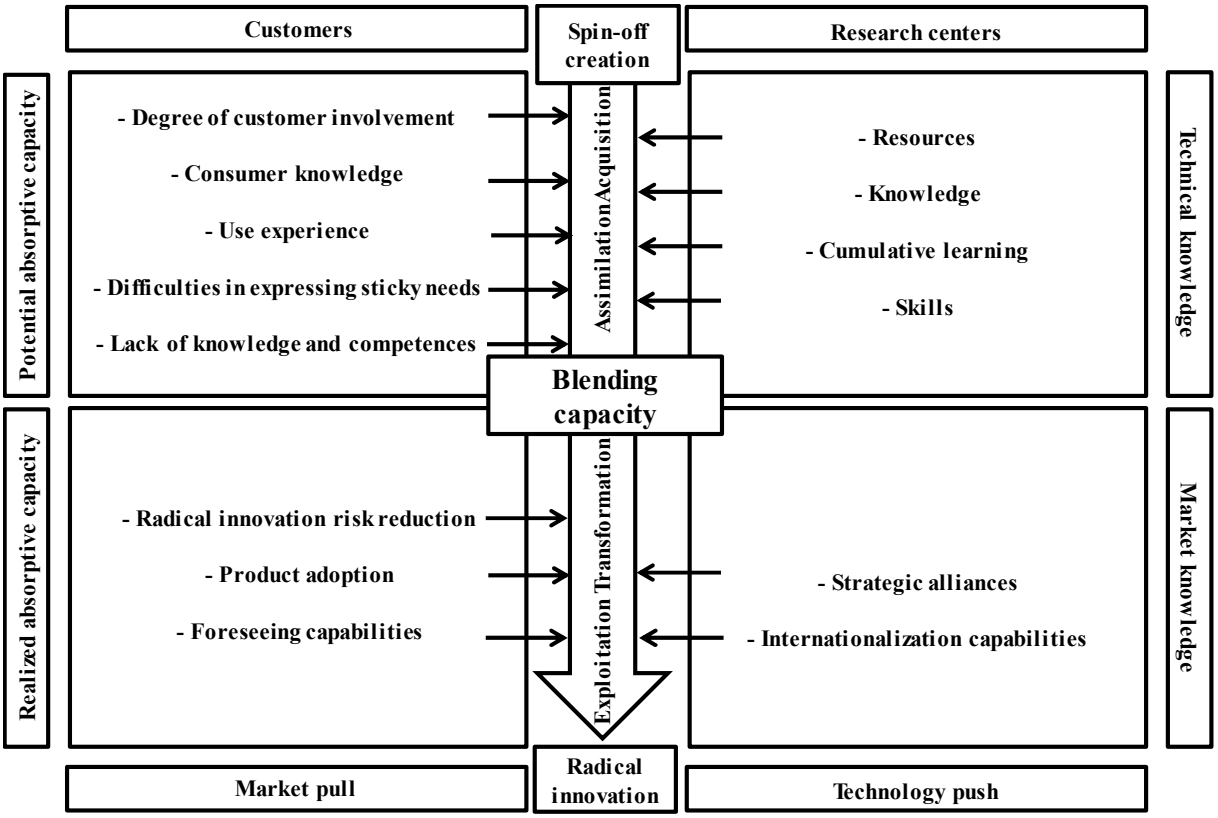
We also identified the key factors of realized absorptive capacity, which characterize how knowledge is transformed and exploited in operations, such as radical innovation risk reduction, product adoption, and foreseeing capabilities. Similar to customers, research centers have an effect on potential absorptive capacity through the supply of resources, knowledge, cumulative learning, and skills as well as on realized absorptive capacity through strategic alliances and the internationalization of capabilities.

In turbulent knowledge environments, we argue that blending capability is needed for spin-offs to conduct NPD toward the commercialization of successful radical innovation (newness, adequate product value, and cost competitiveness). We thus propose the following:

P_5: To conduct successful NPD toward radical innovation success, spin-offs require blending capability as the balance (1) between market and technical knowledge, (2) between market-pull and technology-push approaches, (3) between the involvement of their customers and parent research centers, and (4) between potential and realized absorptive capacity.

Based on proposition 5, we illustrate the blending capacity with Figure 3.

Figure 3: Blending capacity conceptual framework



For managers of spin-offs pursuing radical innovation, our findings highlight the importance of building on the knowledge from both customers and the parent research center. Because spin-offs stem from established research centers, their role and objectives aim to monetize an existing set of technologies, and they are thus more inclined to use a technology-push approach. However, lack of consideration for customer needs may lead to a failure to commercialize technologies. Our recommendation to managers is to develop a blending capability to internalize and exploit the knowledge gained from both customers and the parent research center to improve the fit between the spin-off's technological assets and the research center's potential market. The intensity of customer involvement should also vary across the different NPD stages to ensure that the spin-off is not overwhelmed by the multiple insights brought by its customers.

6. Conclusion, Limitations, and Future Research

Our contribution followed Davis's (1971) recommendations to differentiate an interesting theory (deny assumptions from an audience) from a non-interesting one (affirm assumptions from an

audience). He argued that the evaluation of interesting research is about "what seems to be a good phenomenon is in reality a bad phenomenon" (p. 321). In our work, we did not study the bad phenomenon but, instead, the limitation of customer involvement in radical innovation. In this study, we identified the key benefits and challenges of customer involvement in radical innovation. We also identified the challenges presented by the difficulty of expressing sticky needs and the lack of knowledge or competencies. We critically reviewed the relevant literature and examined how these benefits can be leveraged and how the challenges can be limited by a strong absorptive capacity in the context of radical innovation. Moreover, we focused our study on spin-offs, a particular type of research institution-created start-up that aims to transform technical knowledge into wealth creation through commercialization. Our literature review shows very few studies on this type of start-up, but we believe it deserves more particular attention from innovation scholars given its specificities.

Finally, we identify the study's limitations. First, the scope of our paper is limited to three cases within a particular sector and location. Using this inductive approach, we were only able to formulate propositions and could not generalize from our results. Because there are important differences between spin-offs and regular start-ups, our findings cannot be generalized to regular start-ups or SMEs. Additionally, major differences exist among spin-offs emerging from research centers, from universities, and from corporations; therefore, we cannot generalize our findings to types other than spin-offs emerging from research centers in the Grenoble, France area. Second, we may have retrospective biases when exploring the past events that occurred in the cases. Third, the firms' relatively young ages impose a simpler research framework and limit the study's scope. However, this paper contributes to the development of a multidisciplinary research agenda and identifies several paths for further study.

A general study direction is to continue to investigate the conditions under which customers either assist in or forestall the pursuit of radical innovation. Customer involvement in this type of innovation is subject to controversies, and further studies are necessary to clarify the role of customers

in NPD. Perhaps a follow-up to our study would investigate the appropriate level of involvement in different stages of NPD and how firms can develop superior absorptive capacity to internalize and leverage knowledge gained from customers.

Our study focused on intermediate users, and they differ from end-customer users. Consequently, further studies may be conducted in a B2C setting of radical innovation. We also suggest gathering not only data on advanced and professional users but also on ordinary users. A more specific future study path could be how the use of a toolkit could offset users' lack of knowledge and competences in radical innovation. Radical innovation cases could explore how toolkits (1) allow modifications to account for highly heterogeneous customer preferences; (2) offer user-friendly solutions and give feedback to users as a trial-and-error experimentation process allowing users to learn by doing; and (3) ensure the willingness to pay.

General Conclusion of the dissertation

Involvement in current debates

This dissertation investigated different debates related to the fields of ecosystem, knowledge-based view, absorptive capacity and radical innovation.

We investigated the debate about the convergence or divergence of the four following streams of research: business ecosystem (Moore, 1993), innovation ecosystem (Adner, 2006), entrepreneurial ecosystem (Prahalad, 2005), and the knowledge (based) ecosystem (van der Borgh, Cloodt & Romme, 2012). The increasing number of publications related to the field of ecosystem has multiple negative effects: (1) Research development in silos, (2) poor connection between the streams of research, (3) difficulty to identify the common traits of the streams of research, (4) risk of misuse and overuse of the term ecosystem, (5) and ultimately, risk of discredit of the entire field. In addition, the lack of

theoretical foundation of the field of ecosystems has been identified as a major weakness that require an urgent remedy, for instance by referring to the territorial approach as suggested in the thesis.

This thesis also addressed the debate about technological catch-up of emerging economies from a knowledge-based view perspective (Nonaka & Takeuchi, 1995; Grant, 1996; Spender, 1996). The difference in the organizational learning capabilities, the success or failure of technology transfers, especially occurring with strategic alliances, within the Mashhad ecosystem have been investigated in the thesis. On that specific aspect, the field of absorptive capacity (Cohen & Levinthal, 1990) required further study in investigating the roles of 'teachers' and 'students' in "learning dyad" (Lane & Lubatkin, 1998). More precisely, while the literature is very detailed about a one-way learning dyad between the 'teachers' and the 'students', the literature does not specify the cases of a two-way learning dyads, or even an inverted learning dyad between 'teachers' and 'students'.

Finally yet importantly, the thesis investigated the role of customers in NPD. In particular, by distinguishing radical innovation from incremental innovation, as argued Markides (2006), the literature remained unclear about the impact of involving customers in radical innovation, being either positive or negative. On that specific point, there was a need to further specifying the conditions under which customer involvement can help firms develop or stall radical innovations, developed within the ecosystem of Grenoble.

Answers to sub-research questions

To answer the main research question of the thesis, we will start by providing an answer to all three investigated sub-research questions.

The first sub-research question was: *"What are the conceptualizations of the ecosystem approach, its invariants, and its links with the territorial approach?"*

Based on a systematic literature review on ecosystems, using the methodological approach suggested by Tranfield et al. (2003), we firstly identified 393 references from which we selected 104 items. The conceptualizations of the ecosystem approach embraces four following major and non-convergent research streams: 1) business ecosystems, 2) innovation ecosystems, 3) entrepreneurial ecosystems, and 4) knowledge ecosystems. In comparison with the ecosystem approach, we identified seven major streams of research from the territorial approach: 1) industrial districts, 2) Marshallian districts, 3) innovative milieus, 4) regional innovation systems, 5) new industrial spaces, 6) localized learning, and 7) regional clusters.

We identified the common factors that remain unchanged despite the literature stream, for the ecosystem approach first, and for the territorial approach second, under the name of "invariants". Afterwards, we have been able to make a comparison between the ecosystem approach and the territorial approach, using those invariants. It gave us the opportunity to identify the similarities and the differences across the ecosystem and the territorial approaches.

In terms of similarities, the two approaches have in common: a sense of belonging/trust, stakeholder involvement in the value chain, knowledge dynamics, collaboration/competition, synergies, uncertainty reduction, economics of scale/scope, and innovation outcomes.

We also identified some differences. The ecosystem approach appears as being broader in its scope, by considering entrepreneur, governance/orchestration, knowledge sharing, network/sharing tasks, complementary competencies, interdependence, coevolution, and co-creation, while the territorial approach appears as being more narrow in its focus, in studying the territorial atmosphere, universities and research institutes, tacit knowledge, routine/path dependency, learning, social capital, agglomeration spillovers, and anchoring.

The second sub-research question was: *"What are the challenges of radical innovation, the barriers to technological change, and the difficulties involved in the transfer of tacit and explicit knowledge between two organizations with different degrees of absorptive capacity?"*

From our first empirical study of the Franco-Iranian joint venture between Freyssinet and Azaran, we identified different key challenges to radical innovation: Safety, quality, and planning that engendered negative associated outcomes such as delays, non-conformity to specifications, and additional costs.

From this study, there are numerous take away for practitioners from the Mashhad ecosystem, in defining the right level of innovativeness in projects conducted in developing countries. This specific definition should take into account, as realistically as possible, the local standards of the host country. If the definition of standards intends to impose design newness, small tolerances, and precise sequencing, this would be counterproductive.

Within a given ecosystem, selecting partners having similar knowledge bases, in term of tacit and explicit knowledge, also strongly matter in the success of international joint ventures. Azaran was neglecting the potential learning from Freyssinet's explicit knowledge and was mostly relying on intuitive and imprecise tacit knowledge, which negatively affected the knowledge transfer and the success of the learning dyad. When a 'teacher' as Freyssinet is facing major difficulties in transferring technology, combined with a deficiency of 'student' absorptive capacity, there is no other way for Freyssinet than adapting the operations to the partner.

The third sub-research question was: *"How acquiring knowledge from customers can either facilitate or hinder a firm's quest for radical innovation?"*

The study of technological spin-offs in the ecosystem of Grenoble enabled us to provide an answer to this question. To facilitate the knowledge acquisition from customers in the specific case of

radical innovation, spin-offs had to develop both potential and realized absorptive capacities. Such capabilities were needed to access and absorb knowledge and insights from the market, while offsetting the potential deficiencies of customers' lack of technical knowledge, and difficulties in formulating their needs.

Market knowledge from customers, together with technical knowledge from parent research center CEA driving the ecosystem of Grenoble encourage the spin-offs to develop a unique capability that we call "blending capability" as a balance between (1) market and technical knowledge, (2) market-pull and technology-push approaches, (3) the involvement of customers and parent research centers, and (4) potential and realized absorptive capacities.

Answer to the main research question

After providing an answer to the three sub-research question, we are now able to reply to the main research question of the thesis: *"Which organizational capabilities and inter-organizational knowledge dynamics enable innovation within an ecosystem?"*

To efficiently benefit from both internal and external sources of knowledge to be latterly converted into innovation, organizations have to develop a strong potential and realized absorptive capacity, a good balance between market and technical knowledge, and an equilibrated amount of tacit and explicit knowledge. Ecosystem myopia occurs when a given ecosystem is exclusively focusing on a single aspect, while neglecting the other. First, we emphasized the dominant role of tacit knowledge in the Mashhad ecosystem, which was detrimental to the potential explicit based knowledge transfer. Second, we highlighted the excessive focus on technical knowledge of some firms, like Beamind, within the Grenoble ecosystem, that was suffering of a lack of market knowledge.

Since organizations cannot carry innovation activities on their own, there is a need to involve a large variety of stakeholders such as firms, research centers, universities, public institutions, and

customers from a given ecosystem. Our studies enabled us to identify the advantages and the drawbacks of involving external partners. While most researches focus on positive outcomes, we have been able to mitigate such statements by exploring the risks and the counterproductive effects occurring within ecosystems.

For instance, the literature consider joint venture, as a specific type of strategic alliance, for catalyzing tacit knowledge sharing in dyadic relationship, that was not confirmed in the light of our case study. Different knowledge base associated with a different organizational absorptive capacity did not permit an effective knowledge transfer within the joint venture.

From the other empirical study, involving customers was also of a challenge, depending on the degree of newness of the innovation. In the specific case of radical innovation, we argued that customers might hinder radical innovation NPD. However, we note that the involvement of customers together with the parent research center CEA – central actor within the Grenoble ecosystem - enables spin-offs to offset the deficiencies of the client. In sum, we argue that involving external partners such as firms and clients is challenging, especially in radical innovation.

Beyond the internal perspective and the dyadic perspective, organizations have to identify the Territorial Innovation Model and the ecosystem to operate in. The surrounding environment play an important role in business successes and failures. The choice of operating in a given Territorial Innovation Model matter as they diverge in some fashion. However, beyond the specificity of each kind of Territorial Innovation Model, some common factors emerged such as an enabling territorial atmosphere, the presence of universities and research institutes, the availability of tacit knowledge, the importance of routine/path dependency, potential learning, abundant social capital, agglomeration spillovers, and a strong knowledge anchoring.

In addition to the choice of a given Territorial Innovation Model, there is a need for organization to position themselves in a given ecosystem. Being part of a business ecosystem, an

innovation ecosystems, an entrepreneurial ecosystem, or a knowledge ecosystem carry positive benefits such as the possibility for governance/orchestration, a stronger knowledge sharing, the possibility for networking/sharing tasks, availability of complementary competencies, and opportunities for co-creation.

Contribution

This thesis holds three main contributions. Firstly, we contribute to the field of ecosystem by offering a comparison between the different and divergent sub streams of research. Such a comparison, in addition to the inclusion of different transversal concepts, offer a stronger theoretical base to the entire field in search for a greater legitimacy. The further comparison of the ecosystem approach with the territorial approach contributes to both fields. This further research is meaningful as the two fields of studies co-existed, in isolation, in separated silos, prior to this systematic literature review. Our conceptual framework comparing the list of invariants from both approaches aims at better stabilizing the field of ecosystem with the support of well-established Territorial Innovation Models. In particular, this framework identifies, the invariants of the ecosystem approach (broader side), the invariants of the territorial approach (inner side), and the common invariants. After being in press for only 3 months (Publication date: November 7th, 2018), this contribution seems to be well regarded by many scholars as this specific paper already counts 9 citations and 432 reads on Research Gate (as of January 29th, 2019).

Second, the thesis is also contributing to the field of research of absorptive capacity, in particular on the concept of "learning dyad" by studying two organizations alternatively playing the roles of 'teachers' and 'students' in an international joint venture, within the Mashhad ecosystem. Our intent was to combine individual, organizational, and multi-organizational levels of absorptive capacity, which expands our understanding on the interrelation between those different levels. On that aspect, we observed that the organizational learning nurture (or not) individual learning for different

reasons. Our research also contributes on assessing the complementarity between the sender and receiver during knowledge transfer “from teacher to student”, but also “from student to teacher”. Our main empirical contribution is related to the uniqueness of the case, as of an international joint venture composed of two companies having different knowledge base and different degree of absorptive capacity. Beyond the theoretical contribution to the field of absorptive capacity, this study is meaningful to the Iranian construction sector. In particular, we can identify both economic and social impacts based on our findings. Following the publication of our study in a special issue of Technological Forecasting and Social Change dedicated to the development of science and technology in Iran, the guest editors told us that the Iranian government was considering translating our findings into Farsi to offer vicarious learning to Iranian firms engaged, or about to be engaged, in international strategic alliances.

Third, the thesis contributes to the further study of the customer involvement in the process of radical innovation. The level of involvement of customers along the NPD of radical innovation has been examined in order to determine how customers improved or hindered the process. Our contribution is related to the role of firms’ absorptive capacity in internalizing the knowledge from the customers. Instead of only focusing on the positive impact, our research contribute to tackle the negative impacts of involving customers in product creation and development. Consequently, we have been able to identify both the benefits such as technological awareness, and the challenges such as the difficulty of expressing sticky needs and the lack of knowledge and competencies. From an empirical perspective, we studied the specific case of spin-offs, as a particular type of research institution-created start-up within a given ecosystem that can be differentiated from regular start-up as they transform technical knowledge from their parent research centers into wealth creation through commercialization.

Limitations

Several limitations can be identified in the thesis. First, the SLR only considered peer-reviewed articles in English from the WoS database, meaning that we were not able to consider neither the articles in a different language than English, nor the papers available from another database. Second, from the single in-depth case study of the international joint venture, we are obviously facing the limitation as of the generalization of the findings. Third, from the multiple case studies of spin-offs in Grenoble, there is also a limitation related to the generalization, not only related to the location and to the sector, but also about the type of firms. We cannot generalize the findings of the studied spin-offs to regular start-ups or even SMEs. In addition, spin-offs emerging from research centers diverge from other type of spin-offs emerging either from corporations, or from universities that prevent us from generalizing our findings.

Current and further studies

Following the publication of those three outputs presented in this thesis, I am currently involved in different research projects. Those projects can be considered as further studies as I am continuing my effort in further exploring both fields of ecosystem and absorptive capacity. Those projects are currently under development, and have been submitted to the upcoming EURAM, EGOS, DRUID, and AOM conferences in 2019.

Social Innovation and Social Entrepreneurship from an Innovation Ecosystem Perspective

Together with Steffany Lenis Salcedo (from Colombia) and Agnieszka Radziwon (from Poland), we are currently conducting further studies in the specific stream of innovation ecosystem, by making a novel link with social innovation and social entrepreneurship.

Social challenges such as poverty, inequity, global warming and the lack of education are of increasing importance today. Part of the solution can come from Social Innovation (SI) which could

contribute by revitalizing the social aspects of innovation (van der Have and Rubalcaba, 2016). So far, the SI literature remains scattered among different fields (Cajaiba-santana, 2014) and is marginally addressed from a social entrepreneurship (SE) perspective (Rao-Nicholson, Vorley, & Khan, 2017).

The potential impact of SI is questionable due to the high complexity of social challenges, which should not be underestimated (Avelino et al., 2017). This complexity involves the interdependencies between diverse actors, such as government, NGO's, citizens and firms. The Ecosystem literature embraces such a variety of stakeholders. Consequently, we argue that this specific theoretical background is relevant in addressing SI and the complexity of its dynamics (Phillips *et al.*, 2015; Gomes *et al.*, 2016; Avelino *et al.*, 2017; Rao-Nicholson, Vorley and Khan, 2017).

While Innovation Ecosystem has been studied (Gomes *et al.*, 2016) as a main stream, the specific case of SI, as a potential sub stream, is not studied from an ecosystem perspective. The existence of such a research gap is surprising since innovation ecosystems and SI are highly interconnected and complementary from a territorial perspective. On that specific point, we argue that the economic context matter. SIs outcomes are different whether we consider a developed or a developing country (Rao-Nicholson, Vorley and Khan, 2017; Paolo, Lima and Paroutis, 2018). To further study the overlooked aspects of SI and SE, this study focuses on exploring effectiveness of the implementation of SI and SE from an innovation ecosystem perspective.

Our current understanding is that while SI focuses on finding a solution to social issues through innovation (Avelino et al., 2017), SE focuses on triggering social outcomes for a group of stakeholders (or community). Phillips *et al.* (2015) and Rao-Nicholson, Vorley and Khan (2017) highlight the enabling role of SE in achieving SI. Furthermore, Cajaiba-santana (2014) address SI from a structuralist approach highlighting the importance of external forces embedded into social and cultural contexts enabling SE within an ecosystem.

On the other hand, the ecosystem concept has been evolving since Moore's (1993) seminar work. Within the stream of innovation ecosystem, Gomes *et al.* (2016) argued that the goal is to create value rather than just capturing it, considering all agents involved within an ecosystem that creates complex networks, trust worthy relationships, knowledge spillovers, coopetition, synergies and innovation outcomes. Considering this study and Cajaiba-santana (2014) perspective, we argue that studying SI and SE from an ecosystem view is needed.

In this project, we are currently investigating the following research question: *"What is the role of social innovation – across Columbia and France - from a social entrepreneurship perspective within an innovation ecosystem context?"*

Absorptive capacity as an antecedent of bricolage in resource-constrained firms: The case of Vietnamese SMEs

Together with Thi Kim Son Le (from Vietnam), we are currently working on a research project combining the following bodies of literature: Absorptive capacity, bricolage and Resource Based-View theory.

Resource-poor firms are sometimes able to innovate in unconventional ways. The concept of bricolage is presented to explain how these firms innovate with only limited resources at hand. This finding opens a new research stream exploring which factors encourage some firms to be more innovative through engaging in bricolage behaviour as compared to other firms. Building upon the resources-based view theory, this research suggests bricolage is a strategy to mobilize resources when they are scarce. This research, thus, argues that an internal infrastructure system, absorptive capacity and social networks are fundamental elements driving bricolage behaviour of small and medium enterprises (SMEs) in developing countries.

Previous studies have specified that a prerequisite of innovation in organization is absorptive capacity. The central aspect to the concept of absorptive capacity is the assimilation of external knowledge. From the literature, we know that the accumulated prior knowledge raises a firm's ability to make sense of, assimilate external knowledge to generate new ideas and develop new products (Tsai, 2001). Thus, a firm's knowledge has an important role in raising its ability to engage in bricolage practices (Duymedjian & Rüling, 2010).

In addition, absorptive capacity also requires a learning capability that often involves the ability to exploit and assimilate outside knowledge to use (Kim, 1998). High learning capability supports creativity in inspiring new knowledge and ideas, and, hence, raises the potential to understand and apply these ideas (García-Morales, Ruiz-Moreno, & Llorens-Montes, 2007). Absorptive capacity, influences a firm's ability to identify and assimilate value from external knowledge. Thus, a high level of absorptive capacity could enable a firm to better exploit, apply and recombine knowledge sources when facing new challenges and opportunities.

The fundamental traits of absorptive capacity provide a straightforward argument that it is a necessary antecedent of bricolage. Indeed, bricolage requires ability to access and implement knowledge sources. With bricolage, the purpose is to make/ do with the existing resources the firm has access to. Thus, with a higher absorptive capacity, firms have more efficient processes to identify and exploit the relevant sources of knowledge, ideas and technologies that the firm requires.

Following the same argument, a better ability in applying and using existing resources allows firms to better recombine existing resources to compensate for missing resources (Rosenzweig, Grinstein, & Ofek, 2016; Weick, 1993). Therefore, we argue that a greater accumulation of prior knowledge, experience and learning capability, as the key aspects of absorptive capacity, might encourage a firm to 'make do' and improvise in bricolage activities.

Organizational Learning from Near Misses to Reduce the Occurrence of Adverse Events: An Exploratory Study in Abu Dhabi Hospitals

Together with Maya Mallat (from Lebanon), we currently investigate paths for further studies in relation to the field of organizational learning.

44,000 to 98,000 annual patient deaths are linked to medical errors in the United States. These numbers exceed mortalities due to motor vehicle accidents, breast cancer or AIDS and are equivalent to the crash of a fully loaded 747 jet every 1.5 days (Wachter, 2004). Medical errors are often the result of incidents that cause harmful adverse events. Incidents that could have harmed a patient but were prevented from doing so are referred to as near misses (Kaplan & Fastman, 2003). Amongst other benefits, the analysis of near misses helps to pre-empt injury by revealing deep-rooted system causal factors and by offering recovery strategies. Despite their value, near misses are overlooked as sources of learning in favor of adverse events.

In healthcare, organizational learning from medical errors is a matter of life or death. Although the literature on learning from incidents has grown significantly in the last decades, there is limited research on the concrete learning processes (CLPs) necessary to drive organizational learning (Chuang, Ginsburg, & Berta, 2007; Drupsteen, Groeneweg, & Zwetsloot, 2013). The literature dealing with organizational learning is fragmented and there is a lack of a unified approach integrating the findings from different disciplines (Lindberg, Hansson, & Rollenhagen, 2010).

Using the lens of organizational learning applied to safety science, this study explores organizational learning mechanisms in hospitals. Past researches over the past two decades have revealed three broad factors essential for organizational learning: 1) leadership behavior that provides reinforcement; 2) a supportive learning environment; and 3) CLPs (Garvin, Edmondson, & Gino, 2008).

The latter involves the practices necessary for the generation, collection, interpretation, and dissemination of information. CLPs represent the tangible facet of organizational learning or 'hardware' (Popper & Lipshitz, 1998). The number of studies dealing with CLPs are limited (Lindberg et al., 2010; Wiseman, 2007) that encouraged us to continue investigating in this direction. Furthermore, with the exception of a study from Jeffs (2010), there is no research on the tangible processes used to learn from near misses in healthcare.

Consequently, this research project aims at investigating the following research question: *"What are the CLPs required to drive organizational learning – in Abu Dhabi hospitals in the United Arab Emirates – in order to help reduce the occurrence of adverse events?"*

Final words: Modesty and hard work

My final words I would like to express at the end of this thesis will be about modesty and hard work. Starting with modesty, I personally believe that earning a PhD is somewhat comparable to obtaining the certificate for being able to swim 50 meters, that is frequently asked for kids, as a pre-requisite for signing up in a sailing class. This certificate does not mean you are a great swimmer, it only means that you can survive, without any help, in a swimming pool. To me, earning a PhD is meaningful as it provides a sufficient understanding about how to conduct academic research, but it does not make you a prominent scholar in your field. Consequently, one of my key take away from my experience in research is to remain very modest.

Continuing with hard work, I am aiming at learning something new as daily challenge. Crafting quality research articles and successfully carrying the revision of manuscripts require hard work, no doubt about it. While some people argue about the existence of a rule of thumbs saying that 10,000 hours are needed to become an expert in a field, I personally believe that there is a need for much more than that, not only in term of the number of hours, but also in term of network and international exposure. Hard work is about knowing the evolution of the field of study you intend to contribute to,

but also about know-how, the soft skills in doing research that take much longer to acquire. Those soft skills can be learnt when facing a paper rejection (the hard way) and when discussing with peers (the soft way). I personally believe that I still have a long way to go to further strength both my knowledge and my skills.

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Appendices

Appendix 1: Search Queries

Search	Keyword strings	Total	Total (including only management, business or economics)	Total (excluding proceedings)	Total (excluding duplicates)
1	ecosystem* AND innovat* AND busines*	303	140	96	133
2	ecosystem* AND innovat* AND network*	388	103	62	
3	ecosystem* AND innovat* AND entrep*	107	64	35	
4	ecosystem* AND busines* AND network*	307	89	54	153
5	ecosystem* AND busines* AND entrep*	79	52	32	
6	ecosystem* AND entrep* AND network*	47	19	10	
7	ecosystem* AND innovat* NOT busines* NOT network* NOT entrep*	1,620	128	65	68
8	ecosystem* NOT innovat* AND busines* NOT network* NOT entrep*	874	120	68	
9	ecosystem* NOT innovat* NOT busines* NOT network* AND entrep*	68	12	10	
10	ecosystem* NOT innovat* NOT busines* AND network* NOT entrep*	7,331	96	67	
TOTAL		**11,124**	**823**	**499**	**354**

Last updated on November 3, 2015

Appendix 2: Categories Overview

Category	Subcategory	Definition	Searches 1-6	Searches 7-10
Primary		**The ecosystem term is clearly defined and constitutes the core theme of the paper (AND) the manuscript is well-positioned in the scholarly community.**	**Total: 31**	**Total: 4**
Secondary		**The manuscript refers to an ecosystem definition and does elaborate on it in the theoretical background of the paper; however, it is not the main focus of the paper.**	**Total: 26**	**Total: 4**
	Strategy	These manuscripts mostly focus on platform research (18) and networks (6).	20	4
	Entrepreneurship	These manuscripts mostly focus on entrepreneurial capabilities and innovation.	6	0
Peripheral		**The ecosystem term appears in the manuscript, and it defines a very specific type of an ecosystem (usually in a business ecosystem) represented in a separate literature stream; (OR) the manuscript refers to an ecosystem definition, but it usually does not elaborate on it in the theoretical background of the paper due to a completely different focus of the paper.**	**Total: 50**	**Total: 67**
	Marketing	These manuscripts usually refer to a *service ecosystem*.	20	18
	Information technology	These manuscripts usually refer to various types of technologically immersed ecosystems, usually called a *digital ecosystem*.	9	26
	Urban studies	Regional (innovation) ecosystem or local ecosystem.	9	3
	Others	Not forming any particular group.	12	20
Not relevant		**The ecosystem term appears in the manuscript, but it is rather accidentally used or only appears in the references; (AND) no conceptual link to other scholars is mentioned; (OR) it refers to an ecosystem in a biological sense.**	**Total: 46**	**Total: 126**
	Environmental engineering	These manuscripts usually refer to *ecosystem services*.	13	97
	Others	Not forming any particular group.	33	29

Appendix 3: References of Articles

The 5 character codes were developed based on the first letter of the first author's surname, the title of the article, the two last digits of the publication year, and the first letter of the journal; e.g., the first code, AS13J, was composed of **A**bdelgawad + **S**trategic +20**13** + **J**ournal.

No	Code	Authors	Title	Year	Journal/Publisher
1	AS13J	Abdelgawad et al.	Strategic leadership and entrepreneurial capability for game change	2013	Journal of Leadership & Organizational Studies
2	AM06H	Adner	Match your innovation strategy to your innovation ecosystem	2006	Harvard Business Review
3	AC13E	Adner et al.	Collaboration and competition in business ecosystems	2013	Emerald Group Publishing
4	AV10S	Adner & Kapoor	Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations	2010	Strategic Management Journal
5	AK14R	Agarwal & Shah	Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators	2014	Research Policy
6	AC13A	Alexy et al.	Cui bono? The selective revealing of knowledge and its implications for innovative activity	2013	Academy of Management Review
7	AO14B	Almirall et al.	Open innovation requires integrated competition-community ecosystems: Lessons learned from civic open innovation	2014	Business Horizons
8	AI14T	Autio et al.	Innovation ecosystems: Implications for innovation management	2014	Oxford University Press
9	AE14R	Autio et al.	Entrepreneurial innovation: The importance of context	2014	Research Policy
10	BV09J	Basole	Visualization of interfirm relations in a converging mobile ecosystem	2009	Journal of Information Technology
11	BO11B	Basole & Karla	On the evolution of mobile platform ecosystem structure and strategy	2011	Business & Information Systems Engineering
12	BM13T	Battistella et al.	Methodology of business ecosystems network analysis: A case study in Telecom Italia Future Centre	2013	Technological Forecasting and Social Change
13	BA14E	Benghozi & Salvador	Are traditional industrial partnerships so strategic for research spin-off development? Some evidence from the Italian case	2014	Entrepreneurship & Regional Development
14	BE15C	Blondel & Edouard	Entrance into a platform-dominated market: Virtue of an open strategy on the numerical computation market	2015	Canadian Journal of Administrative Sciences
15	BC08S	Bloom & Dees	Cultivate your ecosystem	2008	Stanford Social Innovation Review
16	BP15T	Bosch-Sijtsema & Bosch	Plays nice with others? Multiple ecosystems, various roles and divergent engagement models	2015	Technology Analysis & Strategic Management
17	BR14I	Buciuni et al.	Rethinking the role of manufacturing in global value chains: an international comparative study in the furniture industry	2014	Industrial and Corporate Change
18	CC12I	Calcei & MaChirgui	Coalition building dynamics in video format wars	2012	Innovation
19	CM12S	Carayannis & Campbell	Mode 3 knowledge production in quadruple helix innovation systems	2012	Springer
20	CC12M	Ceccagnoli et al.	Co-creation of value in a platform ecosystem: The case of enterprise software	2012	MIS Quarterly

No	Code	Authors	Title	Year	Journal/Publisher
21	CP13S	Cennamo & Santalo	Platform competition: Strategic trade-offs in platform markets	2013	Strategic Management Journal
22	CA13I	Chen & Chen	A theory of innovation resource synergy	2013	Innovation: Management, Policy & Practice
23	CE13I	Chen et al.	Evolution of collaborative innovation network in Chinas wind turbine manufacturing industry	2014	International Journal of Technology Management
24	CC14C	Chesbrough et al.	Chez panisse: building an open innovation ecosystem	2014	California Management Review
25	CU14I	Chou & Huang	Understanding the roles of business ecosystems in large public IT infrastructure project development: The case of M-Taipei	2011	International Journal of Information Management
26	CC12I	Christos	Clusters, entrepreneurial ecosystem co-creation, and appropriability: a conceptual framework	2012	Industrial and Corporate Change
27	CC14R	Clarysse et al.	Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems	2014	Research Policy
28	CT02M	Cusumano & Gawer	The elements of platform leadership	2002	MIT Sloan Management Review
29	DM11T	Dedehayir & Makinen	Measuring industry clockspeed in the systemic industry context	2011	Technovation
30	DC06A	Dobson	Competing, countervailing, and coalescing forces: the economics of intra-and inter-business system competition	2006	Antitrust Bulletin
31	DM15A	Dodgson et al.	Managing digital money	2015	Academy of Management Journal
32	EM14T	Ehrenhard et al.	Market adoption barriers of multi-stakeholder technology: Smart homes for the aging population	2014	Technological Forecasting and Social Change
33	FI11E	Faucheux & Nicolai	IT for green and green IT: A proposed typology of eco-innovation	2011	Ecological Economics
34	GC08I	Garnsey & Leong	Combining resource-based and evolutionary theory to explain the genesis of bio-networks	2008	Industry and Innovation
35	GS08R	Garnsey et al.	Speciation through entrepreneurial spin-off: The Acorn-ARM story	2008	Research Policy
36	GC14R	Garud et al.	Contextualizing entrepreneurial innovation: A narrative perspective	2014	Research Policy
37	GA15I	Gastaldi et al.	Academics as orchestrators of continuous innovation ecosystems: towards a fourth generation of CI initiatives	2015	International Journal of Technology Management
38	GB14R	Gawer	Bridging differing perspectives on technological platforms: Toward an integrative framework	2014	Research Policy
39	GI14J	Gawer & Cusumano	Industry platforms and ecosystem innovation	2014	Journal of Product Innovation Management
40	GH12M	Gawer & Cusumano	How companies become platform leaders	2012	MIT Sloan Management Review
41	GE14T	Gomez-Uranga et al.	Epigenetic Economic Dynamics: The evolution of big internet business ecosystems, evidence for patents	2014	Technovation

No	Code	Authors	Title	Year	Journal/Publisher
42	HE12T	Heikkila & Kuivaniemi	Ecosystem under construction: An action research study on entrepreneurship in a business ecosystem	2012	Technology Innovation Management Review
43	HS14J	Hienerth et al.	Synergies among Producer Firms, Lead Users, and User Communities: The Case of the LEGO Producer--User Ecosystem	2014	Journal of Product Innovation Management
44	HS14E	Hu et al.	Sustaining the emerging carbon trading industry development: A business ecosystem approach of carbon traders	2014	Energy Policy
45	IS04H	Iansiti & Levien	Strategy as ecology	2004	Harvard Business Review
46	IT04H	Iansiti & Levien	The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability	2004	Harvard Business Press
47	II06A	Iansiti & Richards	Information technology ecosystem: Structure, health, and performance,	2006	Antitrust Bulletin
48	IA09C	Isckia	Amazon's evolving ecosystem: A cyber-bookstore and Application Service Provider	2009	Canadian Journal of Administrative Sciences
49	IH10H	Isenberg	How to start an entrepreneurial revolution	2010	Harvard Business Review
50	KK15T	Kang & Downing	Keystone effect on entry into two-sided markets: An analysis of the market entry of WiMAX	2015	Technological Forecasting and Social Change
51	KE12H	Kanter,	Enriching the ecosystem	2012	Harvard Business Review
52	KC13S	Kapoor & Lee	Coordinating and competing in ecosystems: How organizational forms shape new technology investments	2013	Strategic Management Journal
53	KD14B	Kshetri	Developing successful entrepreneurial ecosystems: Lessons from a comparison of an Asian tiger and a Baltic tiger	2014	Baltic Journal of Management
54	LU13D	Letaifa et al.	Understanding Business Ecosystems	2013	De Boeck Supérieur
55	LI13C	Leten et al.	IP models to orchestrate innovation ecosystems: IMEC, a public research institute in nano-electronics	2013	California Management Review
56	LP14T	Li & Garnsey	Policy-driven ecosystems for new vaccine development	2014	Technovation
57	LT09T	Li	The technological roadmap of Cisco's business ecosystem	2009	Technovation
58	LB14E	Lu et al.	Business ecosystem and stakeholders role transformation: Evidence from Chinese emerging electric vehicle industry	2014	Expert Systems with Application
59	MI14J	Makinen et al.	Investigating Adoption of Free Beta Applications in a Platform-Based Business Ecosystem	2014	Journal of Product Innovation Management
60	MP93H	Moore	Predators and prey: A new ecology of competition	1993	Harvard Business Review
61	MT96H	Moore	The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems	1996	Harper Business
62	MB06A	Moore	Business ecosystems and the view from the firm	2006	Antitrust Bulletin
63	MP13T	Muegge	Platforms, communities, and business ecosystems: Lessons learned about technology entrepreneurship in an interconnected world	2013	Technology Innovation Management Review
64	NT07E	Nachira et al.	The digital business ecosystem	2007	Edward Elgar Publishing
65	NE13E	Nambisan & Baron	Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-Regulatory Processes and Their Implications for New Venture Success	2013	Entrepreneurship Theory and Practice

No	Code	Authors	Title	Year	Journal/Publisher
66	NO11T	Nambisan & Sawhney	Orchestration processes in network-centric innovation: Evidence from the field	2011	The Academy of Management Perspectives
67	NC13I	Nikayin et al.	Collective action for a common service platform for independent living services	2013	International journal of medical informatics
68	OH15R	Ogilvie	How to Thrive in the Era of Collaborative Services Entrepreneurship	2015	Research-Technology Management
69	OV15J	Oh et al.	Value appropriation between the platform provider and app developers in mobile platform mediated networks	2015	Journal of Information Technology
70	OT14T	Oksanen & Hautamaki	Transforming regions into innovation ecosystems: A model for renewing local industrial structures	2014	The Innovation Journal
71	OC15T	Overholm	Collectively created opportunities in emerging ecosystems: The case of solar service ventures	2015	Technovation
72	PP06E	Peltoniemi	Preliminary theoretical framework for the study of business ecosystems	2006	Emergence: Complexity and Organization
73	PB09S	Pierce	Big losses in ecosystem niches: How core firm decisions drive complementary product shakeouts	2009	Strategic Management Journal
74	PT05P	Prahalad	The Fortune at the Bottom of the Pyramid	2005	Pearson Education
75	PT13H	Prahalad & Ramaswamy	The future of competition: Co-creating unique value with customers	2013	Harvard Business Press
76	PT13A	Priem et al.	Toward reimagining strategy research: Retrospection and prospection in the 2011	2013	Academy of Management Review
77	RV13I	Ritala et al.	Value creation and capture mechanisms in innovation ecosystems: A comparative case study	2013	International Journal of Technology Management
78	RO09R	Rohrbeck et al.	Opening up for competitive advantage - How Deutsche Telekom creates an open innovation ecosystem	2009	R&D Management
79	RB13I	Rong et al.	Business ecosystem extension: facilitating the technology substitution	2013	International Journal of Technology Management
80	RU15I	Rong et al.	Understanding business ecosystem using a 6C framework in Internet-of-Things-based sectors	2015	International Journal of Production Economics
81	RL13I	Rong et al.	Linking business ecosystem lifecycle with platform strategy: a triple view of technology, application and organization	2013	International Journal of Technology Management
82	RR11J	Rong et al.	Reshaping the business ecosystem in China: case studies and implications	2011	Journal of Science and Technology Policy in China
83	RN13I	Rong et al.	Nurturing business ecosystems to deal with industry uncertainties	2013	Industrial Management & Data systems
84	RN15J	Rong et al.	Nurturing business ecosystems for growth in a foreign market: Incubating, identifying and integrating stakeholders	2015	Journal of International Management
85	ST13J	Shang & Shi	The emergence of the electric vehicle industry in Chinese Shandong Province: A research design for understanding business ecosystem capabilities	2013	Journal of Chinese Entrepreneurship

No	Code	Authors	Title	Year	Journal/Publisher
86	SA12S	Shaw & Allen	A systematic consideration of observational design decisions in the theory construction process	2012	Systems Research and Behavioral Science
87	SN13T	Smith	Navigating Risk When Entering and Participating in a Business Ecosystem	2013	Technology Innovation Management Review
88	ST15E	Spigel	The relational organization of entrepreneurial ecosystems	2015	Entrepreneurship Theory and Practice
89	SI14I	Still et al.	Insights for orchestrating innovation ecosystems: the case of EIT ICT Labs and data-driven network visualisations	2014	International Journal of Technology Management
90	SE12E	Suresh & Ramraj	Entrepreneurial ecosystem: case study on the influence of environmental factors on entrepreneurial success	2012	European Journal of Business and Management
91	TI09E	Tee & Gawer	Industry architecture as a determinant of successful platform strategies: A case study of the i-mode mobile Internet service	2009	European Management Review
92	TA14T	Thomas et al.	Architectural leverage: putting platforms in context	2014	The Academy of Management Perspectives
93	VB15T	Valkokari	Business, innovation, and knowledge ecosystems: How they differ and how to survive and thrive within them	2015	Technology Innovation Management Review
94	VV12R	Van Der Borgh et al.	Value creation by knowledge-based ecosystems: Evidence from a field study	2012	R&D Management
95	WW15T	Weber & Hine	Who inhabits a business ecosystem? the technospecies as a unifying concept	2015	Technology Innovation Management Review
96	WT14R	Wei et al.	The fit between technological innovation and business model design for firm growth: evidence from China	2014	R&D Management
97	WE05S	Wessner	Entrepreneurship and the innovation ecosystem policy lessons from the United States, in: Local Heroes in the Global Village	2005	Springer
98	WE12C	Williamson & De Meyer	Ecosystem Advantage	2012	California Management Review
99	WD13M	Woodard et al.	Design capital and design moves: the logic of digital business strategy	2013	MIS Quarterly
100	WA14T	Wright	Academic entrepreneurship, technology transfer and society: where next?	2014	The Journal of Technology Transfer
101	XM10M	Xu et al.	Model of migration and use of platforms: role of hierarchy, current generation, and complementarities in consumer settings	2010	Management Science
102	ZE11A	Zahra & Nambisan	Entrepreneurship in global innovation ecosystems	2011	AMS review
103	ZE12B	Zahra & Wright	Entrepreneurship and strategic thinking in business ecosystems	2012	Business Horizons
104	ZB11T	Zhang & Liang	Business ecosystem strategies of mobile network operators in the 3G era: The case of China Mobile	2011	Telecommunications policy

Appendix 4: Paper Type, Theoretical Perspectives, and Key Contributions

No	Code	Paper type	Theoretical perspectives	Key contributions
1	AS13J	Conceptual	Entrepreneurial capability	Advances the concept of entrepreneurial capability to sense, select, and shape opportunities, and synchronize the strategic moves and resources in pursuit of these opportunities
2	AM06H	Conceptual	Strategic management	Defines and conceptualizes innovation ecosystems linked to value creation, resource allocation, and assessing interdependence, initiative, and integration risks
3	AC13E	Book	Business ecosystem	Deepens the understanding of business ecosystems
4	AV10S	Empirical	Strategic management	Studies the impact of the challenges faced by external innovators on the focal firm's outcomes according to the structure of interdependence
5	AK14R	Literature review	Industry evolution	Offers propositions which provide unique insights into the causes of patterns of industry evolution
6	AC13A	Conceptual	Technology and knowledge management	Discusses selective revealing of knowledge as a strategic mechanism to reshape collaboration
7	AO14B	Conceptual	Open innovation	Offers an integrated ecosystem approach
8	AI14T	Literature review	Innovation ecosystem	Summarizes emerging empirical and conceptual insights regarding innovation ecosystems
9	AE14R	Conceptual	Entrepreneurial innovation	Compares the attributes of national innovation systems, entrepreneurship and entrepreneurial innovation, and categorizes their contextual influences on entrepreneurial innovation
10	BV09J	Empirical	Interfirm relationship and collaboration	Increases the understanding of firm's competitive position in a network context to better characterize the interfirm relationships and ecosystems
11	BO11B	Empirical	Technological platform	Provides a basis for understanding change in the converging mobile ecosystem
12	BM13T	Empirical	Strategic network	Proposes a method for analyzing, modelling and foresighting the business ecosystems as network structures
13	BA14E	Empirical	Strategic alliances	Introduces a new and complementary approach for studying and analyzing the role of alliances in the case of research spin-offs
14	BE15C	Empirical	Open innovation	Concludes that platform strategy coupled with an open strategy could allow a company to penetrate a market dominated by a quasimonopoly of an incumbent platform
15	BC08S	Conceptual	Social entrepreneurship	Offers an ecosystem framework to help social entrepreneurs to create long-lasting and significant social change
16	BP15T	Empirical	Strategic management	Proposes an engagement model
17	BR14I	Empirical	Global value chain	Explores the role manufacturing is playing in the business model of furniture makers operating in mature industrial contexts
18	CC12I	Empirical	Strategic alliance	Demonstrates that various types of agreements are used by the business ecosystem stakeholders to impose their standards
19	CM12S	Conceptual	Quadruple helix	Attempts to provide an emerging conceptual framework for socio-economic prosperity and cultural renaissance based on knowledge and innovation
20	CC12M	Empirical	Platform strategy	Highlights the value of interoperability between software products and stresses that value co-creation and appropriation are not mutually exclusive in interfirm collaboration

No	Code	Paper type	Theoretical perspectives	Key contributions
21	CP13S	Empirical	Platform strategy	Suggests that platform competition is shaped by important strategic trade-offs and that the winner-take-all approach will not be universally successful
22	CA13I	Empirical	Innovation resource synergy	Offers a theoretical model of innovation resource synergy
23	CE13I	Empirical	Collaborative innovation network	Demonstrates the evolutionary trajectory of China
24	CC14C	Empirical	Open innovation	Offers a teaching case
25	CU14I	Empirical	Project development	Differentiates three forms of business ecosystems – knowledge-oriented, resource-oriented, and business-oriented – which emerged in the different phases of project development
26	CC12I	Conceptual	Entrepreneurial theory	Concludes that clusters can involve advantages that help engender superior appropriation of co-created value, as compared to alternatives
27	CC14R	Empirical	Value creation	Analyzes the tension between knowledge and business ecosystems
28	CT02M	Conceptual	Platform strategy	Offers the four levers of platform leadership
29	DM11T	Empirical	Technological system	Shows that the proposed clock speeds together provide informative measures of the pace of change for sub-industries and systemic industry
30	DC06A	Conceptual	Intra-system competition	Highlights the importance of dynamics of market power interactions within and across business systems
31	DM15A	Editorial		
32	EM14T	Empirical	Value network	Develops a generic value network for smart homes and proposes opportunities to improve market adoption of smart home technologies
33	FI11E	Conceptual	Sustainable development	Develops an ecological economic framework
34	GC08I	Empirical	Resource-based and evolutionary theory	Uncovers previously unnoticed features of networks for drug development
35	GS08R	Empirical	Entrepreneurial theory	Proposes the concept of techno-organizational speciation
36	GC14R	Literature review	Actor-centric vs. context-centric	Offers a narrative perspective on how entrepreneurs contextualize innovation
37	GA15I	Editorial		
38	GB14R	Conceptual	Platform	Proposes an integrative framework to advance research in technological platforms
39	GI14J	Empirical	Platform	Identifies and analyzes distinct types of platforms
40	GH12M	Conceptual	Platform strategy	Highlights strategic options for platform leader wannabes
41	GE14T	Empirical	Evolutionary economics	Introduces the concept of epigenetic economic dynamics
42	HE12T	Empirical	Entrepreneurship	Offers an ecosystem model consisting of six sub-ecosystems with different change drivers and clock speeds
43	HS14J	Empirical	NPD synergies	Complements existing studies on user innovation approaches by looking at bilateral interactions
44	HS14E	Empirical	Sustainable development	Explores clean development mechanisms
45	IS04H	Empirical	Ecosystem	Proposes ecosystem strategies
46	IT04H	Empirical	Strategic management	Offers insights into the new dynamics of business ecosystems
47	II06A	Empirical	Ecosystem	Introduces a framework for analyzing the health of a complex business ecosystem
48	IA09C	Empirical	Value network	Discusses the role of web services in the shaping of the ecosystem.

No	Code	Paper type	Theoretical perspectives	Key contributions
49	IH10H	Conceptual	Entrepreneurships	Proposes nine prescriptions for creating an entrepreneurship ecosystem
50	KK15T	Empirical	Platform strategy	Extends the scope of the existing literature on two-sided markets and market entry
51	KE12H	Conceptual	Innovation	Proposes four goals for linking knowledge creation, venture creation, collaboration among firms of different sizes, job creation, university involvement, regional strategy, and investment
52	KC13S	Empirical	Competitive strategies	Highlights the link between firms' coordination choices and their strategic investments
53	KD14B	Empirical	Entrepreneurship theory	Provides unique insights into alternative ways emerging economies can follow to develop successful entrepreneurial ecosystems
54	LU13D	Book	Ecosystem	Confirms the fundamental conceptual nature of the ecosystem metaphor and reconnects the phenomena of scientific conceptualization and linguistic figuration
55	LI13C	Conceptual	Open innovation	Suggests a Dual Core-Dual Site Orchestration Model
56	LP14T	Empirical	Entrepreneurial theory	Shows how research and development networks are needed to further R&D objectives
57	LT09T	Empirical	Technological road map	Explores the ecosystem as a growth strategy enabler
58	LB14E	Empirical	Agent-based system theory	Provides a theoretical framework for analyzing the stakeholders' role transformation
59	MI14J	Empirical	NPD	Concludes that the adoption dynamics of free beta products in a co-creation community follow the Gompertz model rather than the Bass model
60	MP93H	Conceptual	Ecosystem	Defines and conceptualizes business ecosystems
61	MT96H	Conceptual	Ecosystem	Further conceptualizes business ecosystems
62	MB06A	Conceptual	Economic organization	Discusses three pillars of modern business thinking
63	MP13T	Conceptual	Technology entrepreneurship	Provides an entry point to the research literature and identifies gaps in the current body of knowledge, especially regarding the system-level interactions between subsystems
64	NT07E	Book	Digital ecosystem	Insights into software services and technology platforms as well as the complexity of social and economic relationships
65	NE13E	Conceptual	Entrepreneurial innovation	Extends current theory concerning the potential role of self-regulatory processes in entrepreneurship
66	NO11T	Empirical	Product development and network theory	Concludes that network orchestration processes reflect the interplay between elements of innovation design and network design
67	NC13I	Empirical	Platform	Offers insights into organizational perceptions about important factors that encourage inter-organizational collaboration for establishing common platforms
68	OH15R	Empirical	Entrepreneurship	Offers an ecosystem-based business model
69	OV15J	Empirical	Platform	Proposes a new bargaining model
70	OT14T	Empirical	Triple helix	Proposes a model for building innovation ecosystems
71	OC15T	Empirical	Entrepreneurial opportunity	Offers fundamental observations of how opportunity creation and discovery is distributed among a community of entrepreneurs
72	PP06E	Conceptual	Complex adaptive system	Proposes a theoretical framework for the study of business ecosystems
73	PB09S	Empirical	Complementary niche market	Develops the understanding of how competition in business ecosystems evolves
74	PT05P	Book	Bottom of the pyramid	Shows that bottom of the pyramid (BOP) markets are too important to be ignored
75	PT13H	Book	Strategic management	Explores why, despite unbounded opportunities for innovation, companies still can't satisfy customers and sustain profitable growth

No	Code	Paper type	Theoretical perspectives	Key contributions
76	PT13A	Conceptual	Value creation and capture	Proposes an expanded boundary model that includes the demand side, business models, and business ecosystems within the strategy research umbrella
77	RV13I	Empirical	Value creation and capture	Provides new evidence on the facilitating initiatives and underlying mechanisms and structures that are related to the leading firms' orchestration of innovation ecosystems
78	RO09R	Empirical	Open innovation	Identifies opening up traditional development process and embracing external creativity and knowledge resources to enhance the innovation capacity
79	RB13I	Empirical	Technology substitution	Identifies the determinants of sustaining the ecosystem extension
80	RU15I	Empirical	Supply chain	Proposes a 6C framework to understand how a business ecosystem works
81	RL13I	Empirical	Platform strategy	Connects the core firms in the business ecosystem with the evolutionary platform strategies
82	RR11J	Empirical	Traditional network vs. service intermediaries	Identifies five key strategies for reshaping business ecosystems
83	RN13I	Empirical	Platform strategy	Discusses emerging industry uncertainty
84	RN15J	Empirical	Road map	Develops a framework of creating a business ecosystem
85	ST13J	Empirical	Strategic capabilities	Provides a conceptual research framework regarding business ecosystem emergence
86	SA12S	Conceptual	Theory construction	Develops a theoretical model of the theory-building process that avoids bias whilst making best use of the researchers' preconceptions based on a business ecosystem metaphor
87	SN13T	Literature review	Entrepreneurial	Provides five recommendations for entrepreneurs seeking to enter and participate in business ecosystems
88	ST15E	Empirical	Entrepreneurial theory	Demonstrates the variety of different configurations that ecosystems can take
89	SI14I	Empirical	Social network	Demonstrates that data-driven network visualizations offer a powerful approach for providing evidence-based information when talking about ecosystems
90	SE12E	Empirical	Bottom of the pyramid	Offers a conceptual framework along with factors comprising the ecosystem
91	TI09E	Empirical	Platform strategy	Unpacks the interaction between evolutionary processes, industry architecture, and business strategies
92	TA14T	Literature review	Platform	Extends current thoughts on platform evolution
93	VB15T	Conceptual	Ecosystem	Describes how the ecosystem types differ in terms of their outcomes, interactions, logic of action, and actor roles
94	VV12R	Empirical	Value creation	Concludes that ecosystem managers have to deliberately facilitate exit routes for companies that no longer fit the ecosystem in order to enhance and reinforce its business model
95	WW15T	Conceptual	Technospieces approach	Proposes a business ecosystem model anchored around interdependent technospecies
96	WT14R	Empirical	Business model	Concludes that efficiency-centered business model design enhances the negative effect of exploitative innovation and weakens the positive effect of exploratory innovation
97	WE05S	Conceptual	Entrepreneurship	Offers lessons from small business innovation research for comparable initiatives in civic entrepreneurship
98	WE12C	Empirical	Network	Provides insights into a lead firm's strategic approach
99	WD13M	Empirical	Digital business strategy	Advances the notion that conceptualizations of a digital business strategy can and should be grounded in the strategic role of design capital and design moves

No	Code	Paper type	Theoretical perspectives	Key contributions
100	WA14T	Conceptual	Academic entrepreneurship	Provides a broader conceptualization of academic entrepreneurship and an appreciation of the contextual heterogeneity of academic entrepreneurship
101	XM10M	Empirical	Information systems and consumer behavior	Contributes to research on platform leadership and technology ecosystems by conceptualizing complementarities at a micro level
102	ZE11A	Conceptual	Entrepreneurship theory	Concludes that new ventures dependencies with the ecosystem leader define the nature and extent of entrepreneurship within innovation ecosystems
103	ZE12B	Conceptual	Entrepreneurship theory	Distinguishes four types of business ecosystems
104	ZB11T	Empirical	Keystone strategy	Identifies success factors and problems related to ecosystem principles

Appendix 5: Theoretical Background or Articles

No	Code	Ecosystem type	Adner, 2006; Adner & Kapoor, 2010	Moore 1993, 1996, 2006	Iansiti & Levinen, 2004a, 2004b	Isenberg, 2010; Prahalad, 2005
1	AS13J	Business ecosystem	X	X		
2	AM06H	Innovation ecosystem			X	
3	AC13E	Business ecosystem	X	X	X	
4	AV10S	Innovation ecosystem	X	X	X	
5	AK14R	Entrepreneurial ecosystem, innovation ecosystem	X			
6	AC13A	Innovation ecosystem	X			
7	AO14B	Ecosystem			X	
8	AI14T	Innovation ecosystem	X	X	X	
9	AE14R	Entrepreneurial ecosystem				X
10	BV09J	Business ecosystem	X	X	X	
11	BO11B	Business ecosystem		X	X	
12	BM13T	Business ecosystem	X	X	X	
13	BA14E	Business ecosystem		X	X	
14	BE15C	Business ecosystem		X	X	
15	BC08S	Ecosystem	X	X	X	
16	BP15T	Business ecosystem	X	X	X	
17	BR14I	Domestic ecosystem		X	X	
18	CC12I	Business ecosystem		X	X	
19	CM12S	Innovation ecosystem				
20	CC12M	platform ecosystem			X	
21	CP13S	Ecosystem				
22	CA13I	Business ecosystem		X	X	
23	CE13I	Business ecosystem	X	X	X	
24	CC14C	Open innovation ecosystem				
25	CU14I	Business ecosystem		X	X	
26	CC12I	Entrepreneurial ecosystem				
27	CC14R	Knowledge ecosystem	X	X	X	

No	Code	Ecosystem type	Adner, 2006; Adner & Kapoor, 2010	Moore 1993, 1996, 2006	Iansiti & Levinen, 2004a, 2004b	Isenberg, 2010; Prahalad, 2005
28	CT02M	Innovation ecosystem				
29	DM11T	Business ecosystem	X			
30	DC06A	Business ecosystem		X	X	
31	DM15A	Innovation ecosystem	X			
32	EM14T	Business ecosystem		X	X	
33	FI11E	Business ecosystem		X		
34	GC08I	Business ecosystem	X	X		
35	GS08R	Business ecosystem		X		
36	GC14R	Entrepreneurial ecosystem	X			
37	GA15I	Innovation ecosystem	X			
38	GB14R	Innovation ecosystem	X		X	
39	GI14J	Business ecosystem	X	X	X	
40	GH12M	Innovation ecosystem				
41	GE14T	Business ecosystem			X	
42	HE12T	Business ecosystem	X	X	X	
43	HS14J	Business ecosystem	X		X	
44	HS14E	Business ecosystem	X	X	X	
45	IS04H	Business ecosystem				
46	IT04H	Business ecosystem		X		
47	II06A	Business ecosystem		X	X	
48	IA09C	Business ecosystem		X	X	
49	IH10H	Entrepreneurial ecosystem				
50	KK15T	Business ecosystem		X	X	
51	KE12H	Business ecosystem				
52	KC13S	Business ecosystem	X		X	
53	KD14B	Entrepreneurial ecosystem				X
54	LU13D	Business ecosystem		X	X	
55	LI13C	Innovation ecosystem				
56	LP14T	Innovation ecosystem	X	X		

No	Code	Ecosystem type	Adner, 2006; Adner & Kapoor, 2010	Moore 1993, 1996, 2006	Iansiti & Levinen, 2004a, 2004b	Isenberg, 2010; Prahalad, 2005
57	LT09T	Business ecosystem	X	X	X	
58	LB14E	Business ecosystem	X	X	X	
59	MI14J	Business ecosystem	X	X	X	
60	MP93H	Business ecosystem				
61	MT96H	Business ecosystem		X		
62	MB06A	Business ecosystem		X	X	
63	MP13T	Business ecosystem		X	X	X
64	NT07E	Business ecosystem innovation ecosystem		X	X	
65	NE13E	Innovation ecosystem	X	X	X	
66	NO11T	Innovation system			X	
67	NC13I	Business ecosystem		X	X	
68	OH15R	Business ecosystem		X		
69	OV15J	Mobile ecosystem				
70	OT14T	Innovation ecosystem				
71	OC15T	Business ecosystem	X	X		
72	PP06E	Business ecosystem		X	X	
73	PB09S	Business ecosystem		X	X	
74	PT05P	Entrepreneurial ecosystem				
75	PT13H	Entrepreneurial ecosystem				X
76	PT13A	Business ecosystem	X			
77	RV13I	Innovation ecosystem	X	X	X	
78	RO09R	Open innovation ecosystem		X		
79	RB13I	Business ecosystem	X	X	X	
80	RU15I	Business ecosystem	X	X	X	
81	RL13I	Business ecosystem	X	X		
82	RR11J	Business ecosystem		X		
83	RN13I	Business ecosystem		X	X	X
84	RN15J	Business ecosystem	X	X	X	
85	ST13J	Business ecosystem	X	X	X	

No	Code	Ecosystem type	Adner, 2006; Adner & Kapoor, 2010	Moore 1993, 1996, 2006	Iansiti & Levinen, 2004a, 2004b	Isenberg, 2010; Prahalad, 2005
86	SA12S	Business ecosystem	X	X	X	
87	SN13T	Business ecosystem	X	X	X	
88	ST15E	Entrepreneurial ecosystem				X
89	SI14I	Innovation ecosystem				
90	SE12E	Entrepreneurial ecosystem				
91	TI09E	Business ecosystem			X	X
92	TA14T	Platform ecosystem			X	
93	VB15T	Business ecosystem, innovation ecosystem, knowledge ecosystem	X	X	X	
94	VV12R	knowledge ecosystem		X	X	
95	WW15T	Business ecosystem	X	X	X	
96	WT14R	Business ecosystem	X	X		
97	WE05S	Innovation ecosystem				
98	WE12C	Ecosystem	X	X	X	
99	WD13M	Business ecosystem	X		X	
100	WA14T	Business ecosystem, innovation ecosystem		X		
101	XM10M	Innovation ecosystem	X			
102	ZE11A	Innovation ecosystem	X	X	X	
103	ZE12B	Business ecosystem	X	X	X	
104	ZB11T	Business ecosystem	X	X	X	
	TOTAL		**47**	**64**	**61**	**7**

Appendix 6: Outline of the Key Journals that Sourced Publications for the Content Analysis

Journal	Count
International Journal of Technology Management	6
Research Policy	6
Harvard Business Review	5
Technology Innovation Management Review	5
Technovation	5
Strategic Management Journal	4
Antitrust Bulletin	3
California Management Review	3
Journal of Product Innovation Management	3
R&D Management	3
Technological Forecasting and Social Change	3
Academy of Management Review	2
Business Horizons	2
Canadian Journal of Administrative Sciences	2
Entrepreneurship Theory and Practice	2
Industrial and Corporate Change	2
Journal of Information Technology	2
MIS Quarterly	2
MIT Sloan Management Review	2
The Academy of Management Perspectives	2

Appendix 7: Most Frequent Authors and Co-authors

Author	Count
Rong Ke	9
Shi Yongjiang	9
Gawer Annabelle	5
Nambisan Satish	4
Adner Ron	3
Autio Erkko	3
Cusumano Michael A	3
Garnsey Elizabeth	3
Hu Guangyu	3
Iansiti Marco	3
Lin Yong	3
Moore James F	3
Wright Mike	3
Yu Jiang	3
Zahra Shaker	3

Appendix 8: Knowledge and organizational capabilities in various Iranian sectors

Knowledge	Knowledge sharing	Pool et al., 2014
	Knowledge transfer	Bahrami et al., 2014; Tohidi et al., 2012; Tavani et al., 2013
	Knowledge management	Darvish et al., 2012; Chu et al., 2014; Jafari et al., 2013; Shafia et al., 2011; Bahrami et al., 2014
	Tacit knowledge	Pournader et al., 2015; Jafari et al., 2013; Shafia et al., 2011
	Explicit knowledge	Ranjbarfard et al., 2013
	Both tacit and explicit knowledge	Madani et al., 2012; Chu et al., 2014; Mohammadi et al., 2014
	Balanced Scorecard	Akhavan et al., 2013; Darvish et al., 2012; Ghazinoory & Soofi, 2012
	SECI model	Mehralian, Nazari et al., 2014
Organizational capabilities	R&D	Ghazinoory & Ghazinouri, 2009; Soofi & Ghazinoory, 2011
	Technology transfer	Madani et al., 2012; Bahadori, et al., 2012
	Communication	Pournader et al., 2015; Tavani et al., 2013
	Learning	Sharifirad, 2011; Ghazinoory et al., 2014; Nekoei Moghaddam & Beheshti Far, 2007; Ghazinoory & Soofi, 2012; Tohidi et al., 2012; Bahadori et al., 2012; Ahmadi et al., 2014
	Absorptive capacity	Madani et al., 2012; Tavani et al., 2013; Dadfar et al., 2013
	Innovation	Ghazinoory et al., 2014; Tohidi et al., 2012; Akhlagh et al., 2013; Ghazinoory & Ghazinouri, 2009; Soofi & Ghazinoory, 2011; Dadfar et al., 2013; Chu et al., 2014
Sectors	Construction	Tabassi & Abu Bakar, 2009; Akhavan, 2006; Berberian & Yeats, 1999; Ghafory-Ashtiany & Eslami, 1997; Mehrabian & Haldar, 2005; Akhlagh et al., 2013; Tabassi et al., 2012; Pournader et al., 2015; Mehrabian et al., 2005; Jafari & Love, 2013
	Manufacturing	Sharifirad, 2011; Ghazinoory et al., 2011; Azadegan et al., 2011; Soofi & Ghazinoory, 2011; Akhavan et al., 2013; Tavani et al., 2013; Tohidi et al., 2012
	Automotive	Darvish et al., 2012; Mohammadi et al., 2014; Jafari et al., 2013; Shafia et al., 2011
	Nanotechnologies	Ghazinoory & Ghazinouri, 2009; Ghazinoory & Farazkish, 2010; Ghazinoory & Soofi, 2012
	Health care	Bahadori et al., 2012; Nekoei et al., 2007
	Biopharmaceutical	Madani et al., 2012; Dadfar et al., 2013
	Petroleum	Maroofi & Sadqi, 2012; Mousaei et al., 2006
	Services	Sharifirad, 2011
	Tourism	Ahmadi et al., 2014
	Public services	Ranjbarfard et al., 2013

Appendix 9: List of interviews

Interview ID	Date	Location	Language	Length	Name	Organization	Job description	Education background
#1	07/11/2013	Paris	French	30’	BG	Freyssinet	Project manager	Engineer
#2	14/11/2013	Paris	English	20’	JC	RFR	Project manager	Engineer
#3	27/11/2013	Paris	French	50’	JFK	Esmery Caron	Design engineer	Engineer
#4	20/12/2013	Mashhad	French	30’	PB	Esmery Caron	Technical manager	Engineer
#5	11/01/2014	Paris	French	20’	AM	Freyssinet	Sales person	Engineer
#6	19/01/2014	Mashhad	English	40’	SK	Azaran	Site manager	Engineer
#7	23/01/2014	Tehran	English	30’	EM	Azaran	Project manager	Engineer
#8	29/01/2014	Mashhad	English	30’	SG	Civil and development organization of Khorasan	Site manager	Bachelor
#9	02/02/2014	Mashhad	English	25’	GB	Civil and development organization of Khorasan	Design Manager	Engineer
#10	06/02/2014	Mashhad	French	30’	MK	RFR	Managing Director	PhD
#11	10/02/2014	Mashhad	English	35’	MN	Freyssinet	Supervisor	High school
#12	18/02/2014	Mashhad	French	45’	AG	Freyssinet	Method Engineer	Engineer
#13	03/03/2014	Mashhad	Farsi	10’	MR	Azaran	Project director	Engineer
#14	03/03/2014	Mashhad	Farsi	15’	AL	Azaran	Surveyor	Bachelor
#15	15/03/2014	Mashhad	French	60’	MG	Freyssinet	Project manager	Bachelor
#16	28/03/2014	Mashhad	Farsi	20’	MN	Freyssinet	Admin. affairs	High school
#17	08/04/2014	Mashhad	Farsi	15’	EM	Azaran	Worker	No degree
#18	10/04/2014	Mashhad	English	50’	MM	Azaran	Quality manager	Bachelor
#19	13/04/2014	Mashhad	English	60’	MD	Azaran	Survey manager	Engineer
#20	15/05/2014	Mashhad	French	120’	AC	Freyssinet	Bus. Unit manager	Engineer
#21	16/06/2014	Mashhad	English	20’	JC	RFR	Project manager	Engineer

#22	07/07/2014	Mashhad	French	30’	BG	Freyssinet	Project manager	Engineer
#23	14/07/2014	Mashhad	English	25’	NH	Freyssinet	Site engineer	Engineer
#24	18/07/2014	Mashhad	English	30’	SB	Fatzer	Sales manager	Engineer
#25	29/07/2014	Mashhad	English	30’	KT	Fatzer	Project manager	Engineer
#26	09/08/2014	Mashhad	Farsi	35’	OM	Azaran	Tea boy	No degree
#27	27/08/2014	Mashhad	English	60’	JL	Freyssinet	Supervisor	High school
#28	07/09/2014	Mashhad	French	40’	RV	Freyssinet	Store man	High school
#29	15/09/2014	Mashhad	English	60’	EM	Freyssinet	Supervisor	High school
#30	23/09/2014	Mashhad	Farsi	20’	RT	Azaran	Supervisor	No degree
#31	24/09/2014	Mashhad	Farsi	15’	SS	Azaran	Supervisor	High school
#32	30/10/2014	Mashhad	French	30’	TC	Freyssinet	Depot manager	Bachelor
#33	12/11/2014	Mashhad	Farsi	15’	AM	Azaran	Worker	No degree
#34	20/11/2014	Paris	English	40’	RP	E-Man Serve	JV manager	Engineer
#35	14/12/2014	Tehran	French	60’	AB	E-Man Serve	Managing director	PhD
#36	14/12/2014	Mashhad	Farsi	45’	AR	Janbaz construction	Site manager	Bachelor
#37	15/12/2014	Mashhad	French	15’	BG	Freyssinet	Project manager	Engineer
#38	16/12/2014	Mashhad	French	30’	SL	Architexsteel	Director	Bachelor
#39	03/03/2015	Mashha	French	30’	TC	Architexsteel	Technician	High school
#40	03/05/2015	Mashhad	English	20’	RH	Azaran	Drafter	High school
#41	05/05/2015	Mashhad	English	35’	RA	Astân-e Ghods	Managing director	Engineer

Appendix 10: Coding scheme

Technology development (7 codes)	Technological gaps
	Technological investment
	Technological diffusion
	Technological spillovers
	Technological design
	Technological materials
	Technological quality
Innovation (9 codes)	Innovation radicalness
	Innovation to firms
	Innovation to industry
	Innovation to customers
	Innovation usefulness
	Innovation safety
	Innovation standardization
	Innovation costs
	Innovation uncertainty
Individual absorptive capacity (6 codes)	Individual existing knowledge
	Individual ability to learn
	Individual needs of training
	Individual on-the-job training
	Individual off-the-job training
	Individual improvement
Organizational absorptive capacity (7 codes)	Organizational pre-existing knowledge
	Organizational path dependency
	Organizational perception
	Organizational acquisition
	Organizational cognition
	Organizational learning
	Organizational memory
Multi-organizational absorptive capacity (8 codes)	Multi-organizational knowledge transfer
	Multi-organizational routines
	Multi-organizational learning dyad
	Multi-organizational specificity
	Multi-organizational similarity
	Multi-organizational familiarity
	Multi-organizational complementarity
	Multi-organizational overlap
Knowledge (6 codes)	Knowledge in explicit form
	Knowledge in tacit form
	Knowledge socialization
	Knowledge externalization
	Knowledge combination
	Knowledge internalization

Appendix 11: Differences between Spin-Offs and Regular Start-Ups

Discriminant factors	Spin-offs	Regular start-ups
Knowledge base	Technology oriented	Marketing oriented
Access to capabilities	From parent institutions	From the founder
Relationships	Dyadic	Network
Search	Local search	Broad search
Heritage	Parental heritage	No parental heritage
Potential absorptive capacity	Superior	Normal
Trajectory	Inertia	No inertia
Time to market	Long term	Short term
Customers' involvement	Limited interest	Stronger interest
Survival rate	Higher	Normal
Performance	Superior	Normal

Appendix 12: Successful Spin-Offs

Name of CEA-LETI spin-off	Sofradir	ELDIM	Soitec	CORYS
Date of creation	1986	1991	1992	1997
Activity	Development and production of space and commercial applications	Design and production of metrology equipment and optics components	Design and production of silicon-on-insulator (SOI) wafers	Design and production of training simulators for transportation and energy
Customer	Defense and security industry (Thales and Sagem); Anticipation of the future market fit related to optronics defense system	Optic, multimedia, defense, and healthcare industry; 7,000 cancer networks centers worldwide bought the machine; 93% of exportation	Semi-conductor industry (Freescale, IBM, Philips, Sony, Toshiba, etc.)	Transportation and energy industry (EDF, SNCF); Market need: Train people to comply with the regulations, to discover their future line, to react to breakdowns, to face scenarios, etc.
Radical innovation	Infrared space technologies	Optic technology	Pioneer in the use of Smart Cut technology	Simulation
Outcomes	Ranked 1st in Europe and 2nd worldwide in their market; 350 people	Leader in its market; 15% annual growth rate; 45 people	Worldwide leader on SOI substrates; Listed on the Euronext Paris exchange; 520 people	World leader in driver training simulators for transportation and energy; 230 people

Appendix 13: Failed Spin-Offs

Name of CEA– LETI spin-offs	Silmag	Pixtech	PHS MEMS	Alditech
Date of creation	1991	1992	1998	1998
Activity	Production of playback heads for hard drives (26 million of playback heads in 1995)	Production of flat screens with micro-point technology	Design, development, and production of passive components and packaging	Production of high performance heads for multimedia tape recording.
Customers	Samsung only; Refused the offer from Western Digital and Maxtor to produce similar products	Customer goods industry; Refused the opportunity to reuse micro-point technology in aeronautics and automotive applications	The wireless and optical fiber communications industries; Variety of standards for multiple customers; Particular technical needs	Tape drive and reproduction industries; Market not ready to purchase products; Technology perceived as "old-fashioned"
Radical innovation	Tried to impose their technical knowledge as the standard; Ahead to its competitors	Focused on technical knowledge and product perfection; Focused on flat screen application	Development of additional functions Perfect technical integration; Intent to lead a technological revolution	High-performing technologies for data storage and digital video
Issues	Delay of 1 year to launch the manufacturing; Length of the manufacturing; Asian crisis; No payment of Samsung	Delay of product development	Cost constraints	Weak technology acceptance
Outcomes	No positive results generated since its creation; Unemployment of 550 people	No positive results generated since its creation; Unipac took over Pixtech in 1999 and failed in 2001; Never paid the 5 million in royalties due to CEA–LETI	6 million Euros in losses to set up the manufacturing; 1.2 million in turnover; Total investment of 50 million Euros; Unemployment of 93 people	Impairment of assets
Date of failure	1998	2001	2003	2007

Appendix 14: Acquired Mature Start-Ups

Name of CEA– LETI spin-off	Crismatec	ICAP	CSO	Apibio
Date of creation	1970	1986	1987	2001
Activity of the spin-off	Design and production of optics application	Design and production of scientific and technical measurement machines	Design and production of measurement system	Production and commercialization of biochips
Takeover firm	Saint-Gobain	Cybernétix	CSO Sageis	bioMérieux
Radical innovation	Mono-crystal technology	Robotics in hostile environment; Tele-guided technology; Off-shore monitoring; Underwater infrastructure	Optics, optometric, electronics, mechanics, and industrial informatics	R&D integrated within bioMérieux's Molecular Biology and Microsystems Centre in Grenoble; Specialization in infectious diseases
Customers	Entry into laser market dominated by American firms; Medical scanners Good pricing policy	Nuclear market (EDF); Oil & gas Industry; Naval defense (Thalès, and Dassault Systems)	Measurement system of vibration, calibration, speed, thickness and motion	Food applications; BioPharma applications
Outcomes	Difficulties in the construction and industrial activities (2009); 17.2% decrease of sales volume; 189,193 people	Down by 18.2% for the second trimester 2011 compared to 2010; 150 people	Under financial issues; Turnover €1,624,418 (2006); Net result €-465,147 (2006)	Decrease of the price of the share (publication of the second trimester 2011 results)

Appendix 15: List of Interviews

Company	Position held by interviewee	Background	ID #
Tronics	Founder and CEO of Tronics	PhD, researcher at CEA–LETI	1
Tronics	In charge of product testing	Engineer from ENSPG, DEA, product manager	2
Tronics	COO of Tronics, production and R&D	BTS in industrial electro-technics, engineer in electro-mechanics, Merlin Gerin, CEA–LETI for 21 years	3
Beamind	CEO of Beamind	Engineer from Supelec, PhD, industrial job	4
Beamind	Early contributor at Beamind	Senior consultant	5
Beamind	Technical director of Beamind	Engineering degree, PhD in physics, researcher in CEA–LETI, creation of Beamind, initial R&D, supply chain management	6
Beamind	Software development at Beamind	Engineer in informatics, worked for SAGEM	7
Beamind	R&D engineer at Beamind	Engineering degree	8
Beamind	Software development at Beamind	Science degree at university, regional job background	9
Beamind	R&D, Integrated Circuit and laser testing	Technical degree in optics instruments, military industry background	10
ST Microelectronics	Informatics project leader (software development tools)	Master in informatics. 7 years in one SME, half a year in another. Hired by ST as a software developer and then team leader.	11
ST Microelectronics	Chief of the informatics support department of Europe, Middle East and Africa (100 people)	Electronics and informatics master. Software development, project leader, risk manager and central informatics department.	12
ST Microelectronics	Design leader of power ships (4 years). Creation of customized products, platforms and normalization. Top circuits creation and simulations	University diploma A, engineering school (FIUPSO). Hired by ST in 1996 after work placement.	13
ST Microelectronics	Test engineer. Analysis and testing of electronic circuits and creation of software (R&D and programming).	Engineer (INPG), SME experience (Novelec). Hired by ST (14 years).	14
ST Microelectronics	Design project leader for ABB products (multifunction chips for high end mobile phones). Management of a R&D team (6-8 people at the first level and 34 at the second level).	A level E (Math and techniques), university diploma in automatism (Besançon), Engineering School of Mechanics and Micro-techniques (ENSMM).	15
ST Microelectronics	Design layout manager for ASSP circuit before manufacturing. Team of 5 people.	University diploma of electronic. Worked in F6 which became ST afterwards. DEST in electronics. CESI training to became manager (2000).	16
ST Microelectronics	Designer backend, draws circuits according to an initial schema. Translation from layout to silicone composition.	Engineer in materials (INSA), 3 years in a KIBS. Hired by ST (2005).	17
ST Microelectronics	Project leader of the IC. Coordination of tasks to create a new	University diploma in electronics, worked in the engineering section of Thomson. Joint degree between GEM and an engineering school in	18

	product (planning, managerial accounting, and quality).	electronics (ENSERG). Creation of engineering tools and software in quality management.	
ST Microelectronics	Technical marketing of ASSP products for mobile phones. Customer services for Nokia, Samsung, LG, Motorola, Garmin (GPS).	Engineer (ESIEE), design of circuits, definition and specification of products	19
ST Microelectronics	Power management of numerical and mix circuits	A level C university diploma, engineering school (ISIM of Montpellier). Thomson RCM, Thomson Military and Space. ST for 8 years.	20
ST Microelectronics	Test of ASIC (Nokia) and ASSP products for platforms dealing with several circuits (Ship set)	Mathematical preparation school, engineer in electronics (ENSERG). Work placement in Sagem, hired by Thomson Military, Image and Radio. ST for 10 years.	21
ST Microelectronics	Configuration management and solutions on design; management, implementation of methodological tools	Scientific A level, master in mathematics and informatics. Hired by ST (2000).	22
ST Microelectronics	Project leader of the IC. Coordination of tasks to create a new product (planning, managerial accounting and quality)	University diploma in electronics, worked in the engineering part of Thomson. Joint degree between GEM and an engineering school in electronics (ENSERG). Creation of engineering tools and software in quality management.	23 (second interview with respondent 18)
CEA–LETI	Technical coordinator	PhD in electronics, carrier in CEA–LETI	24
CEA–LETI	Program manager of product development (micro capture)	Engineer from ENSERG, career in CEA–LETI	25
CEA–LETI	Specification of micro- and nano-technology based product	DUT in mechanics, DEUG, background in electrics and electronics	26
CEA–LETI	Researcher	Specialist on MEMS development.	27
Grenoble INP	Director of engineering school at Grenoble INP (ENSGI)	PhD, research and teaching practices	28
Grenoble INP	Research director of joint laboratory CNRS-Grenoble INP	PhD, research and teaching practices	29
Grenoble INP	Former director of the ENSPG (Grenoble National Engineering School of Physics).	Research and teaching practices	30
Grenoble INP	Director of the ENSPG (Grenoble National Engineering School of Physics)	Research and teaching practices	31
Grenoble INP	Dean of engineering school at Grenoble INP	PhD, research and teaching practices	32
Grenoble INP	Research director of joint laboratory CNRS-Grenoble INP	PhD, research and teaching practices	33
Institut Néel	Director of Institut Néel	Former scientific director from CNRS, PhD. in physics	34
Mesulog	CEO of Mesulog	Engineer from ENSAM, automotive industry background, lab view developer	35
Williams	Sales manager of Williams product in France	Sofradir, Thompson	36

UNIVERSITE BRETAGNE ECONOMIE LOIRE ET GESTION

UNIVERSITÉ DE RENNES 1

Titre : Quelles capacités organisationnelles et dynamiques de connaissances inter-organisationnelles permettent d'innover dans un écosystème ?

Mots clés : connaissance, capacité d'absorption, innovation, modèles territoriaux d'innovation, écosystème

Résumé : Cette thèse aborde différents thèmes comme les écosystèmes, la capacité d'absorption et l'innovation radicale. À partir de notre étude systématique de la littérature, nous identifions les invariants des quatre courants divergents de l'approche par écosystème et les invariants des sept courants divergents de l'approche territoriale à travers un modèle intégrateur. Notre contribution vise à renforcer les fondations du champ des écosystèmes par les l'approche territoriale. D'après l'étude d'une joint-venture dans le contexte iranien, nos conclusions indiquent que l'innovation radicale est associée à des problèmes de sécurité, de qualité et de planification, entraînant des retards, une non-conformité vis-à-vis du cahier des charges et des coûts supplémentaires.

Notre contribution vise à approfondir le concept de dyade d'apprentissage en caractérisant un phénomène bidirectionnel entre deux organisations jouant à la fois le rôle d'enseignant et d'élève. Dans notre étude des spin-offs technologiques grenobloises, nos résultats montrent l'importance de développer des capacités d'absorption potentielles et réalisées. Ces capacités permettent l'internalisation des connaissances du client et la prise de conscience d'émergence technologique, tout en palliant au manque de connaissances techniques des clients lors de la formulation de leurs besoins. Notre contribution vise à fournir un nouvel éclairage sur la participation des clients au processus d'innovation radicale en observant le degré de participation des clients à différentes étapes et d'évaluer leurs rôles dans le processus de développement d'innovations radicales.

Title : Which organizational capabilities and inter-organizational knowledge dynamics enable innovation within an ecosystem?

Keywords : knowledge; absorptive capacity; innovation; territorial innovation models; ecosystem

Abstract : This dissertation is dealing with different topics such as ecosystem, absorptive capacity and radical innovation. From our systematic literature review of ecosystems based on a selection of 104 articles and books, we identify the invariants across the four diverging streams from the ecosystem approach and the seven diverging streams from the territorial approach toward the proposition of a new research framework. Our contribution aims at enriching the field of ecosystem with the strong theoretical background of the territorial approach. From our study of a joint venture in the Iranian context, our findings indicate that radical innovation is characterized by safety, quality, and planning challenges which engender delays, non-conformity to specifications, and additional costs.

Our contribution aims at further developing the concept of "learning dyad" by characterizing a two-way learning between two organizations playing both roles of teachers and students. From our study of technological spin-offs in Grenoble context, our findings show the importance of spin-offs developing both potential and realized absorptive capacities to internalize customer knowledge and technology emergence awareness and to simultaneously offset customers' lack of technical knowledge in formulating their needs. Our contribution aims at providing new insights to the area of customer involvement in the radical innovation process by examining how the level of customer involvement at different stages has improved or hindered the process of developing radical innovations.