VNIVERSITAT DE VALÈNCIA

Facultat d' Economia

TESIS DOCTORAL

Universidad emprendedora: de los *spillovers* de conocimiento a las *spin-offs* académicas

Presentada por:

Elvira Cerver Romero

Dirigida por:

Dra. Antonia Mohedano Suanes

Dra. Manuela Pardo del Val

Departamento de Dirección de Empresas. *Juan José Renau Piqueras*

Programa de doctorado en Dirección de Empresas

Valencia, mayo 2023

A mi familia,

ama lo que tienes.

“Casi todo lo que realice será insignificante,
pero es muy importante que lo haga”

Mahatma Gandhi

Agradecimientos

Son las últimas líneas que escribo, pero sin duda las más reconfortantes a nivel personal. Al igual que la verdad nos hace libres, agradecer desde la libertad es tremendamente satisfactorio y nos aporta felicidad.

En mi trayectoria investigadora he iniciado varios proyectos que finalmente no vieron la luz como tesis doctoral; por unas razones u otras se interrumpieron o no se culminaron. Sin embargo, personalmente era una asignatura pendiente y un reto que me debía tanto a mí misma, como a muchas personas a las que tengo que agradecer su apoyo y ánimo durante este proceso.

He de comenzar agradeciendo la especial complicidad y el interés continuo durante este largo camino a mis amigos y compañeros de departamento: Juanfran Martínez, Sonia Dasí, Clara Martínez, Lola Garzón y Amparo de la Torre; a mis amigos y compañeros del departamento de Comercialización e Investigación de Mercados, Haydeé Calderón y Alejandro Mollá; a mis amigos y compañeros del equipo decanal del que formo parte, en especial a Paco Muñoz y a Cristina Crespo; a mi amigo y anterior decano José Manuel Pastor, gran profesional y mejor persona que, con su afecto y su generosidad, me ha ayudado a sacar lo mejor de mí.

A los investigadores que han participado en las dos primeras publicaciones de esta tesis, Cristina Fernandes y João Ferreira, he de agradecer sus aportaciones y su interés por conseguir el mejor resultado posible en nuestros trabajos. Igualmente, agradezco la oportunidad que me brindó la Cátedra de Modelo Económico Sostenible de València y su Entorno de colaborar y crecer como investigadora, fruto de la cual surge el tercer artículo.

Agradezco que me hayan acompañado en este camino mis directoras, Toñi Mohedano y Manoli Pardo. Académicamente rigurosas y personalmente inmejorables, cada una de ellas sabe bien lo que me ha enseñado, guiado, aconsejado, revisado, la paciencia que ha tenido, el ánimo y el apoyo que me ha dado, siempre, desde el cariño y la confianza. Si su amistad era ya valiosa para mí, este trabajo nos ha unido para siempre.

Finalizo agradeciendo el apoyo, la entrega y el acompañamiento de mi familia con mayúsculas, a la que tanto cuesta renunciar y robar tiempo y compañía: a mis padres Juan y Elvira, a Marisé, a Raquel y, por supuesto, a mis hijas Claudia y Alejandra, mi inspiración y mi motor.

A todos, incluyendo a los que no he nombrado, mi reconocimiento y gratitud.

En cumplimiento de lo previsto en el artículo 8 del Reglamento sobre Depósito, Evaluación y Defensa de la Tesis Doctoral de la Universitat de València[1] (aprobado por el Consell de Govern de 28 de junio de 2016, ACGUV 172/2016, modificado CG 31-X-2017), que regula la presentación de las Tesis doctorales presentadas como compendio de publicaciones, esta Tesis Doctoral se presenta como un compendio de tres publicaciones, las tres correspondientes a revistas indexadas en el *Journal Citation Report*, en las que el primer firmante es la doctoranda. En atención al resto de requisitos exigidos en esa misma norma, esta tesis se ha estructurado en dos partes. En la primera parte, con el objetivo de justificar la aportación original de la doctoranda, la Tesis comienza con un resumen global que integra la justificación de las cuestiones planteadas, los objetivos planteados, los principales resultados y conclusiones, así como la lista de referencias. En la segunda parte se incluye, en forma de anexos, la copia completa de los tres trabajos publicados que son la base de esta Tesis Doctoral por compendio. Además, en cada anexo se recoge el nombre y filiación de los coautores de los trabajos y la referencia completa de la revista en que cada trabajo ha sido publicado.

[1] https://www.uv.es/sgeneral/Reglamentacio/Doc/Estudis/C63.pdf

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PARTE I.

Resumen global

1. Justificación y objetivos de la investigación

El entorno geográfico en el que se ubica una empresa parece ser un condicionante relevante para su creación (Acs et al*.,* 2013), así como para su supervivencia, crecimiento y desempeño innovador (Audretsch y Dohse, 2007; Howells y Bessant, 2012). Ciertas localizaciones geográficas ofrecen a las empresas, entre otras, ventajas asociadas a la aglomeración, como es el caso de las externalidades derivadas de la existencia de *spillovers* de conocimiento (Audretsch y Lehmann, 2005; Bogas y Barbosa, 2015).

Frente a la "transferencia de conocimiento", que supone una forma de transmisión o difusión del conocimiento intencionada, los *spillovers*[2] o derrames de conocimiento se caracterizan precisamente por ser una forma de difusión no intencionada (Fallah y Ibrahim, 2004). Por tanto, la existencia de *spillovers* de conocimiento implica que las organizaciones que han generado ese conocimiento no pueden apropiarse o internalizar completamente los rendimientos de sus inversiones en conocimiento, ni obtener una compensación a cambio de su uso por terceros. Sin embargo, permiten a una organización beneficiarse de conocimientos de otros actores económicos sin tener que pagar por ellos en una transacción de mercado formal (Grossman y Helpman, 1991), y pueden ser empleados por diferentes actores económicos simultáneamente en diferentes lugares (De Clercq et al., 2008).

Los *spillovers* de conocimiento pueden potenciar la I+D de las empresas al absorber y transformar el conocimiento generado en instituciones públicas de investigación y desarrollo, como universidades, incubadoras de empresas y laboratorios públicos de investigación, convirtiéndolo en innovaciones y soluciones rentables (Beise y Stahl, 1999; Monjon y Waelbroeck, 2003). De la misma forma, la colaboración con otras organizaciones en actividades de I+D, por ejemplo, a través de consorcios (Branstetter y Sakakibara, 1998), inversiones de capital de riesgo, alianzas, *joint ventures*, adquisiciones de empresas emprendedoras (Schildt et al*.,* 2005), permite a las empresas aprender y ofrece un contexto adecuado para que surjan *spillovers* de conocimiento que fluyan más allá de los límites de la empresa e incluso de las fronteras nacionales.

El impacto positivo de los *spillovers* de conocimiento, tanto a nivel de empresa como en su contexto geográfico en términos de avance tecnológico, crecimiento económico y empleo, ha despertado un gran interés y se han realizado numerosas investigaciones que han puesto el foco en diversos aspectos de este fenómeno como, por ejemplo, su alcance geográfico (Jaffe et al., 1993; Maurseth y Verspagen, 2002; Thompson, 2006); su relación con el fenómeno de la aglomeración (Audretsch y Feldman, 1996; Howells, 2002); las etapas del ciclo de vida de la

[2] Puesto que parece no existir acuerdo en la traducción al castellano de '*spillovers* 'y que está extendido el uso de la expresión en inglés entre la academia, mantenemos esta en el resto del trabajo.

industria en las que tienen lugar (Audretsch y Feldman, 1996); los mecanismos que los hacen posible (Breschi y Lissoni, 2001; Boschma et al., 2009); las diferencias en cuanto a la intensidad de este fenómeno cuando ocurre entre organizaciones de una misma industria o de diferentes industrias (Feldman y Audretsch, 1999; Frenken et al., 2007); la influencia del marco institucional (Gilson 1999); la estrategia de localización de la empresa para un mejor aprovechamiento de los *spillovers* de conocimiento que se generan en su entorno o para evitar fugas de conocimiento (Henderson y Cockburn, 1996; Nieto y Quevedo, 2005); la relación con el crecimiento demográfico y económico de las ciudades (Moretti, 2004); o su importancia en la creación de empresas (Armington y Acs, 2002; Acs et al., 2013), entre otros muchos.

El análisis y el número creciente de publicaciones centradas en el concepto "*spillovers* de conocimiento" nos permite afirmar su actualidad e importancia, tanto en el ámbito académico como empresarial y político. Ahora bien, la gran cantidad de aportaciones en torno a este tópico, caracterizada por una notable fragmentación, nos lleva a plantear como objetivo de este trabajo la identificación de las distintas tendencias y líneas de investigación existentes, así como a los autores más relevantes y el perfil de las publicaciones. Asumimos este reto en el presente trabajo planteándolo como el primero de nuestros objetivos, que abordaremos con el primero de los artículos.

Como hemos apuntado, la literatura en torno al fenómeno de los *spillovers* de conocimiento es abundante. Queremos ahora detenernos en aquellas aportaciones que relacionan este tópico con el *entrepreneurship*, conectando así estos dos extensos campos de investigación (Audretsch, 1995; Audretsch et al., 2005; Acs et al., 2013; Qian y Acs, 2013; Park y Vonortas, 2022; Kim et al., 2023). Estos trabajos abordan sus estudios desde la teoría del emprendimiento basada en los *spillovers* de conocimiento (*Knowledge Spillover Theory of Entrepreneurship*) introducida por Audretsch (1995). Como señalan Audretsch y Lehmann (2005), si bien existe consenso entre la academia respecto de que el emprendimiento gira en torno al reconocimiento y búsqueda de oportunidades, esta teoría pone el foco en la fuente de esas oportunidades y señala que son los nuevos conocimientos e ideas creados en un determinado contexto geográfico, y que no son explotados completamente por la organización que los crea, los que constituyen fuente de oportunidades de emprendimiento (Audretsch y Lehmann, 2005; Acs et al., 2013). Del conocimiento creado endógenamente por una organización (por ejemplo, una universidad, un ente público de investigación, o el departamento de I+D de una empresa asentada), pueden derivarse *spillovers* de conocimiento que permiten a un tercero, en este caso al emprendedor, explorar, identificar y explotar nuevas oportunidades a través de la creación de una empresa (Acs et al., 2009). Por tanto, la creación de empresas es en este caso un proceso endógeno en respuesta a la disponibilidad de conocimiento no utilizado por la fuente que lo crea (Audretsch et al., 2006).

En el marco de esta teoría, la concentración de *spillovers* de conocimiento en ciertas zonas geográficas explica la diferencia entre distintas localizaciones en cuanto a la tasa de creación

de empresas (Acs et al., 2013), o respecto de la concentración de empresas de alto crecimiento (Fotopoulos, 2022). Dentro de esta misma línea, algunos investigadores han puesto el foco en la Universidad como fuente de *spillovers* de conocimiento que, a su vez, son fuente de emprendimiento innovador y, en consecuencia, indirectamente, de crecimiento económico (Audretsch et al., 2004; Audretsch et al., 2005; Audretsch et al., 2006; De Silva y McComb, 2012; Fritsch y Aamoucke, 2013; Lasch et al., 2013). Existe evidencia de que las nuevas empresas basadas en el conocimiento y la tecnología tienen una alta propensión a ubicarse cerca de las universidades con el fin de acceder y beneficiarse de *spillovers* de conocimiento generados por estas (Audretsch et al., 2005). Estos se transmiten a través de diferentes mecanismos como, por ejemplo, a través del capital humano que generan, la interacción entre personal de la universidad y de la industria, la formación a personal de la industria, etc. (Audretsch et al., 2005; Audretsch y Lehmann, 2005).

Pero el papel de las universidades en el crecimiento económico va más allá de los *spillovers* de conocimiento que generan. Muchas vienen adoptando una postura proactiva para que el conocimiento que generan sea empleado y llevado a la práctica, tanto por parte de la comunidad universitaria como por parte de agentes externos a ella (Etzkowitz, 2003a). Se trata del fenómeno de la "universidad emprendedora", concepto introducido por Etzkowitz (1998), para referirse a aquella universidad que "…*integra el desarrollo económico …como una función académica junto a la enseñanza y la investigación*" (p. 833). Al adoptar esta nueva misión, las universidades se convierten en parte de un sistema coherente que incluye a la industria y al gobierno para favorecer la innovación y el progreso económico (Etzkowitz y Leydesdorff, 2000). Desde este enfoque teórico, recientes trabajos aportan evidencia del impacto económico de las universidades emprendedoras (Guerrero et al., 2015), y de su efecto positivo sobre la competitividad regional (Bras et al., 2023).

Para cumplir con esa tercera misión, las universidades emprendedoras diseñan e implementan políticas que fomentan el emprendimiento entre sus estudiantes, profesores y resto de personal investigador, como, por ejemplo, la creación de *spin-offs* por su personal, así como la colaboración con la industria a través de la investigación conjunta, la investigación contratada, los acuerdos de consultoría, la concesión de licencias para la explotación de patentes de su propiedad, entre otras acciones (O'Shea et al., 2008; D'Este y Perkmann, 2011; Philpott et al., 2011; Audretsch, 2014; Guerrero y Urbano, 2014).

Surge así un reciente e interesante campo de investigación sobre el que se ha generado un gran número de contribuciones, en su mayoría de tipo teórico (Audretsch, 2014) y predominando los estudios cualitativos entre aquellos que aportan investigaciones empíricas (Deem, 2001; Bramwell y Wolfe, 2008; Martinelli et al., 2008; Sidhu et al., 2011; Guerrero et al., 2015), todo lo cual indica que el estudio de la "universidad emprendedora" se encuentra todavía en una etapa incipiente. Además, la variedad de aspectos analizados sobre este fenómeno, como la relación entre universidad-industria-gobierno (Cooke, 2005), los motivos

de los académicos para participar en actividades emprendedoras (D'Este y Perkmann, 2011), los mecanismos que hacen posible la contribución al desarrollo económico y social (Guerrero et al., 2015), los factores contextuales que inducen a las universidades a incluir entre sus actividades aquellas relacionadas con emprendimiento (Hakala, 2009), o la relación entre productividad científica e intención emprendedora de los académicos (Van Looy et al., 2011) entre otros muchos, nos sugiere que nos encontramos ante un campo de investigación relativamente fragmentado que requiere de una sistematización teórica. Es por ello que en este trabajo nos planteamos como un segundo objetivo identificar las diferentes líneas de investigación y enfoques predominantes en la literatura en torno a este concepto, objetivo que abordaremos en nuestro segundo artículo.

De otro lado, en la literatura sobre "universidad emprendedora" las *spin-offs* académicas son una de las actividades emprendedoras que mayor interés ha suscitado entre los investigadores. Una *spin-off* académica es una empresa con personalidad jurídica propia creada, entre otros posibles socios, por personal de las universidades y/o de entidades públicas de investigación con el fin de explotar comercialmente el conocimiento generado como resultado de las investigaciones que ese personal ha llevado a cabo en el seno de dichas entidades (Pardo et al., 2021).

No son pocos los estudios que vienen destacando los potenciales beneficios de esta forma de emprendimiento académico en términos de generación de nuevos empleos (Steffensen et al., 2000; Pérez y Martínez, 2003) y, en particular, de puestos cualificados para nuevos graduados y doctores (Rizzo, 2015; Dorner et al., 2017), así como su contribución al desarrollo económico (Mian, 1997; Nicolaou y Birley, 2003), y a la generación de riqueza (Walter et al., 2006), entre otros beneficios.

Sin embargo, el número de *spin-offs* académicas que cada año se crean es muy reducido, y todavía lo es más si se compara con el número de patentes que anualmente obtienen las universidades (Pardo et al., 2021). Otro de sus inconvenientes es que mantienen en el tiempo su reducida dimensión (Colombo y Piva, 2005; Harrison y Leitch, 2010). Por ello, trabajos previos han analizado la influencia de distintos factores sobre la creación y desempeño de este tipo de empresas, relacionados con las características del fundador o equipo fundador en cuanto a su formación, experiencia y motivaciones (Prodan y Drnovsek, 2010; Lam, 2011; Miranda et al., 2017), o con la reputación de la universidad de la que surge la *spin-off* (Gómez-Gras et al., 2008; Avnimelech y Feldman, 2015). Ahora bien, solo un limitado número de trabajos, como Fini et al. (2011), Sternberg (2014) o Davey et al. (2016), han considerado el papel del contexto geográfico en el que surgen.

Como ya se ha destacado, en el ámbito de la literatura sobre *spillovers de conocimiento*, se apunta a la localización y el contexto geográfico como un antecedente relevante de la tasa de creación de empresas (Acs et al., 2013; Fotopoulos, 2022), así como para su desempeño posterior (Audretsch y Dohse, 2007; Howells y Bessant, 2012). En el ámbito de las *spin-offs*

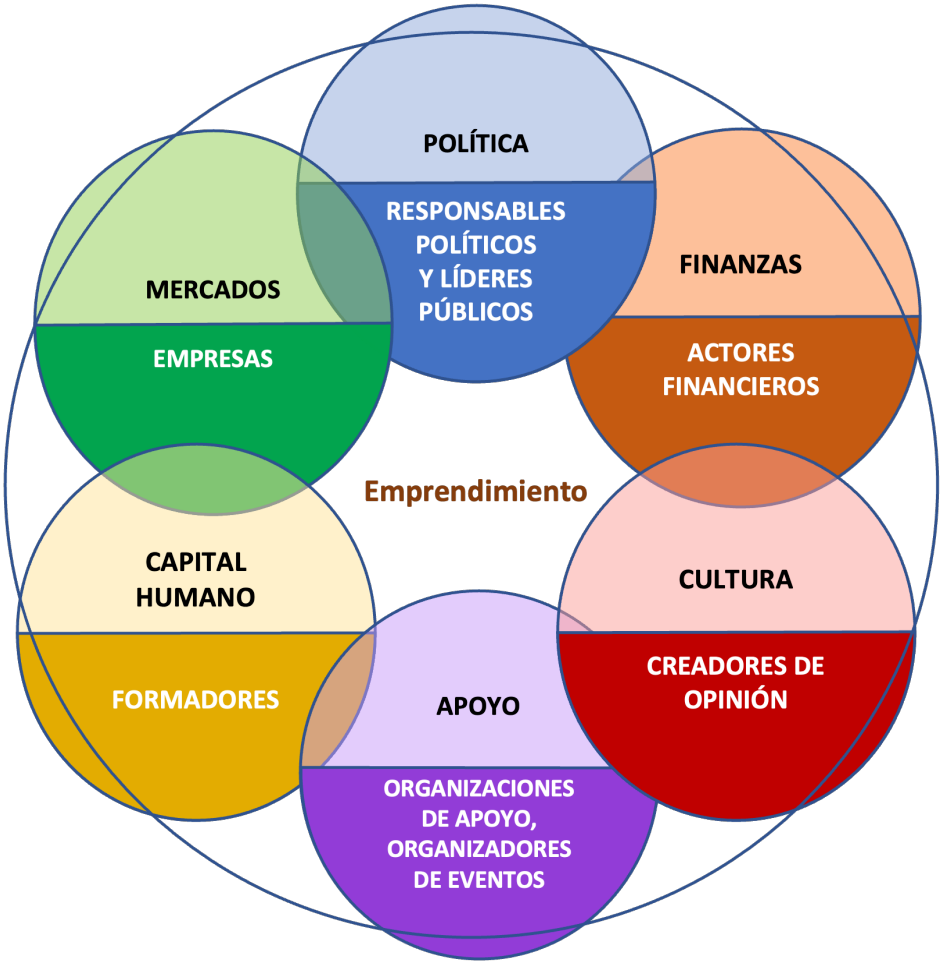
académicas, y desde otra perspectiva teórica, Prokop (2021) toma el concepto de "ecosistema emprendedor" para explicar las diferencias entre localizaciones concretas en el número de *spin-offs* académicas y en su supervivencia.

El concepto de "ecosistema emprendedor" se apoya en la idea de que las empresas nacen en un contexto en el que interaccionan entre sí junto a otros agentes (Malecki, 2018). Mason y Brown (2014) lo definen como un "*conjunto interconectado de emprendedores (actuales y potenciales), organizaciones empresariales, instituciones (tales como universidades, agencias del sector público y organismos financieros) y procesos emprendedores, los cuales formal e informalmente se fusionan para conectar, mediar y dirigir el desempeño dentro del entorno emprendedor local*" (p. 5).

De acuerdo con Brown y Mason (2017) hay tres elementos esenciales que sustentan esta idea de ecosistema emprendedor: su objetivo es el éxito de las empresas, se encuentra localizado en un lugar determinado, y se asienta en las interacciones entre sus componentes. El primero de estos tres elementos se refiere a que el ecosistema persigue estimular un emprendimiento de naturaleza "ambiciosa", pues su objetivo no es solo fomentar la creación de nuevas empresas, sino favorecer su éxito (Isenberg, 2010) poniendo el foco especialmente en las empresas de alto crecimiento (Brown y Mason, 2017). En segundo lugar, en cuanto a la localización espacial, un ecosistema se circunscribe a una ubicación geográfica específica. Es precisamente la proximidad geográfica la que estimula la interacción entre sus distintos agentes favoreciendo el intercambio de conocimiento (Mason y Brown, 2014). En cuanto al tercer y último elemento, el concepto de "ecosistema emprendedor" se sustenta sobre el papel relevante de las interacciones entre sus componentes, las condiciones marco y el entorno local y/o regional. Cada ecosistema emprendedor nace y se desarrolla bajo unas condiciones y circunstancias únicas (Feldman y Braunerhjelm, 2006), por lo que cada uno de ellos posee características e idiosincrasias distintivas propias que están espacial, relacional y socialmente incrustadas (Brown y Mason, 2017). No existen recetas universales ni es posible replicar un ecosistema exitoso en otro lugar, pues cada elemento del ecosistema tiene su propia naturaleza en un territorio concreto (Hospers et al., 2009).

Los distintos elementos que conforman un ecosistema emprendedor pueden agruparse en seis dimensiones: política, finanzas, cultura, apoyo, capital humano y mercados. Dentro cada dimensión, estos elementos interactúan entre sí, así como con los de otras dimensiones, reforzando la intensidad del ecosistema, sin que se den relaciones causa-efecto entre ellas (Isenberg, 2011); a su vez, cada una de estas dimensiones cuenta con un conjunto de agentes clave (Isenberg y Oneymah, 2016). Una combinación de ambas propuestas queda recogida en la Figura 1.

Figura 1. Dimensiones y actores de un ecosistema emprendedor



Fuente: adaptado de Cerver et al. (2022:674)[3]

El objetivo final de la dimensión política es observar hacia dónde se dirige el ecosistema y facilitar su evolución. Incluye tanto las instituciones públicas asociadas al emprendimiento como la normativa que lo regula, además de la interacción entre el emprendimiento y los líderes públicos. Los agentes son los gobiernos, a nivel local, regional o incluso nacional, pero también los responsables de los centros de educación y de investigación (Isenberg, 2010; Isenberg, 2014).

La dimensión de financiación recoge los elementos que dotan de fondos a los emprendimientos, ya sea mediante inversiones, subvenciones, premios, préstamos o ayudas. Los actores clave aquí son los inversores en su más amplio sentido, así como los organismos convocantes de proyectos y premios.

[3] Esta figura se corresponde con la Figura 1 del Anexo3

En cuanto a la dimensión cultural muestra unas normas sociales de tolerancia al fracaso y que recompensan la innovación y la creatividad, y otorgan al emprendedor un estatus social destacado. Estos valores se logran visibilizando historias de éxito que sirvan de motivación a otros (Isenberg, 2011). Los actores clave de esta dimensión son principalmente los medios de comunicación (Isenberg y Oneymah, 2016).

La dimensión de apoyo incluye los servicios e infraestructuras que dan soporte al emprendimiento, desde la asesoría legal, contable, de inversión o técnica, conferencias y concursos de ideas, pasando por las telecomunicaciones, la logística, así como, las incubadoras y aceleradoras (Isenberg, 2011). Los agentes clave en esta dimensión son abogados, contables, asesores de inversión, entidades organizadoras de eventos, gestores de incubadoras, aceleradoras, parques científicos, etc.

En cuanto a la dimensión capital humano, el ecosistema emprendedor debe ser capaz de proporcionar una fuerza laboral en número suficiente y con el grado de cualificación adecuado. Además, en esta dimensión se enmarcan las competencias para emprender con éxito. Los agentes clave incluyen a cuerpos docentes y equipos de dirección de los centros educativos (Isenberg y Oneymah, 2016).

Las empresas y los clientes son los agentes clave de la dimensión de mercados. En particular es imprescindible la existencia de empresas consolidadas como potenciales aliados del emprendimiento, porque pueden ser clientes para las nuevas empresas, y, además, porque el talento de uno y otro lado, corporaciones y nuevas empresas, interactúa y se desplaza, alimentando el éxito del ecosistema (Isenberg, 2014; Mason y Brown, 2014).

Aunque escasos, algunos trabajos han puesto el foco en el estudio del ecosistema emprendedor en el que surgen las *spin-offs* académicas centrándose en describir casos de éxito (véanse, por ejemplo, los trabajos de Schaeffer y Matt, 2016; Miller y Acs, 2017; Huang-Saad et al., 2018). Pero todavía queda por explorar las características que debería tener un ecosistema emprendedor que pueda contribuir a salvar los retos a los que se enfrentan las *spin-offs* académicas, tanto para su creación como para su posterior crecimiento y desarrollo. Por ello, recogemos como tercer objetivo de este trabajo conocer el ecosistema emprendedor "ideal" para la creación y crecimiento de *spin-offs* académicas, objetivo que es abordado mediante un estudio de casos en nuestro tercer artículo.

En síntesis, en esta investigación nos proponemos abordar tres grandes objetivos, cada uno de los cuales se ha trabajado en sus correspondientes artículos, como muestra la Figura 2:

Figura 2. Relación entre los objetivos de la investigación y los artículos publicados

Fuente: elaboración propia

2. Métodos y resultados

En este apartado presentamos tanto los métodos que se han utilizado en cada uno de los artículos que componen este trabajo, como los principales resultados obtenidos.

2.1. Metodología y resultados del primer artículo

En el Anexo 1 de la Parte II se presenta el artículo[4] que nos ha permitido abordar el primero de los objetivos planteados. En concreto, con el fin delinear la estructura intelectual de la investigación en torno al concepto "*spillovers* de conocimiento" e identificar las distintas tendencias y líneas de investigación existentes, hemos llevado a cabo un estudio bibliométrico, utilizando la base de datos de *Web of Science Core Collection*. El término *"knowledge spillover* " se buscó en el título, las palabras clave o el resumen de todos los artículos, sin aplicar ningún filtro cronológico, y la búsqueda recuperó 1.568 artículos publicados entre 1991 (1 artículo) y 2017 (173 artículos); los datos muestran una tendencia creciente en el número de publicaciones a partir de 2007, lo que indica la vigencia del interés sobre este tema en la academia.

En cuanto a los trabajos más citados, encontramos con 1.877 citas el de Jaffe et al. (1993), y con 1.199 citas el de Glaeser et al. (1992). Teniendo en cuenta que en el periodo 1991-2017 el total de los artículos publicados con este concepto fue de 1.568, las revistas que lideraron el número de publicaciones fueron *Research Policy* con 70 artículos, seguida por *Small Business Economics* (52 artículos) y *Regional Studies* (47 artículos). A continuación, y tras delimitar el conjunto de artículos a aquellos con al menos 50 citas, seleccionamos 99 artículos y volvió a ser la revista *Research Policy* la que publicó mayor número, seguida en este caso de *Regional Studies* y de *American Economic Review*.

Mediante el análisis de co-citas y el uso de otras técnicas complementarias como el análisis de conglomerados, el de componentes principales y el análisis factorial, se determinaron y agruparon los artículos que compartían componentes comunes, identificando cinco enfoques principales, que nos permiten responder al primero de los objetivos antes señalados, la identificación de las tendencias y líneas de investigación: (a) localización de los *spillovers* de conocimiento; (b) aglomeración y *spillovers* de conocimiento; (c) enfoque institucional y *spillovers* de conocimiento; (d) demografía y *spillovers* de conocimiento; y (e) teoría del emprendimiento de los *spillovers* del conocimiento.

Los cinco clústers mantienen entre si relaciones mutuas y muestran claramente fuertes interconexiones. Concretamente cabe destacar que el enfoque de localización de los *spillovers*

[4] Cerver-Romero, E., Ferreira, J. J.M., & Fernandes, C. (2020). A scientometric analysis of knowledge spillover research. *The Journal of Technology Transfer*, *45*(3), 780-805.

de conocimiento y el de aglomeración están relacionados, y que el enfoque institucional apoya y respalda al enfoque de localización, en tanto que las instituciones públicas y sus políticas regionales explican la ubicación de dichos *spillovers*. A continuación, pasamos a describir los cinco enfoques:

Localización de los spillovers de conocimiento

Encontramos aquí un grupo de aportaciones que se centra en el estudio del alcance geográfico de los *spillovers* de conocimiento. En su mayoría, estos trabajos argumentan y evidencian que los *spillovers* de conocimiento están localizados geográficamente. Parece que se dan en mayor medida entre regiones de un mismo país que entre países y, principalmente, entre aquellas regiones que están más próximas entre sí. Además, ocurren en mayor medida dentro de una misma industria y entre regiones de un mismo país especializadas en sectores industriales con vínculos tecnológicos específicos entre sí. Los trabajos de Jaffe et al. (1993), Maurseth y Verspagen (2002), o Thompson (2006), entre otros, aportan evidencia en este sentido, confirmando que la proximidad entre los agentes aumenta la probabilidad de un flujo no intencionado de conocimiento.

Aglomeración y spillovers de conocimiento

La aglomeración y, por tanto, la proximidad entre agentes económicos, facilita que haya *spillovers* de conocimiento, pues dicha proximidad resulta especialmente relevante para la difusión de conocimiento tácito (Audretsch y Feldman, 1996; Howells, 2002).

Muchas de las contribuciones de este enfoque avanzan respecto del enfoque anterior identificando los mecanismos a través de los cuales tienen lugar los *spillovers* de conocimiento. Entre estos mecanismos se señalan, entre otros, la movilidad laboral de profesionales altamente cualificados y trabajadores técnicos, las redes o capital relacional (Breschi y Lissoni, 2001; Simmie, 2003; Boschma et al., 2009; Capello y Faggian, 2005); o los vínculos o relaciones personales de confianza entre ingenieros u otros trabajadores que van más allá de la relación formal entre sus respectivas organizaciones (Lissoni, 2001).

Otras aportaciones de este enfoque estudian la existencia de diferencias en cuanto a las consecuencias de los *spillovers* de conocimiento cuando ocurren en una determinada industria, frente al caso en el que ocurren entre industrias (Frenken et al., 2007), la relación de los *spillovers* de conocimiento con el ciclo de vida de una industria y parecen más relacionados con la etapa de creación (Audretsch y Feldman, 1996), el impacto positivo de los *spillovers* de conocimiento sobre la innovación en la empresa (Feldman y Audetsch, 1999) o sobre el desempeño innovador a nivel regional (Bode, 2004; Fritsch y Franke, 2004; Rodríguez-Pose y Crescenzi, 2008), así como el alcance de su impacto económico (Baldwin y Forslid, 2000).

Enfoque institucional de los spillovers de conocimiento

El marco institucional, y más concretamente la legislación existente a nivel regional y/o nacional puede favorecer u obstaculizar las externalidades de conocimiento (Gilson, 1999; Fischer y Newell, 2008), razón por la que la dirección de las empresas y los responsables de las políticas públicas pueden influir de manera más efectiva en la difusión del conocimiento, al comprender los mecanismos y determinantes de sus flujos (Appleyard, 1996).

Como señala Spence (1984), cuanto mayor sea la dificultad que tienen las empresas para apropiarse del nuevo conocimiento que generan, mayor será el *stock* de *spillovers* de conocimiento presentes en la industria en la que compiten. Una legislación eficaz en materia de protección de propiedad industrial e intelectual, unida a una tradición del uso de la misma por parte de las empresas para protegerse de la fuga de conocimiento, disuade a terceros de la explotación gratuita de conocimiento generado por otros, por ejemplo, a través de la contratación de trabajadores clave de sus rivales (Agarwal et al., 2009). Existe evidencia de que en circunstancias en las que la fuga de conocimiento puede darse con facilidad, por ejemplo, cuando una de las características de cierta industria es la elevada rotación del personal, las empresas avanzadas tecnológicamente evitan localizaciones próximas a sus rivales (Alcacer y Chung, 2007). En este sentido, la regulación que rige la movilidad de los empleados puede fomentar los *spillovers* de conocimientos críticos entre empresas cuando es permisiva, o bloquearlos cuando es muy restrictiva (Gilson, 1999).

Un posible efecto pernicioso de un contexto que no favorece que las empresas puedan apropiarse por completo del conocimiento que crean, es la reducción de la inversión en I+D. Existe evidencia de que las empresas innovadoras se ven desincentivadas a invertir en I+D cuando perciben que pueden aprovechar los esfuerzos innovadores de otras empresas, es decir, cuanto mayor es la cantidad de conocimiento "libremente disponible" (Nieto y Quevedo, 2005). La relación entre protección de la propiedad intelectual e industrial y el nivel de los *spillovers* de conocimiento también fue probada por Appleyard (1996); en su trabajo aporta evidencia de que la intensidad de los *spillovers* de conocimiento, incluso dentro de una misma industria, varía entre países debido a las diferencias en sus respectivas legislaciones en cuanto a protección del conocimiento.

De otro lado, aunque se ha apuntado que las externalidades de conocimiento disminuyen con la distancia geográfica (Keller, 2002) dado que (Branstetter, 2001) los *spillovers* de conocimiento también pueden ser transfronterizos. Algunos trabajos han estudiado los mecanismos que hacen posible que las empresas de un país aprovechen el conocimiento generado en otro. Entre estos mecanismos se ha apuntado al comercio internacional, pues las importaciones permiten acceder, explotar, e imitar tecnologías desarrolladas en otros países (Grossman y Helpman, 1991; Engelbrecht, 1997; Hausmann et al., 2007). Otro mecanismo es la inversión directa de las empresas en otros países, en la medida en que permite el flujo de conocimiento a nivel organizativo entre la matriz y su filial (De Mello, 1999; Branstetter, 2006;

Cantwell, 2009); pero también entre el país receptor de la inversión y el país de origen de la multinacional, esto es, la inversión directa extranjera contribuye al avance tecnológico del país receptor y aumenta los *spillovers* de conocimiento (Liu y Buck, 2007). El volumen y el tipo de inversión extranjera que recibe un país depende de la capacidad de absorción de las empresas del país anfitrión, del nivel de cualificación de la mano de obra, y, en última instancia, de factores institucionales como el régimen económico, la legislación y la estabilidad política, entre otros (De Mello, 1999). Pero las decisiones sobre a qué filial asignar la responsabilidad sobre actividades de I+D parece ser también una cuestión de isomorfismo mimético. Tomando los argumentos de la teoría institucional (DiMaggio y Powell, 1983), Feinberg y Gupta (2004) argumentan y encuentran que para aprovechar los *spillovers* de conocimiento del país anfitrión, de entre el conjunto de subsidiarias, las multinacionales asignan responsabilidades de I+D a aquella ubicada en aquella localización con mayor inversión en I+D por parte de otras empresas de la misma industria. Para Keller (2002) una cuestión determinante de la decisión de localización de la i+d por parte de las empresas multinacionales en cierto lugar, es precisamente la concentración de actividades de I+D de otras empresas, en tanto que le ofrece mayor oportunidad para capturar y beneficiarse de los *spillovers* de conocimiento de los competidores.

De otro lado, el país de origen de la multinacional también se beneficia de la inversión directa en otro país. A este respecto, el trabajo de Singh (2007) encuentra que los *spillovers* de conocimiento fluyen en una doble dirección entre el país anfitrión y el país en el que la multinacional tiene su sede. En este caso el flujo de personal entre la multinacional extranjera y las empresas locales es un mecanismo de transmisión de conocimiento tácito. Es más, sus resultados muestran que, en los países tecnológicamente avanzados, las salidas de *spillovers* de conocimiento hacia las multinacionales extranjeras superan con creces las entradas de conocimiento. En esta misma línea, Griffith et al. (2006), encuentran que las empresas extranjeras que invierten en actividades de I+D en un país tecnológicamente más avanzado, consiguen aumentos de productividad, incluso, por encima de las empresas instaladas en el país que acoge la inversión. Los autores lo justifican porque las empresas extranjeras tienen acceso a conocimiento tácito; por ello, argumentan, un *stock* más grande de I+D en un país es un reclamo para la inversión extranjera por los efectos indirectos y positivos de esa inversión en otros países.

Demografía de los spillovers de conocimiento

La demografía también puede explicar por qué algunos lugares son más emprendedores que otros, dado que el capital humano, su edad y nivel educativo, es el ingrediente crucial para la mayoría de las nuevas empresas (Glaeser y Kerr, 2009).

Dentro de este grupo de aportaciones relacionadas con la demografía, algunos estudios se han centrado en analizar el vínculo entre el crecimiento de la ciudad y el capital humano, la relación entre los procesos de urbanización y las características demográficas, otros tratan de

explicar los patrones demográficos de movimiento y comportamiento asociados a los *spillovers de conocimiento*.

Ellison et al. (2010) señalaron como causas que explican la aglomeración industrial el ahorro de costes de transporte asociado a la proximidad a proveedores de insumos y/o consumidores finales, la agrupación de personas y del mercado de trabajo, y la facilidad de acceso a los *spillovers de conocimiento*; sin embargo, aunque algunos tipos de información parecen fluir muy bien a largas distancias, otros aún requieren una proximidad muy cercana.

Las economías de aglomeración se benefician de los *spillovers* de conocimiento a nivel altamente localizado, debido a que dichos *spillovers* se atenúan rápidamente en el espacio (Rosenthal y Strange, 2001). Por su naturaleza localizada, los *spillovers de conocimiento* promueven la aglomeración y la acumulación de capital humano y fomentan el crecimiento económico endógeno; *spillovers de conocimiento locales y* acumulación de capital humano posibilitan conjuntamente que las ciudades crezcan demográficamente, aumentando su tamaño y el empleo (Black y Henderson, 1999); de hecho, las ciudades que contaban con niveles más altos de capital humano crecieron más rápidamente a lo largo del siglo XX, básicamente porque los *spillovers* de conocimiento se limitan geográficamente a la ciudad, y porque gran parte del conocimiento es más productivo en la ciudad en la que se adquiere (Simon y Nardinelli, 2002). Confirmando lo anterior, Moretti (2004) identificó que, cuanto más aumenta la proporción de graduados universitarios en las ciudades, más aumenta la productividad de sus plantas de producción y que los *spillovers* entre industrias que son económicamente cercanas en términos de flujos de entrada-salida, especialización tecnológica y citas de patentes, son mayores que los *spillovers* entre industrias que son económicamente distantes.

Por otro lado, existe una causalidad bidireccional entre los flujos interregionales de migración laboral y capital humano de recién graduados universitarios y el rendimiento innovador de las regiones, siendo la innovación de una región uno de los principales factores que alienta a los graduados universitarios a buscar empleo en esa región (Faggian y McCann, 2009); el tamaño y la densidad de la ciudad reflejan efectos que son externos a la empresa, pero no a la ciudad misma.

Diversos estudios muestran que la densidad de la población y del empleo en las áreas metropolitanas altamente urbanizadas está relacionada positivamente con la intensidad de las patentes o la tasa de invención per cápita. Estos hallazgos confirman la opinión generalizada de que los lugares más densos del país juegan un papel importante en la creación del flujo de ideas que generan innovación y crecimiento, y de que las estructuras de mercado local más competitivas son más propicias para la innovación (Bettencourt et al., 2007; Carlino, et al., 2007). También se ha apuntado que el conocimiento, tanto codificado como tácito, se puede difundir a través de redes étnicas o comunidades formadas por científicos que difunden las tecnologías del país en el que residen hacia sus países de origen; este personal expatriado

juega así un importante papel en la transferencia internacional de tecnología a sus países de origen, necesaria para el crecimiento económico global (Kerr, 2008).

Spillovers de conocimiento y emprendimiento

Muchas de las aportaciones de esta línea parten de la idea de que los emprendedores irrumpen en el mercado local con la creación de una nueva empresa que involucra cierto grado de *spillovers* de conocimiento local, asumiendo así que, en ocasiones, existe una separación entre quien desarrolla un nuevo conocimiento y quien aprovecha comercialmente ese conocimiento o parte de él.

Desde este enfoque, enmarcado en la teoría del emprendimiento de los *spillovers* de conocimiento (*Knowledge Spillover Theory of Entrepreneurship*), introducida por Audretsch (1995), el emprendimiento sirve como canal para la difusión del conocimiento, por lo que se le considera el eslabón perdido entre las inversiones en nuevos conocimientos y el crecimiento económico (Agarwal et al., 2007; Audretsch, 2007; Audretsch y Keilbach, 2008). Del conocimiento creado endógenamente por una organización, por ejemplo, a través de inversiones en I+D, finalmente pueden derivarse *spillovers* de conocimiento, que permiten a un tercero, en este caso al emprendedor, identificar, explorar y explotar nuevas oportunidades a través de la creación de una empresa (Acs et al., 2009). Los trabajos de Armington y Acs (2002), Acs y Armington (2004 a,b), Audretsch y Lehmann (2005), entre otros, aportan evidencia en este sentido. Por su parte, Acs y Varga (2005) matizan estos resultados y encuentran que, si bien tanto el emprendimiento por oportunidad como por necesidad contribuyen a la creación de empleo y al crecimiento económico, es el emprendimiento por oportunidad el que favorece el cambio tecnológico y el crecimiento económico de una región o un país.

Por último, Audretsch y Lehmann (2005) sugieren que la creación de empresas es un mecanismo de transmisión de los *spillovers* de conocimiento y en su investigación encuentran que las nuevas empresas que explotan ese conocimiento tienden a agruparse geográficamente alrededor de la fuente de dicho conocimiento, por ejemplo, una universidad o una gran empresa. Por tanto, de nuevo, la proximidad a la fuente de conocimiento facilita el reconocimiento de oportunidades de negocio.

2.2. Metodología y resultados del segundo artículo

A continuación, en el Anexo 2, se recoge el artículo[5] que da respuesta al segundo de los objetivos planteados. En concreto, esta investigación en torno al concepto de "universidad emprendedora" aborda los siguientes objetivos: (a) identificar las contribuciones clave; (b) identificar las revistas científicas de mayor impacto en esta área, así como los autores más destacados; (c) conocer la distribución geográfica de la producción científica, en términos de países y (d) determinar las líneas de investigación que constituyen su estructura intelectual.

Para alcanzar estos objetivos hemos realizado un análisis de co-citas (White y McCain, 1998) a partir de la información extraída de la base de datos *Web of Science*. El análisis de co-citas resulta especialmente útil para identificar y comprender los artículos científicos fundamentales de un campo de investigación (Zitt y Bassecoulard, 1994; White y McCain, 1998; Di Guardo y Harrigan, 2012). La recuperación de datos se realizó mediante la búsqueda de aquellos artículos que tuvieran los términos "Entrepreneur* Universit*" en el título, resumen o palabras clave y que hubieran sido publicados en revistas en las categorías de administración, negocios y economía, sin filtro cronológico. Obtuvimos 479 documentos escritos en inglés, publicados entre 1983 y 2018.

Respondiendo al primer objetivo, identificamos la evolución temporal de las publicaciones, los artículos y las revistas en los que se publicaron. Si bien el primer artículo se publica en 1983, el crecimiento en importancia de este campo científico atendiendo al número de publicaciones es reciente, pues arranca en 2015. Entre otros resultados, el estudio bibliométrico revela que el trabajo de Etzkowitz, et al., (2000) acumula a la fecha de elaboración del estudio 802 citas, erigiéndose como el trabajo más influyente de este campo de investigación. Otros tres trabajos de Etzkowitz ocupan las tres siguientes posiciones en número de citas, por lo que todo apunta a que estamos ante un autor clave en la materia.

En relación con los resultados alcanzados respecto del segundo objetivo, al analizar los datos de los 933 autores de los 479 documentos publicados en el campo de las Universidades Emprendedoras en revistas académicas, destacamos que el estudio bibliométrico revela que Etzkowitz, con 16 artículos, es el autor más prolífico del campo. Le siguen dos investigadores españoles, Guerrero y Urbano, ambos coautores de 11 artículos.

En cuanto a las fuentes, identificamos 269 revistas con publicaciones de trabajos sobre el tema. Las más importantes son *Journal of Technology Transfer* (26 artículos), *Research Policy*

[5] Cerver Romero, E., Ferreira, J. J.M., & Fernandes, C. I. (2021). The multiple faces of the entrepreneurial university: A review of the prevailing theoretical approaches. *The Journal of Technology Transfer, 46*(4), 1173-1195.

(16 artículos) y *Higher Education* (11 artículos) e *International Journal of Technology Management* (11 artículos).

Por lo que respecta al tercer objetivo, en relación con la distribución geográfica de las publicaciones en torno al tópico de "universidad emprendedora", encontramos que Estados Unidos, con 89 publicaciones, es el país origen del mayor número de publicaciones para el periodo analizado, seguido de Reino Unido (77 publicaciones), Italia (66 publicaciones), España (59 publicaciones) y Alemania (44 publicaciones).

Finalmente, para abordar el cuarto objetivo y determinar las principales líneas de investigación, delimitamos el conjunto de artículos a aquellos con al menos 30 citas, reduciendo así a 54 publicaciones las 479 iniciales. Mediante el análisis de acoplamiento bibliográfico identificamos seis enfoques en torno al estudio de la universidad emprendedora, que hemos denominado como sigue: (a) modelo de triple hélice; (b) sociedad del conocimiento; (c) perspectiva globalizada; (d) investigador vs emprendedor; (e) doble personalidad; y (f) frenesí.

A continuación, presentamos las líneas de investigación que subyacen a cada clúster:

Modelo de triple hélice

Los trabajos incluidos en este grupo asumen que la innovación es un proceso sistémico y en red, en el que se fomenta la hibridación entre las tres hélices o esferas institucionales, esto es, universidad, industria y gobierno. En este modelo cada una de estas esferas puede asumir el rol de cualquiera de las otras. Por ejemplo, las universidades pueden asumir el papel de la industria creando *spin-offs* como una forma de explotar el conocimiento que generan. Por su parte, las empresas también pueden proporcionar financiación a la universidad a través de investigación contratada, reemplazando así al gobierno en su papel de proveedor de recursos financieros. El gobierno, por su parte, no solo legisla y regula cuestiones relativas a la innovación, sino que también puede actuar como empresario público o capitalista de riesgo, reemplazando así a la industria (Etzkowitz, 2003a).

En este enfoque se sitúan también diferentes trabajos que, respondiendo a quienes cuestionan el nuevo rol asumido por las universidades emprendedoras, aportan evidencia de que dicho rol no tiene un efecto negativo sobre las funciones tradicionales de las universidades, es decir, sobre la docencia y la investigación (Etzkowitz, 2003b; Ranga et al., 2003; Meyer, 2006 a, b).

Sociedad del conocimiento

El conjunto de trabajos de este grupo estudia cómo la universidad emprendedora contribuye al desarrollo regional y nacional. Por ejemplo, a través de la formación, la universidad emprendedora dota a su entorno de capital humano con las habilidades demandadas por los empleadores, pero también con las habilidades adecuadas para convertirse en

emprendedores y creadores de empleo (Urbano y Guerrero, 2013; Guerrero et al., 2015). Dotar al entorno de egresados con habilidades sobre emprendimiento es una forma de generar "capital emprendedor" (Guerrero et al., 2015), como también lo son la creación de incubadoras de empresas o de oficinas de transferencia de tecnología, entre otras acciones (Guerrero et al., 2016).

Finalmente, a través de la investigación, la universidad emprendedora genera "capital de conocimiento" que puede repercutir en el crecimiento económico local, ya sea mediante *spillovers* de conocimiento y/o mediante la transferencia intencionada del conocimiento con acuerdos de licencias sobre las patentes que protegen los resultados de la investigación, o con la creación *spin-offs* (Kirby et al., 2011; Urbano y Guerrero, 2013; Guerrero et al., 2015).

Perspectiva globalizada

En este grupo se incluyen un conjunto de aportaciones que ponen el foco en el proceso de transformación de las universidades en "emprendedoras", resaltando el papel de la globalización en esa transformación (Deem, 2001; Tuunainen, 2005b; Stromquist, 2007; Lam, 2010). Otros trabajos tratan de identificar los factores que condicionan dicha evolución; entre otros, estos factores incluyen la cultura organizativa, la historia de la universidad, o el carácter público o privado de la universidad (Tuunainen, 2005a; Yokoyama, 2006).

Rol investigador vs. rol emprendedor

Esta cuarta línea de investigación centra su interés en el papel del personal investigador de las universidades y analiza cuestiones diversas como su actitud hacia el emprendimiento (Martinelli et al., 2008), los factores contextuales que favorecen esta actitud (O'Shea et al., 2007; Bramwell y Wolfe 2008; Chang et al., 2009; Baldini, 2010; Yusof y Jain, 2010), las tensiones entre investigación y emprendimiento (Van Looy et al., 2011) y los motivos del investigador para participar en actividades emprendedoras (Czarnitzki et al., 2009; Baldini, 2010; D'Este y Perkmann, 2011).

Doble personalidad

Algunas de las aportaciones de este grupo destacan el necesario equilibrio que debe realizar la universidad emprendedora entre sus misiones tradicionales, es decir, la formación y la investigación, y la tercera misión (el crecimiento económico), además de establecer un correcto vínculo entre ellas (Jacob et al., 2003; Rasmussen y Sorheim, 2006; Wong et al., 2007; Sam y Van der Sijde, 2014). Por ejemplo, a través de la formación la universidad emprendedora también podría contribuir al logro de la tercera misión, incluyendo formación sobre emprendimiento en los planes de estudio de las carreras técnicas, lo que favorecería la creación de negocios innovadores y, probablemente, exitosos por parte de egresados de esas titulaciones (Rasmussen y Sorheim, 2006). De hecho, la falta de formación sobre emprendimiento de los investigadores egresados de titulaciones técnicas puede explicar que

tan solo el 10% de las patentes producidas en las universidades sean explotadas a través de *spin-offs* académicas (Meyer et al., 2003). En este grupo de aportaciones, también se ha destacado el necesario apoyo de los gobiernos para legitimar la incorporación de la tercera misión por parte de las universidades (Jacob et al., 2003).

Frenesí

Dentro de esta última línea, el trabajo de Philpott et al. (2011) señala que la orientación hacia un mismo tipo de actividades emprendedoras dentro de una misma universidad conduce a una división "esquizofrénica" entre las disciplinas que alberga. Los autores cuestionan si existe un modelo único de universidad emprendedora, y sugieren que al diseñar estrategias para lograr la tercera misión, los responsables de las universidades deben tener en cuenta que, además de patentes, licencias y *spin-offs*, hay otras formas de transferencia de conocimiento y de creación de riqueza, como, por ejemplo, los cursos de formación para el personal de la industria, o los servicios de consultoría, que a menudo son los mecanismos a través de los que académicos de los campos de las artes, humanidades y ciencias sociales contribuyen a la tercera misión.

Finalmente, al igual que el trabajo de Philpott et al. (2011), el resto de aportaciones de esta línea ponen el foco en el estudio de distintos aspectos de la relación universidad-empresa, como la influencia de la disciplina académica y de la orientación hacia el emprendimiento del departamento al que pertenece el personal académico, respecto del tipo de actividades emprendedoras en las que participan (Philpott et al., 2011, Kalar y Antoncic, 2015), o los motivos del personal de la industria y del personal académico para participar en actividades de colaboración universidad-industria (Ankrah et al., 2013), entre otros. También dentro de esta línea, Metcalfe (2010) destaca la mayor presión que experimenta el mundo académico para llevar a cabo aquellas actividades que permiten a las universidades obtener financiación alternativa a los fondos de carácter público.

2.3. Metodología y resultados del tercer artículo

El Anexo 3, dando respuesta al tercer objetivo, recoge un estudio[6] cualitativo de múltiples casos que nos ha permitido identificar las características que debería tener un ecosistema emprendedor para estimular la creación de un mayor número de *spin-offs* académicas, pero, de modo particular para facilitar su desarrollo sostenible y su éxito, partiendo de los desafíos a los que se enfrentan. Planteamos para abordarlo una propuesta teórica inicial de los contenidos de cada una de las dimensiones del ecosistema emprendedor de las *spin-offs* académicas, así como de sus actores clave (ver Figura 3, propuesta que incorpora al modelo de Isenberg (2011) e Isenberg y Onyemah (2016) los factores que hemos identificado en la literatura determinantes de la creación de *spin-offs* académicas y aquellos que les ayudan a desarrollarse y conseguir ser exitosas.

A la hora de escoger la población objeto de estudio para abordar el citado objetivo, y dado que, en España, el 96,46 % de las *spin-offs* académicas tuvo su origen en universidades públicas durante el periodo 2010-2019, centramos la selección de casos en este tipo de universidades y pusimos el foco en la Universidad Miguel Hernández (UMH) por ser la primera universidad de España en número de *spin-offs* creadas por cada 100 profesores, pese a ser de las más pequeñas del país y la más pequeña de su comunidad autónoma, según datos de ese mismo periodo. Para ampliar el número de casos a analizar, recurrimos a las *spin-offs* de la Universitat de València (UV) y de la Universidad Politécnica de Valencia (UPV), ambas universidades públicas de la misma comunidad autónoma que la UMH, y por tanto todas ellas comparten valores culturales similares y están sujetas a un mismo marco legislativo e institucional, pero distan mucho en número de *spin-offs* creadas (véase la Tabla 1).

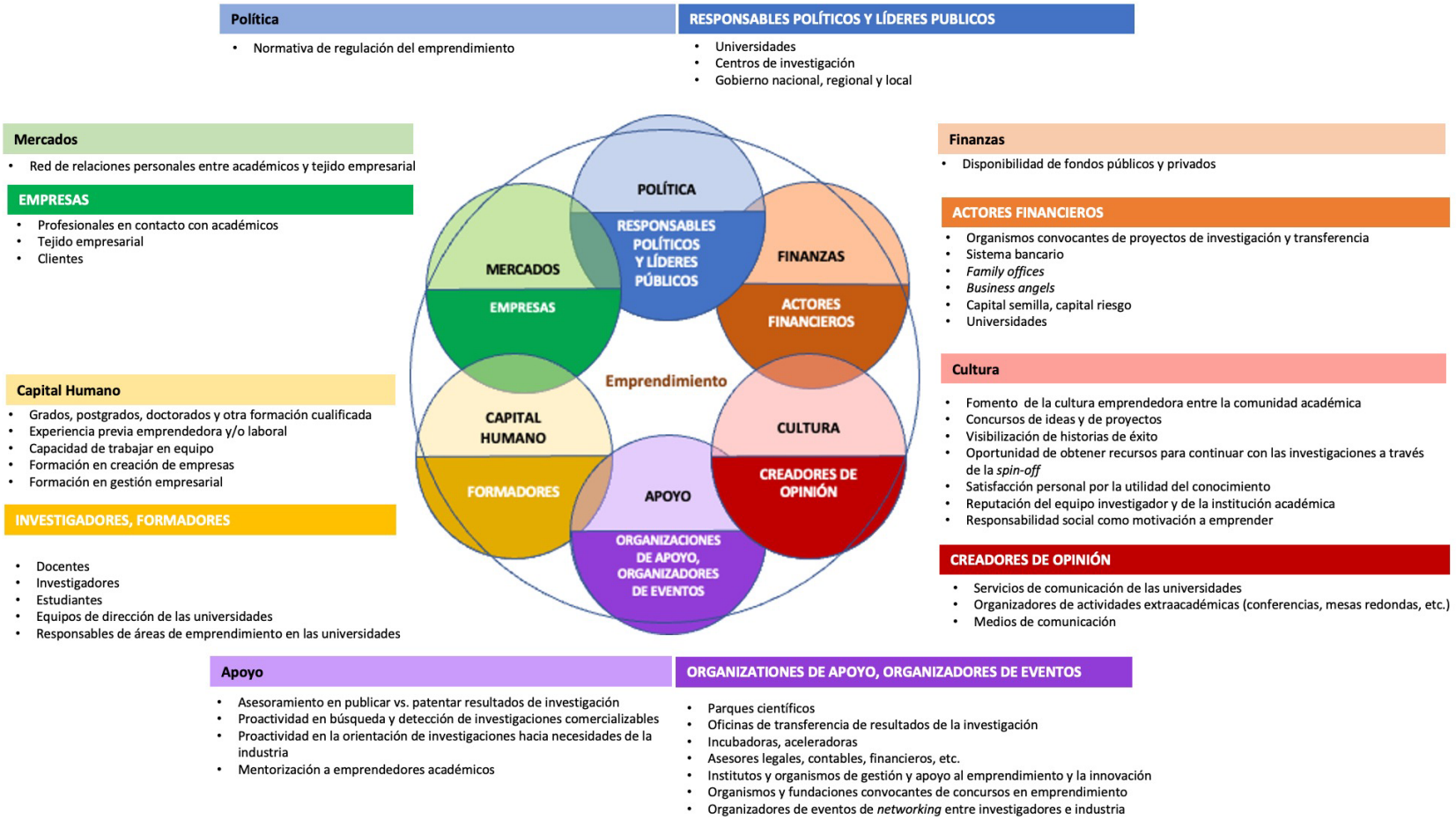
Tabla 1. Universidades públicas de la Comunitat Valenciana seleccionadas

Universidad	Promedio de profesores 2010-2019	*Spin-offs* creadas por cada 100 profesores 2010-2019	*Spin-offs* creadas 2010-2019
Universidad Miguel Hernández (UMH)	458,2	0,95	44
Universidad Politécnica de Valencia (UPV)	1.823,0	0,10	18
Universitat de València (UV)	2.181,1	0,02	4

Fuente: elaboración propia a partir de datos del IUNE (2019)

[6] Cerver-Romero, E., Mohedano-Suanes, A., Pardo-del-Val, M. (2022), "An Entrepreneurial Ecosystem for Successful Academic Spin-offs", *Transformations in Business & Economics*, Vol. 21, No 3C(57C), pp.667-698.

Figura 3. Propuesta teórica del ecosistema emprendedor para la creación y éxito de *spin-offs* académicas



Fuente: adaptado de Cerver et al. (2022: 675)[7]

[7] Esta figura se corresponde con la Figura 2 del Anexo 3

La investigación se sustenta en el estudio de 16 *spin-offs* académicas, combinando casos de éxito y de fracaso, para así contar con una composición heterogénea de los casos (Eisenhardt, 1989). Las características principales de los casos seleccionados se sintetizan en la Tabla 2.

Tabla 2. Características básicas de los casos analizados

*Spin-off*ª	Año de creación	Sector	Nº empleados	Universidad de origen
SpO-01	2006	Agroalimentario/industria auxiliar	6	UV
SpO-02	2007	Tecnologías de la información	6	UV
SpO-03	2014	Biotecnología médica	7	UV
SpO-04	2012	Tecnología médica	5	UPV
SpO-05	2019	Tecnología médica	1	UPV
SpO-06	2019	Diseño industrial	1	UPV
SpO-07	2013	Psicología	12	UMH
SpO-08	1999	Biotecnología cosmética	12	UMH
SpO-09	2014	Biotecnología médica	2	UMH
SpO-10	2015	Biotecnología médica	11	UMH
SpO-11	2016	Biotecnología médica	5	UMH
SpO-12	2019	Biotecnología médica	3	UV
SpO-13	2013	Biotecnología médica	3	UMH
SpO-14	2004	Biotecnología agroalimentaria	10	UMH
SpO-15	2013	Biotecnología agroalimentaria	0	UMH
SpO-16	2011	Tecnología fotónica	18	UPV

Fuente: adaptado de Cerver et al. (2022:676)[8]

La información se ha obtenido principalmente mediante entrevistas semiestructuradas, con una duración media de noventa minutos, realizadas durante octubre y noviembre de 2020. En la mayoría de los casos se entrevistó al fundador o fundadores académicos. Todas las entrevistas fueron grabadas y posteriormente transcritas y se condujeron siguiendo el protocolo diseñado al efecto. Además, también se utilizaron fuentes secundarias de información para cada caso. La triangulación de la información entre las distintas fuentes empleadas garantiza un elevado grado de consistencia. A continuación, mediante el análisis de contenido, se realizó el informe de cada caso. Cada investigadora del equipo realizó su propio análisis e interpretación de la información, lo que permitió posteriormente la triangulación entre investigadoras, además de con los entrevistados, quienes recibieron una copia del informe y fueron invitados a aportar sus consideraciones, alcanzándose así también un elevado grado de consistencia (Yin, 2003).

En la Tabla 3 sintetizamos los principales resultados obtenidos, recogiendo los retos o desafíos más habituales que identificamos en el análisis de los casos, así como los contenidos o elementos que deben incorporar las dimensiones de un ecosistema emprendedor académico

[8] Esta tabla se corresponde con la Tabla 1 del Anexo3

para darles respuesta. Esta misma información queda recogida bajo otro formato en la Figura 10 del Anexo 3.

Tabla 3. Desafíos del emprendimiento académico e implicaciones sobre su ecosistema

Desafíos	**Implicaciones sobre el ecosistema emprendedor académico**
Motivos del emprendimiento académico: devolver a la sociedad lo que esta ha hecho por el investigador, saber que las investigaciones tienen una utilidad práctica, dar salida profesional a investigadores. El sistema de incentivos asociado a la carrera profesional orienta al investigador a publicar resultados y no a explotarlos comercialmente.	DIMENSIÓN POLÍTICA ✓ Normativa de regulación del emprendimiento académico ✓ Incentivos adecuados a la investigación y a la transferencia DIMENSIÓN CULTURA ✓ Fomento de la cultura emprendedora y de la transferencia entre la comunidad académica ✓ Fomento de la satisfacción personal por la utilidad del conocimiento como valor ✓ Deseo de generación de empleo entre doctorandos y otro personal investigador ✓ Dar visibilidad a historias de éxito
Desconocimiento de la posibilidad de transferencia desde las universidades, bien a través de acuerdos, como por ejemplo licencias sobre patentes, o de *spin-offs* académicas con la participación de empresarios no académicos, académicos e, incluso, la propia universidad.	DIMENSIÓN POLÍTICA ✓ Creación y apoyo de parques científicos DIMENSIÓN APOYO ✓ Organización de encuentros entre el mundo académico y el tejido empresarial
Importancia de orientar al mercado las investigaciones, valorando utilidad en la práctica, su viabilidad comercial y económica.	DIMENSIÓN APOYO ✓ Asesoramiento para identificar qué resultados de investigación son comercializables ✓ Asesoramiento sobre cuándo publicar y patentar resultados de investigación ✓ Proactividad en búsqueda y detección de investigaciones comercializables ✓ Visibilizar los servicios de asesoramiento de las OTRI's DIMENSIÓN CAPITAL HUMANO ✓ Formación a emprendedores académicos ▪ para que tengan presente la orientación al mercado o potencial práctico de sus investigaciones ▪ en creación de empresas ▪ en gestión empresarial ▪ en propiedad industrial ▪ en servicios y funciones de las OTRI's DIMENSIÓN MERCADOS ✓ Capacidad de adopción de las innovaciones por parte del tejido empresarial ✓ Relaciones colaborativas entre académicos y tejido empresarial

Importancia de los premios tanto económicos, como aquellos consistentes en formación o mentorización, y de los concursos, que aportan visibilidad, relaciones con el ecosistema y fomentan una cultura emprendedora.	DIMENSIÓN MERCADOS ✓ Facilitar el *networking* entre emprendedores DIMENSIÓN APOYO ✓ Organizar y/o apoyar la existencia de concursos DIMENSION FINANZAS ✓ Premios vinculados a concursos de emprendimiento
Necesidad de apoyo y asesoramiento empresarial.	DIMENSIÓN POLITICA ✓ Programas públicos de acompañamiento a los académicos emprendedores DIMENSIÓN APOYO ✓ Soporte con trámites administrativos ✓ Asesoramiento sobre financiación ✓ Asesoramiento de especialistas por áreas funcionales por parte de OTRIS y parques científicos
Necesidad de incorporar en los equipos fundadores a investigadores de reconocido prestigio científico y a miembros con competencias directivas.	DIMENSIÓN MERCADOS ✓ Interacción entre gerentes profesionales y académicos emprendedores DIMENSION DE CAPITAL HUMANO ✓ Grados, postgrados, doctorados y otra formación cualificada DIMENSION DE CULTURA ✓ Reconocimiento y puesta en valor del prestigio del investigador
Necesidad de contar con la financiación necesaria en cantidad y momento adecuados. Necesidad de programas de apoyo e inversores adecuados en cada etapa.	DIMENSIÓN FINANZAS ✓ Ayudas a la contratación de doctores y otro personal investigador ✓ Ayudas públicas que tengan en cuenta la idiosincrasia del sector de la spin-off y que lleguen en los momentos oportunos DIMENSION CAPITAL HUMANO ✓ Grados, postgrados, doctorados y otra formación cualificada (en ingenierías, ciencias, etc.) DIMENSIÓN APOYO ✓ Iniciativas para facilitar el contacto con inversores adecuados a cada etapa

Fuente: elaboración propia

En cualquier caso, debemos considerar que los elementos de cada dimensión están interrelacionados y, siguiendo el planteamiento teórico del ecosistema como conjunto de elementos que se equilibra a partir de sus relaciones complejas, esta investigación muestra la existencia de interacciones entre los elementos de una misma dimensión, así como entre los de distintas dimensiones, que colaboran al equilibrio y al refuerzo de los componentes del ecosistema (véase la Tabla 2 del Anexo 3). A modo de ejemplo destacamos las dos más potentes por implicar a cinco de las seis dimensiones del ecosistema. En primer lugar, las políticas de creación y respaldo a parques científicos (dimensión política) permiten a los

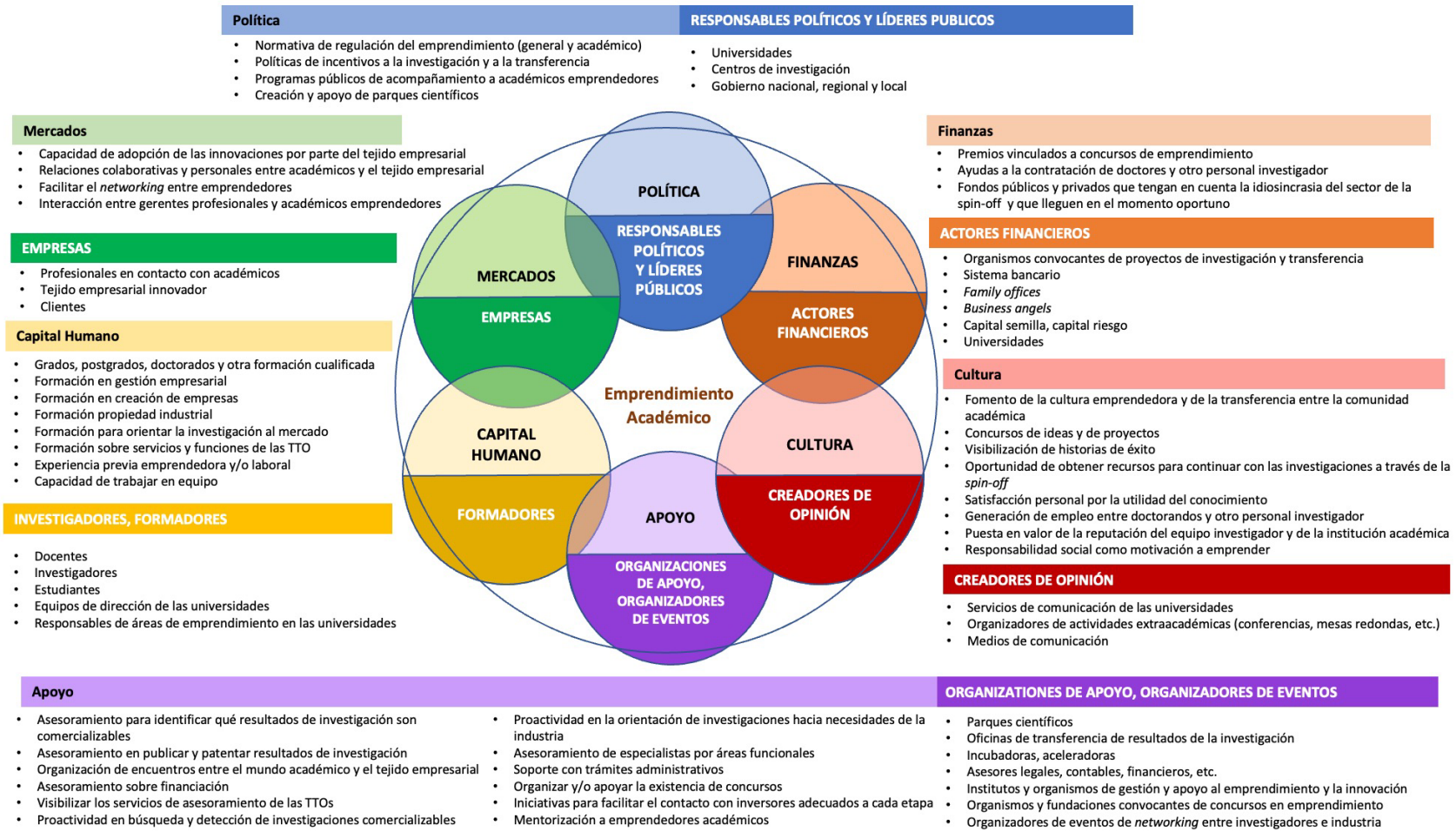
emprendedores académicos disponer de instalaciones y servicios con un coste reducido (dimensión finanzas), así como acceder a otros servicios de apoyo como asesoramiento (dimensión apoyo), formación (dimensión capital humano), contacto y *networking* entre emprendedores (dimensión mercados), empresas (dimensión mercados), e inversores (dimensión apoyo). En segundo lugar, la organización de concursos de ideas o de emprendimiento (dimensión apoyo) contribuye a reforzar la cultura orientada al emprendimiento (dimensión cultura); si conllevan premios en metálico completan la financiación (dimensión finanzas) y si conllevan programas de formación y/o mentorización mejoran la cualificación del equipo fundador (dimensión capital humano); facilitan el *networking* entre emprendedores y/o con empresas (dimensión mercados) e, incluso, el contacto con inversores (dimensión finanzas).

Finalmente, nuestra propuesta de ecosistema emprendedor favorecedor para la creación y éxito de *spin-offs* académicas (véase la Figura 4) confirma sustancialmente el contenido del ecosistema emprendedor inicial que surge de la revisión teórica sobre los factores determinantes para la creación y el éxito de *spin-offs* académicas, y lo amplía con los hallazgos de la investigación empírica que dan mayor consistencia a sus dimensiones. Los actores o agentes responsables en cada dimensión garantizarían la presencia de todos los elementos identificados.

Nuestros resultados sugieren que un ecosistema emprendedor adecuado para la creación y éxito de las *spin-offs* académicas requiere que las dimensiones política, cultural, financiera, de apoyo, capital humano y de mercados tengan un contenido y unos actores específicos que complementen al ecosistema emprendedor ´convencional´ y la idiosincrasia del contexto académico se vea recogida.

En el siguiente apartado recogemos las conclusiones, limitaciones y futuras líneas de investigación que se derivan de los estudios que acabamos de presentar.

Figura 4. Ecosistema emprendedor para la creación y éxito de *spin-offs* académicas



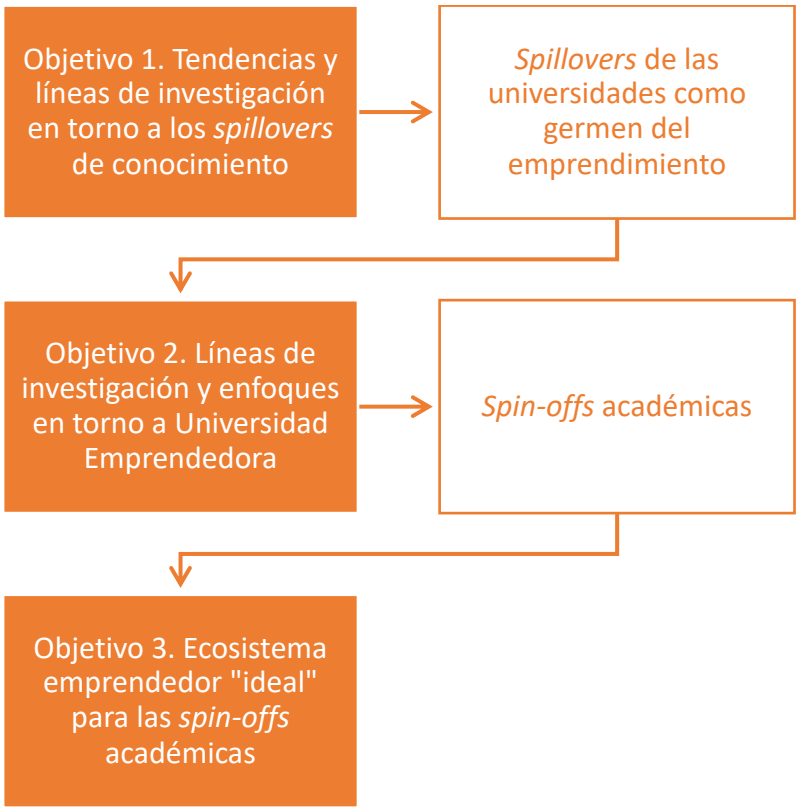
Fuente: adaptado de Cerver et al. (2022: 690)[9]

[9] Esta Figura se corresponde con la Figura 11 del Anexo 3

3. Conclusiones, limitaciones y futuras líneas de investigación

El hilo conductor de esta investigación es la utilización del conocimiento generado en las universidades para crear una empresa innovadora. El primer artículo destaca el rol de la universidad como generadora de *spillovers* de conocimiento, el segundo describe cómo son las universidades emprendedoras y en el tercero analizamos el contexto en el que se crean y desarrollan las *spin-offs* académicas. La Figura 5 recoge la línea argumental de esta investigación.

Figura 5. Universidad Emprendedora: de los *spillovers* de conocimiento a las *spin-offs* académicas



Fuente: elaboración propia

Nuestra primera investigación, metodológicamente cuantitativa sobre los *spillovers* de conocimiento, nos permitió sistematizar la literatura, constatar en las publicaciones la heterogeneidad de los estudios, e identificar cinco tendencias en la investigación de este fenómeno.

Los *spillovers* de conocimiento tienen un impacto positivo en el desempeño innovador y económico a nivel empresarial, regional y nacional, por lo que los gobiernos deberían considerarlos en el diseño de políticas de apoyo a la innovación. El marco institucional, y concretamente la legislación a nivel regional y/o nacional, puede favorecer u obstaculizar las

externalidades de conocimiento, en función del nivel de protección que imponen a la propiedad intelectual e industrial.

La revisión realizada nos permite afirmar que los *spillovers* de conocimiento promueven la aglomeración y la acumulación de capital humano en un territorio, están localizados geográficamente y tienen un alcance principalmente intranacional. No obstante, mecanismos como la inversión directa o el comercio internacional permiten los *spillovers* de conocimiento transfronterizos y que las empresas de un país aprovechen el conocimiento desarrollado en otro.

Muchos de los trabajos revisados han puesto el foco en las universidades y las externalidades positivas para su entorno. No son pocas las empresas que eligen localizaciones cercanas a universidades u otros organismos orientados a la investigación, con el fin de aprovechar el capital humano que generan, los últimos avances científicos, pero también beneficiarse de posibles *spillovers* de conocimiento que permiten que otros agentes económicos identifiquen y exploten.

Esas conclusiones iniciales motivaron que nuestra investigación se orientase hacia el análisis de las universidades emprendedoras y abordáramos en el segundo artículo un estudio bibliométrico que nos permitió identificar seis enfoques en torno a este concepto.

La transformación que están experimentando muchas universidades para contribuir al crecimiento económico como parte de su misión ha abierto un nuevo debate entre los investigadores. Mientras algunos autores argumentan que se trata de una transformación isomórfica, otros defienden que está condicionada por factores contextuales, como su condición de universidad pública o privada, su cultura organizativa, las políticas gubernamentales del país o la necesidad de buscar financiación. Profundizar en el estudio de los factores que influyen en esta transformación, además de ser una interesante línea de investigación, podría servir como una guía útil a los equipos directivos para saber si ciertas prácticas y estrategias implementadas por universidades que han alcanzado un alto nivel de actividad emprendedora pueden ser imitadas por universidades de otras regiones o países y adaptarse con éxito a sus contextos particulares.

Esa transformación de las universidades también ha abierto otro debate en cuanto al tipo de relación, beneficiosa o no, entre la tercera misión y las misiones tradicionales de la Universidad. La revisión realizada nos lleva a concluir que se trata de una relación positiva y que docencia, investigación y transferencia se refuerzan entre sí, siendo necesario, además, mantener un equilibrio entre las actividades de exploración, creación y explotación del conocimiento. Estos estudios abogan por la necesidad de que los planes de formación de las distintas titulaciones universitarias incluyan también la formación sobre gestión y dirección de empresas, así como sobre emprendimiento, con el objetivo de fomentar el espíritu emprendedor entre estudiantes y académicos. Sin embargo, faltan estudios que midan el impacto que este tipo de formación tiene en la creación de empresas y en el

intraemprendimiento de las empresas que contratan a titulados que han recibido esta formación.

De otro lado, la investigación realizada nos ha permitido identificar un importante sesgo en la literatura especializada sobre universidad emprendedora, pues la gran mayoría de trabajos se centran exclusivamente en torno a la transferencia de tecnología a la industria a través de la explotación de patentes de su propiedad, bien a través de acuerdos de licencia o bien mediante la creación de *spin-offs* académicas. Por ello, consideramos que nuevos trabajos podrían dirigirse al análisis de la transferencia de conocimiento no necesariamente tecnológico, por ejemplo, en el ámbito de las ciencias sociales, lo que plantea una interesante línea de investigación.

Otra conclusión que extraemos de este trabajo es que el modelo de triple hélice, esto es, las relaciones entre universidad, industria y gobierno impactan directamente tanto en la transferencia de conocimiento como en la innovación y, a través de esta última, contribuyen al desarrollo económico regional y nacional. De hecho, numerosos trabajos analizan cómo las universidades pueden contribuir a través de la formación, la investigación y las actividades emprendedoras, al desarrollo económico de un territorio. De otro lado, queda por explorar cómo las universidades emprendedoras también pueden contribuir a la sostenibilidad ambiental de la región en la que operan y al logro de los Objetivos de Desarrollo Sostenible (ODS) que recoge la Agenda 2030 de las Naciones Unidas.

Todavía hay cuestiones que deben examinarse con más profundidad para mejorar nuestra comprensión de la universidad emprendedora. Para ello, esta podría ser estudiada desde diferentes teorías y enfoques teóricos, tanto desde el ámbito de la gestión como desde otras áreas, como la psicología o la sociología. Otra línea de investigación podría analizar si existen diferencias entre el impacto económico y social de la universidad emprendedora frente al impacto de las universidades tradicionales.

Por otra parte, aunque algunos trabajos en el marco de la universidad emprendedora han considerado el papel de variables como la disciplina del investigador o el género en el desarrollo de actividades emprendedoras, se podría explorar la relación entre las características de los miembros del equipo de gestión de la universidad emprendedora y el éxito de las relaciones entre la universidad y la industria.

Finalmente, los investigadores no han considerado el papel que podrían jugar las nuevas tecnologías de la información y la comunicación en las actividades que lleva a cabo la universidad emprendedora y sus funciones, lo que proporciona otra interesante línea de investigación.

Las conclusiones de nuestro segundo artículo sobre las universidades emprendedoras y las relaciones de la triple hélice nos llevaron a interesarnos por el papel del ecosistema emprendedor en el que surgen las *spin-offs* académicas, cuestión que había atraído una

atención limitada entre los investigadores. Mediante un estudio de múltiples casos, nuestro tercer trabajo identifica las características de un ecosistema emprendedor "ideal" facilitador de la creación y el desarrollo exitoso de las *spin-offs* académicas, y aporta como contribución la idiosincrasia del ecosistema emprendedor académico frente al ecosistema emprendedor "convencional".

Manteniendo las dimensiones de un ecosistema emprendedor "convencional", en el ecosistema emprendedor académico se pone el énfasis en políticas e incentivos a la investigación y a la transferencia, en la importancia de una cultura que las ponga en valor y en la necesidad de contar con capital humano de alta cualificación. En cuanto a la especificidad de la dimensión de apoyo, de nuestro trabajo se desprende la importancia de las OTRI's para garantizar, previamente a la creación de la *spin-off*, la correcta definición y protección de la propiedad intelectual e industrial. Posteriormente, OTRI's y parques científicos, junto a otras infraestructuras de apoyo, deberían dar soporte para el inicio de la actividad. Adicionalmente, en lo que respecta a la dimensión financiera, son necesarios en el ecosistema fondos públicos que permitan contratar personal altamente cualificado, como doctores y otros investigadores, avanzar en la investigación y generar innovaciones desde las universidades y entidades públicas de investigación. La cooperación entre investigadores y empresas bajo diferentes tipos de acuerdo es otro elemento necesario y especifico del ecosistema de las *spin-off*s académicas.

En cualquier caso, nuestra propuesta no ignora el carácter autosuficiente y autorregulador de cada ecosistema emprendedor y que cualquier actuación sobre el mismo debería hacerse considerando su carácter sistémico. Tratar de mejorar una de sus dimensiones puede ser ineficaz si se ignora su interrelación con otras dimensiones, así como la interrelación entre elementos de una misma dimensión. En este sentido, las políticas de apoyo a la creación de infraestructuras para la incubación y soporte a las *spin-offs* académicas, como parques científicos y OTRI's, pueden resultar ineficaces si no se acompañan de otras políticas que establezcan una carrera profesional para investigadores en universidades y entidades públicas de investigación que valore tanto sus logros investigadores como emprendedores.

Este trabajo no está exento de limitaciones. En primer lugar, nuestro estudio se ha centrado en casos de *spin-offs* académicas surgidas de universidades localizadas en un determinado contexto geográfico, que posteriores estudios deberían ampliar. En segundo lugar, la información obtenida proviene principalmente de los fundadores de las *spin-offs* analizadas. Dado el carácter sistémico propio de los ecosistemas emprendedores, considerar la perspectiva de otros *stakeholders* como, por ejemplo, responsables de políticas públicas, parques científicos, OTRIS, e inversores, entre otros, enriquecería los resultados. Futuras líneas de investigación podrían asimismo avanzar en la medición de cada una de las dimensiones, así como en propuestas de actuaciones sistémicas que mejoren el ecosistema emprendedor para las *spin-offs* académicas.

En el contexto económico actual, para que las organizaciones y los países mejoren su competitividad, deben comprender que el conocimiento es un recurso estratégico clave que deben gestionar de una forma adecuada como *input* básico de la innovación. Esta investigación, a través de sus tres artículos, nos permite afirmar que el desarrollo económico regional y nacional depende tanto de la existencia de *spillovers* de conocimiento, como de las relaciones entre industria-universidad-gobierno por su papel en la transferencia de conocimiento y en la innovación, y que las *spin-off* académicas son una potente herramienta precisamente para transferir el conocimiento generado en universidades y entidades públicas de investigación a la sociedad, razón por la que las políticas públicas, para potenciar el crecimiento de las regiones o países a las que dan soporte, deben apoyar y fomentar tanto las relaciones y mecanismos que tienen un impacto directo o indirecto en la innovación, como el ecosistema en el que tienen lugar.

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PARTE II.

Anexos: artículos de la tesis por compendio

Artículo 1. A scientometric analysis of knowledge spillover research

The Journal of
TECHNOLOGY
TRANSFER

Volume 45, No. 3
June 2020
ISSN 0892-9912

Springer

A scientometric analysis of knowledge spillover research

Publicado en la revista *The Journal of Technology Transfer***,** en 2020, Vol. 45, No 3, pp.780-805. ISSN 0892-9912

https://doi.org/10.1007/s10961-018-9698-9

Esta revista está incluida en los siguientes índices:

1. **Journal Citation Reports 2020**
   Social Sciences Citation Index (SSCI), Journal Impact Factor 5.783
   CATEGORY MANAGEMENT Rank by Journal Impact Factor 65/226 (Q2)
2. **SCOPUS 2020**
   CiteScore 8.8; Q1 93% 25/399 Business and International Management
3. **Scimago Journal Rank 2020**
   SJR 1.768; Q1 Business and International Management

JEL Classification M20, M21, O32, O33

Número de accesos al artículo: 1.482
Número de citas en Google Scholar: 23
Número de citas en Web of Science: 12
(datos a 2 de mayo de 2023)

A scientometric analysis of knowledge spillover research

Elvira Cerver Romero[1]· João J. M. Ferreira[2] · Cristina I. Fernandes[2]

[1] Departamento de Dirección de Empresas Juan José Renau Piqueras, Universidad de Valencia, Valencia, Spain
[2] Department of Management and Economics & NECE Research Unit in Business Sciences, University of Beira Interior, Covilhã, Portugal

Published online: 20 September 2018

Abstract

This paper explores current trends in knowledge spillover research using scientometric analysis of all papers published in journals indexed in the Web of Science. No chronological filter was applied. The search yielded 1568 articles. The bibliometric study presented herein was based on co-citations analysis. Given that this paper deals with a complex research area, multidimensional scaling was used to map connections between articles that present different approaches. Hierarchical cluster analysis was then applied to group related articles into sets. Finally, principal component analysis with Varimax rotation was applied to obtain further insight into existing knowledge spillover research. This process showed which articles share common elements and which articles have the largest weights for each of the previous factors. The knowledge spillover literature focuses on five main approaches: (i) knowledge spillover location; (ii) knowledge spillover agglomeration; (iii) knowledge spillover institutional approach; (iv) knowledge spillover demography; and (v) knowledge spillovers of entrepreneurship. This is the first comprehensive scientometric study of knowledge spillover research to describe the state of the art and provide suggestions for the future research agenda for this field.

Keywords: Knowledge spillovers · Entrepreneurship · Location · Clusters · Demography

1 Introduction

The importance of entrepreneurship is reflected by the large number of regional-level studies showing that the basis for creating new companies is knowledge, thereby highlighting the role of knowledge spillovers. This knowledge, which emanates from universities and other research and development (R&D) institutions, is generated and fostered through collaborations between companies and these R&D institutions (Varga 2000; Audretsch and Lehmann 2005; Riddel and Schwer 2003). For Acs et al. (2009), entrepreneurship tends to increasingly improve in the sense that investment in new knowledge is relatively high while companies, especially new ones, turn to the real sources of knowledge (universities and R&D institutions). For Varga (2002) studying the location of knowledge spillovers as a type of economic cluster and the way knowledge spillovers contribute to the development of regional economies should set the agenda for political practices. Entrepreneurship is also a factor of

regional development as reported by Schumpeter (1934, 1939, 1942). Entrepreneurs constitute the primary driving force of economic development because they are able to create innovations that allow them to make a profit by taking the risks inherent in these creations. Steffensen et al. (2000) and Feller et al. (2002) argue that this entrepreneurship, especially in the case of new companies may have its roots in universities, since many students develop projects during their education that are later realized or commercialized. Given the wealth of studies on the importance of knowledge spillovers and the development of knowledge spillover theory, the literature on this concept is highly fragmented and problematic. In this study, we mapped the scientific publications, intellectual structure, and trends in knowledge spillover research. Our aim was threefold: (1) delineate the intellectual structure of research reported in the academic literature; (2) map a two−dimensional illustration of the intellectual structure of this research using the visualization of spatial distances between related subjects; and (3) determine the areas of research that make up the intellectual structure of this field and identify possible relationships between these areas. To achieve these aims, we performed a scientometric analysis of all articles published in journals indexed in the Web of Science. No chronological filter was applied. This analysis combined several quantitative methods based on statistical analysis. The goal was to analyze the citations in articles published in scientific journals to evaluate the impact of publications in terms of their dissemination (Thomsom 2008). We sought to contribute by systematizing knowledge spillover theory while highlighting the theoretical approaches that future studies in this field of research should embrace.

2 Literature review

Helpman (1992) define technological spillovers as situations in which: (1) companies can acquire information created by others without paying for it in a market transaction; and (2) the creators (or current owners) of the information have no effective recourse under existing laws if other companies use the information acquired in this way. Several authors argue that spillovers can be embedded (Terleckyj 1974; Griliches 1990; Coe and Helpman 1995; Debresson and Hu 1999; OECD 1999; Roelandt and den Hertog 1999). Spillovers can be embedded if they relate to the purchase of equipment, goods, or services. Embedded spillovers can also be defined as rental spillovers because they result from a company's efforts—products sold to other companies are not fully absorbed by a competing price increase. Parker and Zilberman (1993) argue that the transfer of academic knowledge can be defined as a process that is based on understanding, information, and innovation that is moved from universities to companies. Steurs (1994) defines R&D spillovers as the involuntary escape and voluntary exchange of useful technological information.

In 2007, the OECD noted that universities were playing an increasingly important role in transferring knowledge and competitiveness in their local regions (OECD 2007). For Acs et al. (2009), endogenous growth theories fail on a key point: the transmission of knowledge by spillovers for entrepreneurship or entrepreneurs (Audretsch and Lehmann 2005). This implies

that knowledge by itself is a fundamental condition for the successful growth of companies (Acs et al. 2009).

Through this relationship, it is possible to innovate (in products or services) and consequently increase market share (Jaffe 1989; Feldman and Florida 1994; Anselin et al. 1997, 2000; Varga 1998; Fischer and Varga 2003). Thus, spillovers can appear anywhere through: (i) the movement of highly specialized professionals; (ii) the use of a given technology in the production of certain products; and (iii) the relationship between the knowledge applied by professionals to the R&D service (i.e., human capital), thereby generating formal and informal exchanges of people and ideas while increasing operational efficiency (Ellison et al. 2010; Acs 2002; Delmar and Wennberg 2010).

Knowledge transfer between universities and companies can also be carried out directly through formally established partnerships or other business relationships. Geographic proximity influences cooperation between companies and universities, and such cooperation influences the capacity to undertake and generate innovation (Fernandes and Ferreira 2014). Braunerhjelm et al. (2018) concluded that there are essentially advanced knowledge flows between firms and that they have a significant influence on innovation. The mobility of skilled workers is stronger when companies are already involved in innovative activities with each other. Identifying the magnitude of spillovers is a major contribution to the policy debate on innovation and growth because the impacts of any policy may depend not only on the behavior of a particular inventor and/or entrepreneur but also on a "multiplier effect" that affects the innovation process at a broader level (Aghion and Jaravel 2015).

3 Method and data

3.1 Method

Co-citation analysis is used to map in detail the relationship between the key ideas of a given scientific domain (Small 1973). It helps identify the fundamental scientific articles in the corresponding body of scientific research (Zitt and Bassecoulard 1994). White and Grifith (1981) pioneered co–citation analysis of authors through their study of research on decision and judgment. Two documents are co–cited when they are quoted jointly in one or more published articles (Smith 1981). The number of joint quotations is a way of viewing a representative part of the literature in a knowledge area, identifying influential authors, and discovering interrelationships (White and McCain 1998). Several studies have demonstrated the validity of co-citation analysis to understand the intellectual structure of a research area (Di Guardo and Harrigan 2012). To pursue the aims of the study, we first performed descriptive analysis of the articles retrieved by the research. Subsequently, the bibliometric method of co-citation analysis described by White and McCain (1998) was used to analyze the most cited publications on knowledge spillover theory. The number of times two studies or authors dealing with knowledge spillover theories were quoted together in the resulting universe of

publications was analyzed to obtain relationships in citations and map the dominant approaches in research on knowledge spillover theory. To graphically map the articles, multidimensional scaling analysis was used. This process yielded a two-dimensional plot showing co-citation links between articles. In this plot, the points that are next to the origin represent articles with connections to other articles that have different approaches and with a set of highly heterogeneous citations. After multidimensional scaling, hierarchical cluster analysis was applied to group related articles into sets using the graph yielded by the multidimensional scaling to visualize the groups. Finally, principal component analysis with Varimax rotation was used to obtain additional information on current knowledge spillover research. More specifically, this technique was used to determine which articles share common components and which articles have the greatest weight for each of the above factors. In this method, the values arising from the analysis also indicate the relative importance of each of the resulting factors.

3.2 Data

Data were collected from the Science Citation Index Expanded (SCI-Expanded). Social Sciences Citation Index (SSCI), and Social Science Citation Index (A & H CI), all of which are compiled by the Thomson Reuters-ISI online databases. These databases contain thousands of academic publications and extensive bibliographic information on authors, affiliations, and citations. The research was conducted using the Web of Science Core Collection database. No chronological filter was applied. The term “knowledge spillovers” was searched for in the title, keywords, or abstract of all articles. The search retrieved 1568 articles published between 1991 (1 article) and 2017 (173 articles). These articles were cited 40.970 times by 21.209 publications (an average of 26.15 citations per article), and the articles themselves contained citations of 64.153 articles. Figure 1 shows the number of articles published each year. The first publication was in 1991. The number of articles published did not grow substantially until 1999. From 2007 onwards, there was major linear growth in the number of articles. The number of articles published was greatest in recent years (173 articles in 2017, 166 articles in 2016, 144 articles in 2015, and 142 articles in 2014). The median year of publication was 2011, indicating that this research area has become particularly relevant in recent times.

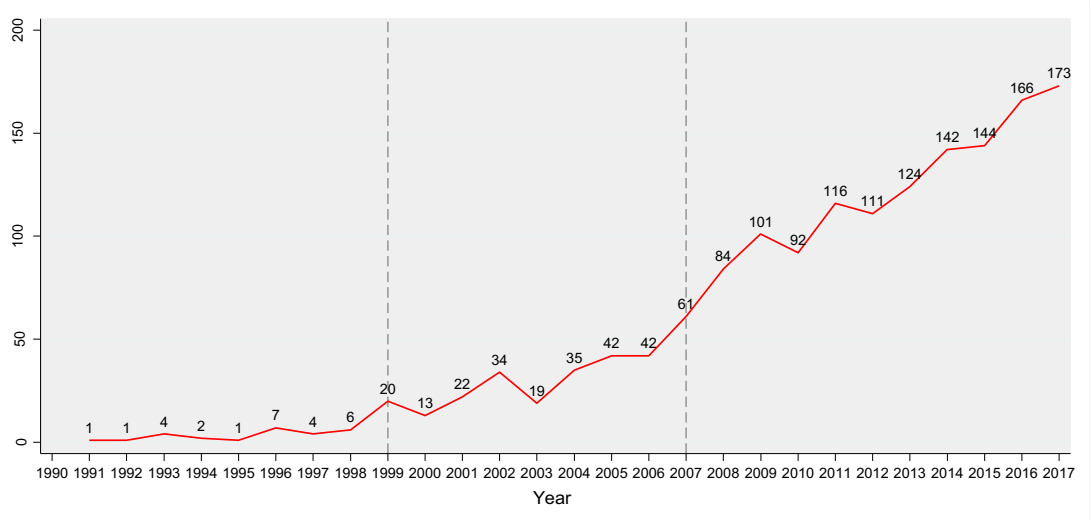

Fig. 1 Number of articles by year

The five articles with most citations, in descending order, are as follows:

1. Jaffe, A. B., Trajtemberg, M.. & Hndersone, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal Of Economics, 108*(3), 577–598. (1877 citations).
2. Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., & Shleifer, A. (1992). Growth in cities. *Journal of Political Economy, 100*(6), 1126–1152. (1199 citations).
3. Malmberg, A.. & Maskell, P. (2002). The elusive concept of localization economies: Towards a knowledge-based theory of spatial clustering. *Environment and Planning A: Economy and Space, 34*(3), 429–449. (454 citations).
4. Feldman, M. P., & Audretsch, D. B. (1999). Innovation in cities: Science-based diversity, specialization and localized competition. *European Economic Review, 43*(2), 409–429 (409 citations).
5. Henderson, R.. & Cockburn, I. (1996). Scale, scope, and spillovers: The determinants of research productivity in drug discovery. *Rand Journal of Economics, 27*(1), 32–59, (403 citations).

Figure 2 presents the 15 journals where most articles have been published. Leading the number of publications is Research Policy with 70 articles, followed by Small Business Economics (52 articles). Regional Studies (47 articles). Journal of Economic Geography (37 articles), and Annals of Regional Science (35 articles). The 15 journals listed in the table have published 436 articles or 37.3% of all articles considered in this study.

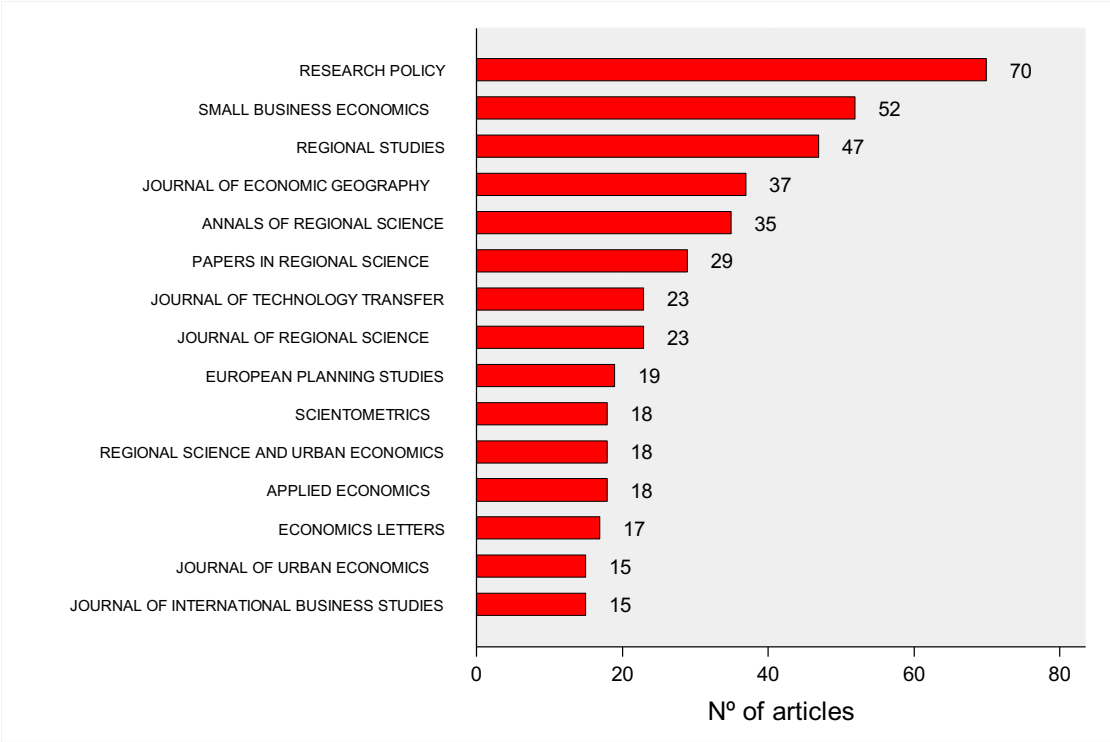

Fig. 2 Distribution of articles by journal (top 15 journals)

Once the 1568 articles had been identified, a criterion had to be established to select the articles that would serve as the basis for the analysis to respond to the aims of the study. A criterion of relevance was used to select articles, given that the inclusion of a large number of articles would help enrich the analysis. Accordingly, articles with at least 50 citations were selected. This yielded 99 articles. The list of these 99 articles is presented in the Appendix (Table 3).

The distribution of these 99 articles by journal again revealed that Research Policy had published more articles than any other journal (15 articles), followed by Regional Studies and the American Economic Review (Fig. 3). These three journals accounted for almost one-third of the articles under study.

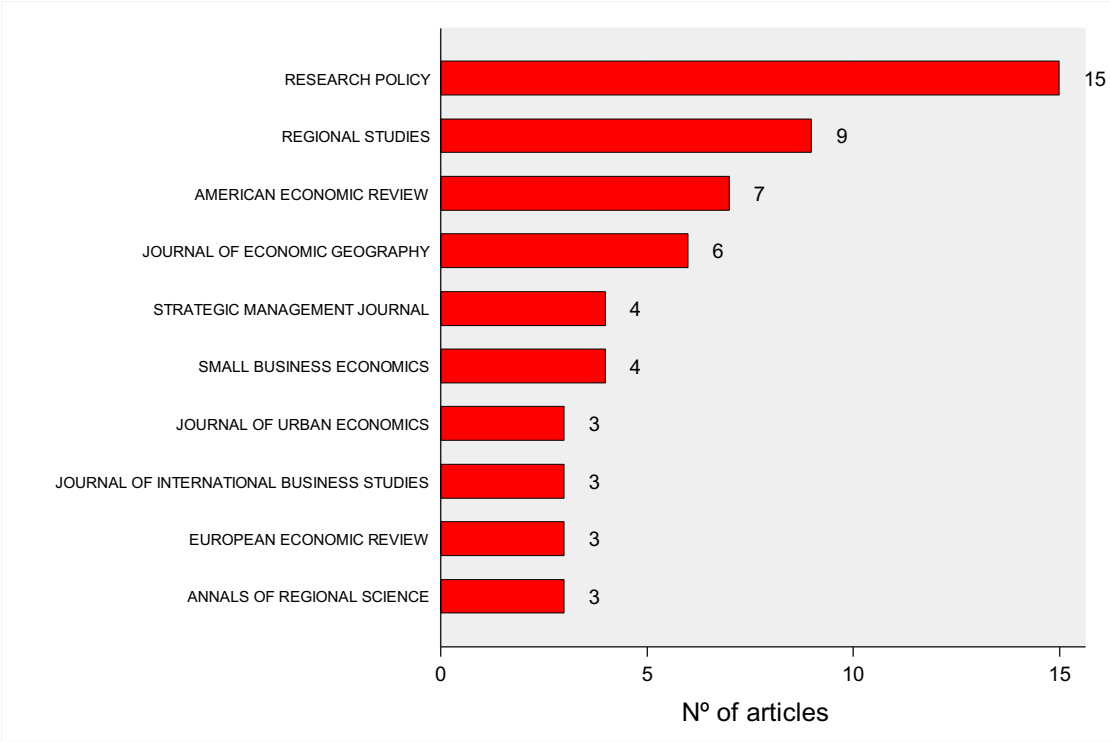

Fig. 3 Distribution of articles by journal (top 10 journals)

3.3 Data analysis

For the data analysis, three techniques were applied to the co-citation matrix. Network and graph theory was used to generate a map to analyze the relationships between the articles. UCINET version 6.554 (Borgatti et al. 2002) and NetDraw version 2.148 (Borgatti 2002) were used for this purpose. For the cluster analysis and principal component analysis, we used IBM SPSS version 23.0 for Windows (IBM Corporation. New York. USA).

4. Results

Figure 4 presents the two-dimensional map of the articles. This map was obtained using network and graph theory. The articles are numbered. The numbering alludes to their rank by number of citations (Table 3 in the Appendix). The articles appearing in the network were clustered using cluster analysis. The articles included in each group are presented in Table 1.

The principal component analysis aimed to identify the articles that constituted each factor and indicated the influence of each article in its corresponding conceptual approach according to the factor weight. For the principal component analysis, we considered that an article should be included in a trend when its factor weight was greater than or equal to 0.4. An article was considered to have a highly relevant contribution in the corresponding conceptual approach if its factor loading was greater than or equal to 0.7. Table 2 presents the results of the principal component analysis. The scree plot highlighted five factors explaining 48.3% of the variance. Some articles had factor loadings that were greater than 0.7, reflecting the

importance of these articles in their associated areas. We also observed that some articles had factor loadings of more than 0.4 in more than one factor. These articles can be considered potential links between different conceptual approaches.

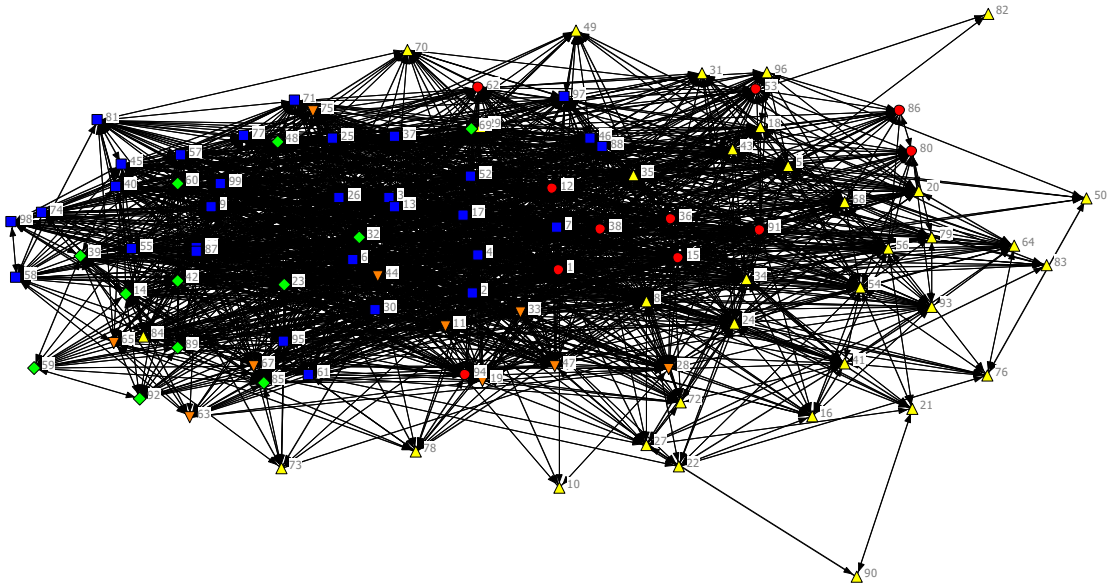

Figure 4 Co-citation network and cluster analysis

The principal component analysis revealed the importance of each article within each approach or possibly as in the case of the knowledge spillover institutional approach (cluster 3), which is diluted by the other approaches. In this case, we can consider that this approach especially supports the approach of knowledge spillover location (cluster 1) because this approach essentially supports the location strategies of knowledge spillovers, the public institutions and respective policies of their regions become particularly important. Now supporting the four types of research of the institutional approach that are particularly important in the approach to the location we conclude that to understand the approach to the location we need the support of the institutional approach (cluster 3). Thus, regional innovation systems are crucial to the appearance of knowledge spillovers (Branstetter 2001, 2006). Just as the mode of corporate entrepreneurship and the technological relationship have a significant effect on the probability of exploratory learning (Griffith et al. 2006).

Table 1 Cluster Analysis

Cluster 1: ***KS Location***	**Cluster 3:** ***KS Institutional Approach***	**Cluster 4:** ***KS Demography***
Jaffe, Trajtemberg, & Hndersone (1993)	Henderson & Cockburn (1996)	Rosenthal & Strange (2001)
Singh (2005)	Keller (2002)	Black & Henderson (1999)
Jaffe, Trajtenberg, & Fogarty (2000)	Benabou (1996)	Moretti (2004)
Maurseth & Verspagen (2002)	Hausmann, Hwang, & Rodrik (2007)	Ellison, Glaeser, & Kerr (2010)
Thompson & Fox-Kean (2005)	Gilson (1999)	Carlino, Chatterjee, & Hunt (2007)
Tijssen (2001)	Appleyard (1996)	Kerr (2008)
Giuri et al. (2007)	Fischer & Newell (2008)	Simon & Nardinelli (2002)
Criscuolo & Verspagen (2008)	de Mello (1999)	Faggian & McCann (2009)
Stolpe (2002)	Grossman & Helpman (1991)	Glaeser & Kerr (2009)
Thompsori (2006)	Jones & Williams (2000)	Bettencourt, Lobo, & Strumsky (2007)
Fischer, Scherngell, & Jansenberger (2006)	Beise & Stahl (1999)	**Cluster 5:** ***KS of Entrepreneurship***
Cluster 2: ***KS Agglomeration***	Uzzi & Gillespie (2002)	Armington & Acs (2002)
Glaeser, Kallal, Scheinkman, & Shleifer (1992)	Branstetter (2001)	Acs, Braunerhjelm, Audretsch, & Carlsson (2009)
Malmberg & Maskell (2002)	Alcacer & Chung (2007)	Audretsch & Lehmann (2005)
Feldman & Audretsch (1999)	Engelbrecht (1997)	Acs & Armington (2004)
Frenken, van Oort, & Verburg (2007)	Feinberg & Gupta (2004)	Acs & Varga (2005)
Zucker, Darby, & Armstrong (1998)	Nieto & Quevedo (2005)	Audretsch, Lehmann, & Warning (2005)
Torre & Rallett (2005)	Schildt, Maula, & Keil (2005)	Sternberg & Wennekers (2005)
Howells (2002)	Whisenant, Sankaraguruswamy, & Raghunandan (2003)	Audretsch & Keilbach (2007)
Audretsch & Feldman (1996)	Branstetter (2006)	Agarwal, Audretsch, & Sarkar (2007)
Capello & Faggian (2005)	Liu & Buck (2007)	Acs & Armington (2004b)
Breschi & Lissoni (2001)	Feinberg & Majumdar (2001)	Audretsch & Keilbach (2008)
Rodriguez-Pose & Crescenzi (2008)	Singh (2007)	Audretsch (2007)
Lissoni (2001)	Monjon & Waelbroeck (2003)	
Simmie (2003)	Gilbert, McDougall, & Audretsch (2008)	
Frenken & Boschma (2007)	Audretsch (2002)	
Fritsch & Franke (2004)	Chuang & Lin (1999)	
Fischer & Varga (2003)	LeSage & Pace (2008)	
Ter Wal & Boschma (2009)	Cantwell (2009)	
Boschma, Eriksson, & Lindgren (2009)	Danzon, Nicholson, & Pereira (2005)	
Asheim, Boschma, & Cooke (2011)	Branstetter & Sakakibara (1998)	
Hoekman, Frenken, & Tijssen (2010)	Fischer (2001)	
Ponds, van Oort, & Frenken (2010)	Gillingham, Newell, & Pizer (2008)	
Baldwin & Forslid (2000)	Griffith, Harrison, & Van Reenen (2006)	
Hauser, Tappeiner, & Walde (2007)	Agarwal, Ganco, & Ziedonis (2009)	
Maggioni, Nosvelli, & Uberti (2007)		
Toedtling, Lehner, & Trippl (2006)		
Adams (2002)		
Autant-Bernard (2001)		
Wallsten (2001)		
Kaiser (2002)		
Boschma & Frenken (2011)		
Bode (2004)		

Table 2 Factor analysis (rotated factor loadings)

	Factor				
	KS location	**KS of Entrepreneurship**	**KS Demography**	**KS agglomeration**	**Location agglomeration of KS**
1	**0,68**	0,26	0,30	0,32	0,34
91	**0,59**	0,07	0,23	-0,01	0,33
38	**0,56**	0,12	0,23	0,08	0,34
34	**0,56**	0,04	0,05	0,05	0,03
15	**0,51**	0,10	0,10	0,00	0,23
54	**0,50**	-0,01	0,03	0,02	-0,03
36	**0,49**	0,10	0,13	0,10	**0,45**
8	**0,49**	0,04	0,09	0,05	0,00
68	**0,48**	-0,01	0,05	0,03	0,02
93	**0,45**	-0,01	0,06	0,01	-0,05
80	**0,40**	0,01	0,02	-0,05	0,15
35	**0,40**	0,03	0,14	0,12	0,01
43	0,39	0,01	-0,03	0,07	-0,06
86	0,37	0,05	0,02	0,02	0,18
88	0,36	0,09	0,04	0,26	0,25
7	0,31	0,13	0,06	0,24	0,24
53	0,28	0,02	-0,02	-0,02	0,15
87	0,24	0,05	0,13	0,14	0,24
64	0,24	-0,04	0,00	0,00	-0,09
97	0,24	0,01	0,02	0,15	0,02
96	0,22	0,00	0,00	-0,03	0,02
5	0,19	0,00	-0,02	0,00	-0,03
29	0,16	0,04	-0,08	0,10	0,10
41	0,16	-0,05	0,02	0,00	-0,11
62	0,16	0,04	0,02	-0,04	0,11
56	0,12	-0,03	-0,03	-0,01	-0,02
20	0,12	-0,02	-0,02	0,02	-0,01
24	0,11	-0,01	0,00	-0,02	-0,09
70	0,11	0,00	-0,10	0,08	-0,01
79	0,10	-0,06	-0,01	0,02	-0,08
18	0,08	-0,03	0,01	-0,01	-0,02
49	0,05	-0,02	-0,04	0,03	-0,03
83	0,04	-0,03	-0,02	-0,03	-0,03
73	-0,04	0,02	0,03	-0,04	-0,03
23	-0,05	**0,74**	0,02	0,06	0,00
32	0,05	**0,73**	-0,01	0,10	0,07
60	0,02	**0,73**	0,00	0,02	0,00
14	-0,09	**0,57**	0,15	0,00	-0,04
89	-0,09	**0,56**	-0,09	0,06	0,01
69	0,13	**0,47**	-0,02	-0,01	0,01
48	0,11	**0,46**	-0,04	0,09	0,14
85	-0,09	**0,45**	0,31	0,05	0,00
92	-0,06	**0,40**	-0,03	-0,05	-0,04
42	0,02	0,39	0,06	-0,02	0,02
39	-0,05	0,38	0,19	0,01	-0,03
59	-0,08	0,22	-0,01	-0,10	-0,06
71	0,10	0,21	0,00	0,18	-0,02
16	0,00	-0,04	0,01	-0,03	-0,04
2	0,05	0,17	**0,68**	0,31	0,08
67	0,08	0,16	**0,59**	-0,01	0,00
11	0,10	0,03	**0,58**	0,04	-0,03
33	0,09	0,01	**0,56**	-0,04	-0,02
63	-0,03	0,04	**0,51**	0,04	-0,04
4	0,13	0,22	**0,50**	0,35	0,15
44	0,15	0,07	**0,44**	0,08	0,26
6	-0,20	0,02	**0,42**	**0,42**	0,19

	Factor				
	KS location	KS of Entrepreneurship	KS Demography	KS agglomeration	Location agglomeration of KS
19	0,06	0,00	0,33	0,01	-0,04
75	0,03	0,01	0,30	0,15	0,27
28	0,09	-0,02	0,30	-0,04	-0,01
95	0,18	0,17	0,30	0,29	0,05
98	-0,11	-0,02	0,29	0,28	0,00
65	-0,09	0,01	0,29	-0,02	0,03
47	0,15	-0,04	0,21	-0,07	0,12
72	0,06	-0,04	0,07	-0,01	-0,03
37	0,06	0,04	0,01	**0,51**	0,02
25	0,04	0,02	-0,08	**0,50**	-0,01
3	0,00	-0,04	0,01	**0,50**	-0,03
57	-0,22	-0,04	0,26	**0,47**	0,30
9	0,00	-0,02	-0,10	**0,46**	0,05
26	0,17	0,05	0,08	**0,45**	0,21
13	0,13	0,04	0,02	**0,44**	-0,02
81	-0,04	-0,08	-0,08	**0,41**	-0,02
40	-0,01	-0,04	0,00	0,36	-0,06
46	0,20	0,06	0,04	0,34	0,05
17	0,06	0,01	0,15	0,31	0,05
45	-0,12	-0,04	0,27	0,30	0,06
74	-0,07	0,02	-0,11	0,30	0,05
58	-0,21	-0,06	0,13	0,24	0,08
90	-0,04	-0,06	-0,03	-0,08	-0,04
21	-0,02	-0,05	-0,02	-0,07	-0,04
82	-0,01	-0,05	-0,04	-0,06	-0,06
27	-0,01	-0,05	-0,01	-0,06	-0,04
51	-0,04	-0,04	-0,02	-0,06	-0,03
50	0,00	-0,04	-0,03	-0,06	-0,04
10	-0,03	-0,04	-0,01	-0,05	-0,03
77	0,04	-0,02	0,00	0,14	**0,74**
94	0,13	-0,01	-0,01	-0,08	**0,61**
66	-0,07	0,00	0,20	0,29	**0,50**
61	-0,07	-0,06	-0,06	-0,02	**0,46**
55	-0,13	-0,09	-0,02	0,16	**0,42**
12	0,28	0,03	0,00	0,04	**0,42**
99	0,09	0,12	0,21	0,32	0,35
30	-0,09	0,03	0,14	0,30	0,31
52	0,24	0,20	0,18	0,14	0,30
78	-0,06	-0,05	-0,02	-0,16	0,24
84	0,09	-0,01	-0,05	0,06	0,17
76	0,05	-0,06	0,00	-0,04	-0,08
31	0,04	-0,04	-0,04	0,01	-0,06
22	-0,02	-0,05	-0,02	-0,05	-0,06

Factorial loads are given in bold

Alcacer and Chung (2007) concluded that the more technologically advanced a company is, the more likely it is to be located close to academic knowledge. Thus, the institutional approach has a supportive effect at the level of the location approach. If we do not have the explicit training of the approach belonging to cluster 3, on the other hand we observe the formation of a factor, possibly a new support approach. In factor five, we verified the intersection between the location approach and the agglomeration approach. Based on social immersion theory, Uzzi and Gillespie (2002) examined how the competencies and resources of a corporate actor in a network are transferred to another actor who uses them to enhance

dealings with a third actor. This strategic process is called the transitivity of a network. It has thus been verified that the more developed a country is, the greater the escape of knowledge spillovers to multinationals (Singh 2005). According to Fischer et al. (2006), however, knowledge flows much faster in Europe than elsewhere in the world, particularly between high-tech companies, and geographic proximity influences this transfer of knowledge. Maggioni et al. (2007) showed the relationship between these two approaches when studying the knowledge-intensive services that, due to their specificity, use relational and geographical knowledge spillovers. This consideration is particularly important at the level of the research activities of universities, where researchers from different parts of the globe collaborate remotely, without having to be geographically close to that collaboration (Hoekman et al. 2010; Ponds et al. 2010). Through the increasing use of information technology, the use of social network analysis techniques in economic geography is crucial because these techniques bring a more dynamic approach to the traditional study of networks (Ter Wal and Boschma 2009).

5 Discussion: typology of knowledge spillover theory

Based on the results of the principal component analysis, multidimensional scaling, and cluster analysis, a typology of five approaches to knowledge spillover theory was developed. These approaches, which share a mutual relationship and have strong interconnections, are as follows: (i) knowledge spillover location; (ii) knowledge spillover agglomeration; (iii) knowledge spillover institutional approach; (iv) knowledge spillover demography; and (v) knowledge spillovers of entrepreneurship.

(i) Knowledge spillover location: According to this approach, knowledge spillovers are strategically and geographically localized (Jaffe et al. 1993, 2000). These considerations are also supported when analyzing the citations of articles on patent location, which provide strategic information on the country- and sector-specific factors in national and cross-border scientific and technological linkages (Tijssen 2001). From here, we start with the interpretation of the innovative activity between European regions according to the traditional geographic spillovers and relational spillovers. Thus, it is possible to test whether hierarchical relationships based on spatial networks between geographically distant centers of excellence, verifying that they prevail over diffusive patterns based on spatial contiguity (Maurseth and Verspagen 2002).

The analysis of the nature of R&D knowledge spillovers is particularly important to control the effects of geographical location (Stolpe 2002). It is thus verified that the more developed a country is, the greater the knowledge spillovers to multinationals will be (Singh 2005; Thompson and Fox-Kean 2005). The localization of spillovers of international knowledge also declines over time, but international borders pose a persistent barrier to spillovers (Thompsori 2006). In Europe, however, knowledge flows much faster than in other parts of the world,

especially among high-tech companies, and geographic proximity influences this transfer of knowledge (Fischer et al. 2006; Giuri et al. 2007; Criscuolo and Verspagen 2008).

(ii) Knowledge spillover agglomeration: Economic growth theories, such as those of Jacobs (1969), Romer (1986), and Porter (1990) emphasize the role of technological spillovers in generating growth. Because these knowledge spillovers are particularly effective in cities, where interpersonal communication is more extensive, data on the growth of industries in different cities enable us to test some of these theories. However, for Glaeser et al. (1992), local competition and urban variety rather than regional specialization stimulate the growth of employment in industries. These authors suggest that the most important relationships between knowledge spillovers are between rather than within industries, a view that is consistent with the theories of Jacobs (1969). The life-cycle theory is another approach used and defended by Audretsch and Feldman (1996) in the study of the location of knowledge spillovers. They conclude that there may be a propensity for innovative activities to cluster spatially at the startup stage of the industry life cycle. Knowledge spillover theory, based on the knowledge production function for innovative activities, suggests that geographical proximity is more important in situations where tacit knowledge plays an important role in generating innovative activities. Audretsch and Feldman (1996) thus conclude that agglomeration effects are much more positive during the early stages of the industry life cycle and can be replaced by congestion effects during the later stages of the industry life cycle. A number of possible advantages of industrial agglomeration, or spatial agglomeration, have also been identified in the literature, notably those related to shared costs for infrastructure, the formation of a skilled workforce, transaction efficiency, and knowledge spillovers that lead to learning and innovation, such as cooperation between universities and firms (Zucker et al. 1998; Adams 2002; Boschma et al 2009). Given the diversity of industries, it is cooperation between a greater range of industries that fosters a greater existence of innovative activities as well as the existence of knowledge spillovers rather than industrial specialization (Feldman and Audretsch 1999). Thus, long-term growth and industrial location are jointly endogenous. Baldwin and Forslid (2000) introduced the growth of product innovation in the Krugman periphery model, thereby focusing on stability (Kaiser 2002). They found that growth is a powerful centripetal force but that knowledge spillovers represent a powerful centrifugal force. Integration policies that reduce the cost of business transactions are shown to encourage dispersion of economic activity while reducing the cost of trade in goods and encouraging crowding. This agglomeration encourages the growth of regions (Bode 2004). However, even within specialized local clusters of small and medium-sized enterprises (SMEs), knowledge can be highly codified and specific to companies (Breschi and Lissoni 2001). Lissoni (2001) has shown that knowledge, instead of flowing freely within the boundaries of the cluster, circulates within a few smaller “epistemic communities.” each centered on mechanical engineers producing individual machines and covering a selected number of suppliers and customer technicians. The physical distance between members of each

community varies greatly, but even local messages can be highly encoded (Howells 2002). As public policies are important for the emergence of knowledge spillovers, and in the greater codification or decoding of knowledge processes, however, even these policies are geographically localized (Autant-Bernard 2001; Wallsten 2001; Torre and Rallett 2005; Frenken et al. 2007). Malmberg and Maskell (2002) thus verified the need to establish a specific theory of clusters where learning plays a prominent role.

The basic requirements for such clusters theory (explain the existence of the cluster on the one hand, and its internal organization on the other) are discussed here. Simmie (2003) argues that knowledge is a key resource for innovation, which in turn is one of the main drivers of economic growth. The most innovative companies show access to international sources of knowledge. Questions arise about the relative importance of local versus international knowledge spillovers for the most innovative companies. Innovative companies tend to focus on a small number of major metropolitan regions. Thus, knowledge created by universities has some of the characteristics of public goods and creates value for companies and other organizations (Fischer and Varga 2003; Fritsch and Franke 2004). Capello and Faggian (2005) argue that the innovative capacity of companies has traditionally been explained through intra-company characteristics. Increasingly the emphasis has been placed on determinants that are external to the company. These external factors, called knowledge spillovers, refer to the positive externalities that companies receive in terms of knowledge of the environment where they operate. However, the authors argue that there is an important difference between the knowledge spillover approach and the socialized processes of local knowledge creation developed by regional economists; while in the former, the mere probability of contacts explains the transfer of local knowledge, in the latter, the channels through which knowledge spillovers act on a local area are clearly identified in the relational capital of the area. Relational capital is defined as all relationships (i.e., market relations, power relations, and cooperation) that are established among companies, institutions, and individuals. These relationships result from a strong sense of belonging and a highly developed cooperative capacity typical of culturally similar individuals or organizations (Frenken and Boschma 2007). Thus for Toedtling et al. (2006), the intersection of clusters located geographically and strategically with knowledge spillovers forms a new sector: the knowledge-intensive services sector. This sector is highly innovative and contributes to regional development. In this sector, there are two types of knowledge spillovers: relational and geographical (Maggioni et al. 2007). The concept of a “learning region” originated with Hauser et al. (2007). In this concept, it is argued that regions have specific characteristics that make them learning regions, with innovative and competitive capacities superior to their congeners that do not of learning. Thus, the literature on the impact of innovation on regional economic performance in Europe essentially follows three approaches: (1) analysis of the link between R&D investment, patents, and economic growth; (2) study of the existence and efficiency of regional innovation systems; and (3) examination of the geographical diffusion of regional knowledge spillovers

(Rodriguez-Pose and Crescenzi 2008). With the rapid evolution of information technologies, it has become necessary to analyze social networks as a promising tool to investigate the structure and evolution of interorganizational interaction and knowledge flows within and between regions. It is critical to use social network analysis techniques in economic geography because they provide a more dynamic approach to the traditional study of networks (Ter Wal and Boschma 2009). This consideration is particularly important at the level of the research activities of universities, where researchers from different parts of the globe collaborate remotely, without having to be geographically close to that collaboration (Hoekman et al. 2010; Ponds et al. Asheim et al. 2011; Boschma and Frenken 2011).

(iii) Knowledge spillover institutional approach: The endogenous growth of commercial countries can be studied through the influence of knowledge spillovers. Generally, it is assumed that these spillovers occur automatically. In many countries, scientific and technological knowledge from abroad is related to the extent of foreign trade. In this environment, trade generates an externality that coexists with the externality of domestic innovation. Thus, policies that reduce the extent of international trade tighten the lack of innovation supply. The economy grows very slowly for both reasons. In fact, some trade promotion policies reduce the harmful effects of the externality of innovation, accelerate growth, and enhance national well-being (Grossman and Helpman 1991; Henderson and Cockburn 1996; Benabou 1996). Although knowledge spillovers between companies play a critical role in technological evolution, there are issues that need to be answered. For example, how does knowledge flow across the boundaries of the company? How do industry characteristics and national institutions shape the diffusion of knowledge? And to what extent do companies drive knowledge flows? (Appleyard 1996; Engelbrecht 1997). Despite the existence of extensive theoretical literature analyzing the potential benefits and costs of R&D consortia, the study of their effectiveness is increasingly necessary. One surety that exists is the fact that the major contributors to these consortia are knowledge spillovers (Branstetter and Sakakibara 1998). There is once again a growing importance in studying industrial districts and their characteristics at the formal level to better understand the functioning and emergence of knowledge spillovers (Gilson 1999). Another knowledge spillover birth and development factor is foreign direct investment. This powers and facilitates spillovers (de Mello 1999; Chuang and Lin 1999; Branstetter 2006). The relationship with public R&D institutions, such as universities, business incubators, and public research laboratories also enhances innovation. However, the greatest contribution is to internal R&D services of organizations that can transform the knowledge generated in public institutions into profitable solutions through knowledge spillovers (Beise and Stahl 1999; Monjon and Waelbroeck 2003). R&D is thus a key determinant of long-term productivity and well-being. A central question is whether a decentralized economy performs more or less R&D. Jones and Williams (2000) developed an endogenous growth model that incorporates four important R&D distortions: the problem of appropriability of surplus, knowledge spillovers, creative

destruction, and congestion externalities. Fischer (2001) argues that regional innovation systems are also crucial to the appearance of knowledge spillovers (Branstetter 2001). Research on R&D localization options by multinational corporations has largely focused on factor endowments of the recipient country and has broadly neglected the fact that the potential of capturing and using knowledge spillovers from competitors can also play a determining role in such choices (Feinberg and Majumdar 2001; Keller 2002; Feinberg and Gupta 2004; Liu and Buck 2007; Singh 2007; Cantwell 2009). However, for Audretsch (2002), the greatest sources of innovation and growth are SMEs. Based on the theory of social immersion. Uzzi and Gillespie (2002) examined how competencies and resources of a corporate actor in a network are transferred to another actor who uses them to enhance dealings with a third actor in a strategic process known as the transitivity of a network. From the transitivity of the network in the context of the corporate financing of small companies, we consider how the relationships between a company and its banks facilitate the company's access to different capacities that allow it to strategically manage its commercial credit financing relationships (Whisenant et al. 2003; Danzon et al. 2005). Nieto and Quevedo (2005) analyzed the influence of two variables related to industrial structure (technological opportunities and knowledge spillovers) and a management variable (absorptive capacity) in the innovative efforts developed by companies. Absorptive capacity determines innovative effort to a greater degree than the two structural variables. The authors also verified that absorptive capacity has a moderating effect on the relationship between technological opportunity and innovative effort. Schildt et al. (2005) examined the background of exploratory learning of technological know-how from outside corporate ventures (i.e., venture capital investments, alliances, joint ventures, and acquisitions) as alternative paths to interorganizational learning. They found that corporate entrepreneurship and technological relationships have a significant effect on the probability of exploratory learning (Griffith et al. 2006; Fischer and Newell 2008).

Alcacer and Chung (2007) concluded that the more technologically advanced a company is, the greater the likelihood that it will be located close to academic knowledge. Companies in geographically agglomerated industrial regions potentially enjoy performance advantages due to superior access to knowledge spillovers. This is because companies located within geographic clusters absorb more knowledge from the local environment and have greater growth and innovative performance. Contrary to what is commonly thought, however, technological spillovers are not the cause of these companies' higher performance (Gilbert et al. 2008; LeSage and Pace 2008; Agarwal et al. 2009).

(iv) Knowledge spillover demography: At a time when the economy was demonstrating endogenous economic growth and exogenous population growth. Black and Henderson (1999) explored two major themes: how urbanization affects the efficiency of the growth process and how growth affects urbanization patterns. Localized information spillovers promote agglomeration and accumulation of human capital and foster endogenous growth.

Individual cities grow with the accumulation of local human capital and knowledge spillovers (Rosenthal and Strange 2001).

Similarly, cities that start with a greater proportion of highly capable people grow faster in the long run because: (a) knowledge spillovers are geographically limited to the city; and (b) much knowledge is more productive in the city where it is acquired. Thus, urban aggregates and metropolitan areas with higher average levels of human capital grew more rapidly throughout the 20th century (Simon and Nardinelli 2002). This gives rise to a new approach to knowledge spillovers that are spillovers of human capital. Within a city, spillovers between industries that are economically close are greater than spillovers between economically distant industries (Moretti 2004). Economists, starting with Alfred Marshall, have studied the significance of cities in the production and exploitation of informational externalities that we now call knowledge spillovers. For example, Carlino et al. (2007) showed that the intensity of patents (i.e., the per capita invention rate) is positively related to the density of employment in highly urbanized metropolitan areas. Thus, the most densely populated places in the country play an important role in creating the flow of ideas that generate innovation and growth (Bettencourt et al. 2007). It is also important to study this population. This population does not always consist of citizens of the country where knowledge is generated, and it is important to verify that this foreign population and even ethnic minorities can spread the knowledge they learn in their countries of origin (Kerr 2008; Faggian and McCann 2009). Hence, the following question may also arise: why are some places more enterprising than others? Glaeser and Kerr (2009) responded by arguing that the explanation lies in the demography of each place. Places with a greater population tend to have more businesses. The question is what causes industrial agglomeration? Ellison et al. (2010) responded that agglomeration: (1) saves transportation costs through proximity to input suppliers or final consumers; (2) allows labor market grouping; and (3) facilitates intellectual spillovers.

(v) Knowledge spillovers of entrepreneurship: Whereas much of the literature in the 1980s on the formation of new enterprises was motivated by high levels of unemployment, much of the focus on startups in the early 21st century was motivated by high technology. Human capital, education and training, and the business environment play a fundamental role in the formation of new companies. Thus, it is possible to observe significant differences in the rates of formation of new companies from industrial regions to technologically progressive regions. Variations in business birth rates can thus be explained by industrial density, population growth, and income. These results are consistent with thick labor markets and localized knowledge spillovers (Armington and Acs 2002). It is thus important to emphasize the relevance of externalities in the creation of knowledge. Such externalities include levels of entrepreneurial activity, diversity between geographically close industries, and the extension of human capital (Acs and Armington 2004a, b). These externalities also differ considerably from the local concentration of existing establishments in the same sector, especially for industries that serve non-local markets, suggesting that an important mechanism is relevant

knowledge spillovers (Acs and Armington 2004b). It is also argued that variations between countries, the level of entrepreneurial activity, and the spatial structure of economies could potentially be sources of different knowledge spillover efficiencies and, ultimately, economic growth. Acs and Varga (2005) developed an empirical model that endogenizes both entrepreneurial activity and agglomeration effects in knowledge spillovers. Consequently, entrepreneurial activity has a positive effect on economic growth in highly developed countries while exerting a negative effect in developing nations. It should be noted that different types of entrepreneurship can have a different impact on a nation's capacity for innovation and economic growth. In particular, potentially high-growth startups and so-called opportunity entrepreneurship enhance knowledge spillovers and economic growth. Finally, entrepreneurship can once again be seen as a regional event that can only be understood if the conditions of the regional structure, including regional networks and policies, are taken into account (Sternberg and Wennekers 2005).

Audretsch and Lehmann (2005) tested whether the knowledge spillover theory of entrepreneurship is valid for regions. They linked investments in knowledge by universities and regions to the amount of entrepreneurial activity associated with each university. They verified that the number of companies located near a university is positively influenced by the knowledge capacity of that region and the knowledge production of the university. Thus, there is considerable evidence to suggest that the knowledge spillover theory of entrepreneurship holds true for both regions and industries. It is also important to analyze the impact of the choice of location as a firm's strategy for accessing university knowledge spillovers. Knowledge transfer mechanisms, like types of transfer, are heterogeneous. In particular, technology-based and knowledge-based new firms are highly likely to be located near universities, presumably to access knowledge spillovers. However, the exact role that geographical proximity plays is shaped by two factors: the particular knowledge context and the specific type of knowledge transfer mechanism (Audretsch et al. 2005). Audretsch (2007) showed how and why Solow's growth accounting framework is useful for linking entrepreneurship capital to economic growth. The knowledge filter prevents knowledge spillovers from being marketed, thereby weakening the impact of investment in knowledge on economic growth. By serving as a channel for knowledge spillovers, entrepreneurship is the missing link between investments in new knowledge and economic growth. Entrepreneurship is an important mechanism that permeates the knowledge filter to facilitate the spillover of knowledge and, ultimately, generate economic growth. The emergence of entrepreneurship policy to promote economic growth can be interpreted as an attempt to promote entrepreneurial capital or the ability of an economy to generate the start and growth of new enterprises. Agarwal et al. (2007) discussed the underlying mechanism of knowledge spillover strategic entrepreneurship whereby existing organizations' investments in knowledge, when combined with the entrepreneurial action of individuals inserted in their context, result in the creation of new ventures, heterogeneity in performance, and subsequent growth of industries, regions, and

economies. Thus, we can stress that the dominant theories of entrepreneurship have revolved around the ability of individuals to recognize opportunities and then act upon them by initiating new projects. The following question therefore arises: why does entrepreneurial behavior vary among individuals with different characteristics while implicitly maintaining the external context in which individuals find themselves? By marketing knowledge that would otherwise remain unmarked through the start of a new project, entrepreneurship serves as a knowledge spillover channel. According to knowledge spillover entrepreneurship theory, a context with more knowledge will generate more entrepreneurial opportunities. In contrast, a context with less knowledge will generate fewer entrepreneurial opportunities. Thus, entrepreneurial opportunities are not exogenous but rather systematically created by investments in knowledge by established organizations (Audretsch and Keilbach 2007). Thus, the knowledge paradox suggests that high levels of investment in new knowledge do not necessarily automatically generate the expected levels of growth and competitiveness. In particular, investments in knowledge do not automatically translate into balanced growth and competitiveness. Entrepreneurship thus serves as a knowledge spillover channel (Audretsch and Keilbach 2008). Contemporary theories of entrepreneurship generally focus on the recognition of opportunities and the decision to exploit them. Although the entrepreneurship literature treats opportunities as exogenous, the dominant theory of economic growth suggests that they are endogenous. Knowledge created endogenously results in knowledge spillovers, which enables entrepreneurs to identify and explore opportunities (Acs et al. 2009).

5.1 Final considerations

The main objective of our study was to map the scientific publications, intellectual structure, and research trends in knowledge spillover theories. Scientometric analysis provides an interesting insight into the work of scholars. Given the well-documented diversity in the field of knowledge spillovers, different authors have proposed a range of alternative approaches. Because of the importance of studying the applicability of knowledge spillovers to contemporary society, this study provides relevant insights that are applicable to research in this field. Using bibliometrics and multivariate statistical analysis based on cluster and principal component analysis, we verified that this research field contains a diverse range of concepts. Specifically, five types of underlying knowledge spillover theories were discovered: (i) knowledge spillover location; (ii) knowledge spillover agglomeration; (iii) knowledge spillover institutional approach; (iv) knowledge spillover demography; and (v) knowledge spillovers of entrepreneurship. Figure 5 shows the development of these five knowledge spillover research approaches over time.

This examination of the literature highlights theories that are embedded in different areas but that contribute to the study of knowledge spillovers. This finding indicates that a consensus regarding knowledge spillover-related phenomena and all that they entail remains a distant goal.

The five underlying theories identified in our study reflect the heterogeneity in knowledge spillover research. Despite the need for further development, empirical applications, and experimental methods, today's dominant knowledge spillover theories have unquestionably resulted from this systematization of the literature.

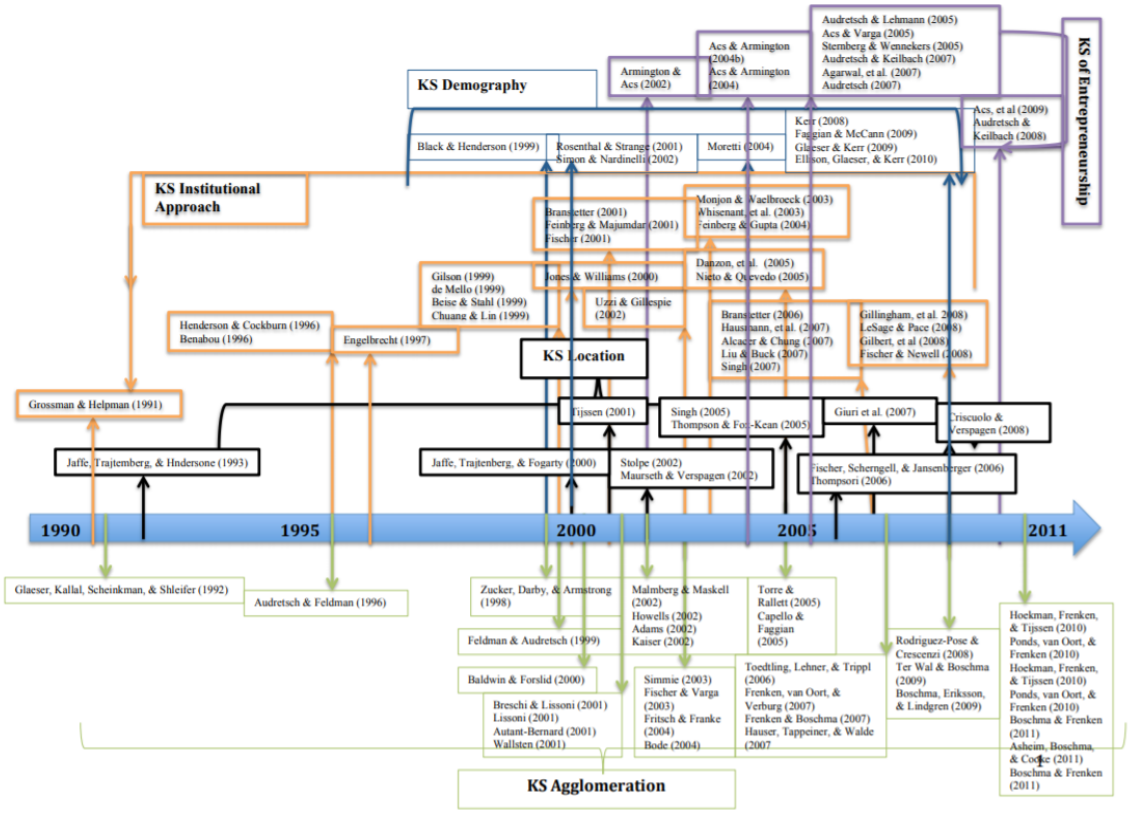

Fig. 5 Chronological evolution of these five KS research approaches

It is important to keep in mind that the analysis presented in this paper covers a variety of studies and therefore a variety of methods for analyzing intellectual structures and research trends related to knowledge spillovers. This creates potential difficulties in terms of generalizing results. Therefore, one must consider the way in which the data were obtained. This is as a major limitation. Despite this limitation, however, this paper undoubtedly provides new insights into knowledge spillover research.

As challenges to be addressed by future research, we advocate empirical studies focusing on each of the five typologies identified and discussed herein. Because of its examination of co-citation data and the use of a quantitative approach to map relevant scientific publications and their intellectual structure, our study has major implications for knowledge spillover research and highlights key research trends in this knowledge area. We hope that this research will stimulate discussion and that scholars will continue to work toward the ongoing advancement of knowledge spillover research.

Appendix

See Table 3.

Table 3 Articles used in results and number of citations (#)

Article		#	Article		#
1	Jaffe, Trajtemberg, & Hndersone (1993)	1877	51	Whisenant, Sankaraguruswamy, & Raghunandan (2003)	91
2	Glaeser, Kallal, Scheinkman, & Shleifer (1992)	1199	52	Fischer & Varga (2003)	89
3	Malmberg & Maskell (2002)	454	53	Tijssen (2001)	86
4	Feldman & Audretsch (1999)	409	54	Branstetter (2006)	85
5	Henderson & Cockburn (1996)	403	55	Ter Wal & Boschma (2009)	83
6	Frenken, van Oort, & Verburg (2007)	334	56	Liu & Buck (2007)	81
7	Zucker, Darby, & Armstrong (1998)	318	57	Boschma, Eriksson, & Lindgren (2009)	79
8	Keller (2002)	264	58	Asheim, Boschma, & Cooke (2011)	78
9	Torre & Rallett (2005)	259	59	Sternberg & Wennekers (2005)	78
10	Benabou (1996)	255	60	Audretsch & Keilbach (2007)	77
11	Rosenthal & Strange (2001)	254	61	Hoekman, Frenken, & Tijssen (2010)	76
12	Singh (2005)	244	62	Giuri et al. (2007)	76
13	Howells (2002)	207	63	Simon & Nardinelli (2002)	75
14	Armington & Acs (2002)	205	64	Feinberg & Majumdar (2001)	73
15	Jaffe, Trajtenberg, & Fogarty (2000)	184	65	Faggian & McCann (2009)	71
16	Hausmann, Hwang, & Rodrik (2007)	176	66	Ponds, van Oort, & Frenken (2010)	70
17	Audretsch & Feldman (1996)	176	67	Glaeser & Kerr (2009)	70
18	Gilson (1999)	175	68	Singh (2007)	69
19	Black & Henderson (1999)	171	69	Agarwal, Audretsch, & Sarkar (2007)	67
20	Appleyard (1996)	163	70	Monjon & Waelbroeck (2003)	67
21	Fischer & Newell (2008)	162	71	Baldwin & Forslid (2000)	67
22	de Mello (1999)	157	72	Gilbert, McDougall, & Audretsch (2008)	66
23	Acs, Braunerhjelm, Audretsch, & Carlsson (2009)	153	73	Audretsch (2002)	66
24	Grossman & Helpman (1991)	152	74	Hauser, Tappeiner, & Walde (2007)	65
25	Capello & Faggian (2005)	151	75	Bettencourt, Lobo, & Strumsky (2007)	65
26	Breschi & Lissoni (2001)	143	76	Chuang & Lin (1999)	65
27	Jones & Williams (2000)	137	77	Maggioni, Nosvelli, & Uberti (2007)	64
28	Moretti (2004)	130	78	LeSage & Pace (2008)	62
29	Beise & Stahl (1999)	127	79	Cantwell (2009)	60
30	Rodriguez-Pose & Crescenzi (2008)	124	80	Criscuolo & Verspagen (2008)	60
31	Uzzi & Gillespie (2002)	124	81	Toedtling, Lehner, & Trippl (2006)	59
32	Audretsch & Lehmann (2005)	123	82	Danzon, Nicholson, & Pereira (2005)	59
33	Ellison, Glaeser, & Kerr (2010)	121	83	Branstetter & Sakakibara (1998)	59
34	Branstetter (2001)	121	84	Fischer (2001)	55
35	Alcacer & Chung (2007)	120	85	Acs & Armington (2004b)	54
36	Maurseth & Verspagen (2002)	120	86	Stolpe (2002)	54
37	Lissoni (2001)	115	87	Adams (2002)	54
38	Thompson & Fox-Kean (2005)	111	88	Autant-Bernard (2001)	54
39	Acs & Armington (2004)	107	89	Audretsch & Keilbach (2008)	53
40	Simmie (2003)	105	90	Gillingham, Newell, & Pizer (2008)	53
41	Engelbrecht (1997)	105	91	Thompsori (2006)	53
42	Acs & Varga (2005)	104	92	Audretsch (2007)	52
43	Feinberg & Gupta (2004)	101	93	Griffith, Harrison, & Van Reenen (2006)	52
44	Carlino, Chatterjee, & Hunt (2007)	99	94	Fischer, Scherngell, & Jansenberger (2006)	52
45	Frenken & Boschma (2007)	97	95	Wallsten (2001)	52
46	Fritsch & Franke (2004)	94	96	Agarwal, Ganco, & Ziedonis (2009)	51
47	Kerr (2008)	93	97	Kaiser (2002)	51
48	Audretsch, Lehmann, & Warning (2005)	93	98	Boschma & Frenken (2011)	50
49	Nieto & Quevedo (2005)	92	99	Bode (2004)	50
50	Schildt, Maula, & Keil (2005)	91			

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Artículo 2. The multiple faces of the entrepreneurial university: a review of the prevailing theoretical approaches

The Journal of
TECHNOLOGY
TRANSFER

Volume 46, No. 4
August 2021
ISSN 0892-9912

Special Section: University Technology Transfer, Regional Specializations and Local Dynamics: Lessons from Italy

Guest Editors: Andrea Piccaluga · Martin Kenney · Rosa Grimaldi · Alberto Di Minin

Springer

The multiple faces of the entrepreneurial university: a review of the prevailing theoretical approaches

Publicado en la revista *The Journal of Technology Transfer***,** en 2021, Vol. 46, pp. 1173–1195.
ISSN 0892-9912
EISSN 1573-7047

https://doi.org/10.1007/s10961-020-09815-4

Esta revista está incluida en los siguientes índices:

1. **Journal Citation Reports 2021**
   Social Sciences Citation Index (SSCI), Journal Impact Factor 5.337
   CATEGORY MANAGEMENT-SSCI Rank by Journal Impact Factor 96/228 (Q2)
2. **SCOPUS 2021**
   CiteScore 9.2; Q1 92% 31/423 Business and International Management
3. **Scimago Journal Rank 2021**
   SJR 1.609; Q1 Business and International Management

JEL Classification O3

Número de accesos al artículo: 1.937
Número de citas en Google Scholar: 42
Número de citas en Web of Science: 22
(datos a 2 de mayo de 2023)

The multiple faces of the entrepreneurial university: a review of the prevailing theoretical approaches

Elvira Cerver Romero[1]· João J. M. Ferreira[2] · Cristina I. Fernandes[2,3]

[1] Departamento de Dirección de Empresas Juan José Renau Piqueras, Universidad de Valencia, Valencia, Spain
[2] Department of Management and Economics & NECE Research Unit in Business Sciences, University of Beira Interior, Covilhã, Portugal
[3] Centre for Corporate Entrepreneurship and Innovation, Loughborough University, Loughborough, UK

Published online: 31 July 2020

Abstract

The importance and the definition of an entrepreneurial university (EU), together with the factors that lead to its existence, have been widely discussed in the literature. Moreover, in recent years, the EU has also been the target of some public policies. This study aims to identify the different theoretical approaches to entrepreneurial universities prevalent in the literature. Using information from the Web of Science database, we performed a co-citation bibliometric analysis, which made it possible to identify six distinct EU approaches: the triple helix model, the knowledge society model, the global perspective, the researcher-entrepreneur model, the dual personality approach, and also a frenzied approach.

Keywords Entrepreneurial university · Knowledge transfer · University spin-off · Triple helix · Bibliometrics

1 Introduction

Knowledge has become a primary source when it comes to boosting economic growth, employment, and competitiveness in today's increasingly globalized economy (Audretsch 2007, 2014), and proof of this is that regions with better economic indicators are also those whose environment is capable of generating greater knowledge and innovation (Huggins and Izushi 2007). In this context, universities can play a crucial role as producers and disseminators of knowledge (Kirby 2006). Hence, since the 1980s, a growing number of universities have embraced economic and social development as part of their mission, giving birth to the so-called entrepreneurial university (hereafter, EU) (Etzkowitz 1983), in other words, a university which incorporates "economic development (…) as an academic function along with teaching and research" (Etzkowitz 1998, p. 833).

According to Guerrero et al. (2014), factors like scientific progress, the development of new collaborative ways of multidisciplinary research, the decrease in university state funding, as well as society's changing demands and expectations regarding the role of universities, can be

considered antecedents of the transformation process that many universities begin in order to become entrepreneurial.

The academic entrepreneurial spirit that has emerged in universities, together with the creative and productive coexistence of this new function with the traditional functions of higher education institutions (teaching and research), have positioned universities as equal partners in their relationship with industry and government. These relations are crucial to innovation in a knowledge-based economy (Etzkowitz 2003a), and based on them, a model was developed that explains the innovation process: the triple helix model (Etzkowitz and Leydesdorff 1997). In this model, each of the three institutions or helices (university, industry, and government) interact with each other and establish diverse bilateral and trilateral relations to support the generation of new knowledge and its transfer, and this way contribute to regional and national economic development (Clark 1998; Etzkowitz 1998, 2003a; Motohashi 2005). In this regard, the OECD (2012) points out that regional growth and sustainable development depend on how well universities adapt to unpredictable environments which are becoming increasingly global rather than isolated; increasingly international rather than national, and increasingly competitive rather than regulated.

But what characterizes an EU is not only its essential role in innovation by transfer- ring technology to industry, but also that its contribution to economic development is achieved through implementing other initiatives such as training its students with the skills demanded by industry (Philpott et al. 2011).

Over the past few decades, the central role played by EUs in the knowledge-based economy has aroused increasing interest among scholars, who have concentrated their research efforts on different aspects of this phenomenon, among which are the following: the relationships between university, industry, and government (Cooke 2005); the mechanisms through which EUs contribute to economic and social growth (Guerrero et al. 2015); the contextual factors that foster an orientation towards entrepreneurial activities in universities (Hakala 2009); the motives for academics participating in entrepreneurial activities (D'Este and Perkmann 2011); or how the entrepreneurial intention of academics is related to their scientific productivity (Van Looy et al. 2011).

Thus, we find that we are in the presence of a relatively fragmented field of investigation and in need of a theoretical systematization which would allow us to contribute to the advancement of this subject.

The aim of our paper is therefore to address the following objectives:

(1) to determine the lines of research that constitute the intellectual structure; (2) to identify the key research contributions in the EU field; and (3) to distinguish the scientific journals with the most significant impact on the subject area, as well as the most prominent authors. Also,

our study aims to outline the geographical distribution of knowledge production in terms of countries.

The rest of the paper is structured as follows. In the next section, we will discuss the concept of an entrepreneurial university, pinpointing the activities that characterize it. In the third section, the methodology used in the research is described. The fourth section presents the results of the bibliometric analysis, and the fifth and last section provides the conclusions.

2 The entrepreneurial university

Entrepreneurial universities are those that aim to maximize the potential of commercializing their knowledge while also creating value for society, without considering this as a threat to their academic values and traditional functions (Gibb and Hannon 2006).

As maintained by Philpott et al. (2011), for a university to accomplish the third mission, i.e., to contribute to social and economic development (Etzkowitz 1983), it can engage in a wide range of entrepreneurial initiatives which vary from “hard” to “soft”. “Hard” initiatives are those closer to the entrepreneurial paradigm, such as patenting and licensing, or the creation of spin-offs and technology parks, whereas “soft” initiatives are those nearer to the traditional paradigm, like the publishing of academic research, grantsmanship, or the production of highly-qualified graduates. Between both extremes, there are also other entrepreneurial initiatives such as consultancy, training of industry personnel, or research contracts.

The “harder” initiatives can contribute directly to economic development, for example, by creating new businesses through the development of university spin-offs. On the other hand, a contribution can also be made indirectly by supporting the set-up of new firms in technology parks or by licensing patents to partners in the industry. For instance, new knowledge embodied in a patent may allow the industrial partner to gain a competitive advantage and so grow and create employment opportunities.

The remaining entrepreneurial activities contribute to economic growth indirectly. In the case of contracted research, research will help the industrial firm to solve a practical problem which could improve its business performance. Through training courses for industry personnel, companies can increase their capacities and, consequently, their competitive- ness. Both scholarships and the publication of quality academic research increase the EU’s reputation which, in both cases, can attract outside companies to the region and generate new university–industry relations, which, in turn, allow “hard” entrepreneurial activities to be set in motion. Similarly, consultancy services may also increase business performance and be the origin of new university–industry relations that can later be exploited by means of other entrepreneurial activities. Through teaching, the EU provides the industry with highly qualified graduates and, in this way, meets its demand for human capital. Moreover, as Guerrero et al. (2015) pointed out, among these EU graduates, skilled entrepreneurs will emerge who will then become job creators.

In addition to pursuing social and economic development by means of the entrepreneurial initiatives mentioned above, another characteristic of the EU is that it aims to be more productive and creative by establishing innovative relationships between its teaching and research dimensions. Furthermore, it seeks to be the best in all of its endeavors, like selecting the best students and teachers, optimizing fundraising, etc. Among its other distinctive features are its capacity to adapt to changes in the environment and to design policies aimed at developing an entrepreneurial organizational culture, and also, with regard to university management and governance, that it commonly uses management practices typical of the for-profit sector (Davies 1987; Deem 1998, 2001; Todorovic et al. 2011; Guerrero et al. 2015; Abreu et al. 2016; Migliori et al. 2019).

Finally, it should be mentioned that some researchers have suggested that universities are facing an isomorphic pressure in their transformation process towards an EU (Etzkowitz et al. 2000; Etzkowitz 2013). In contrast, other authors provide evidence that this transformation can give rise to different types of EUs, since the way in which each university responds to external pressures is influenced, among other factors, by the relationship with its stakeholders, the particular context in which it develops its activities, and its history (Deem 2001; Tuunainen 2005b; Yokoyama 2006; Miller et al. 2014; Seguí-Mas et al. 2018).

3 Methodology and data

Co-citation analysis is a methodology used to map in detail the relationships between the key ideas of a given scientific domain (Small 1973), and also serves to identify the fundamental scientific articles of that same scientific field (Zitt and Bassecoulard 1994). White and Grifith (1981) were the precursors of co-citation analysis in their pioneering study on the existing research on decision and judgment. Two documents are co-cited when they are quoted jointly in one or more published articles (Smith 1981), with the number of joint quotations being a way of viewing a representative part of the literature on a subject area like that of entrepreneurial universities (EU), identifying influential authors and displaying their interrelationships (White and McCain 1998). Several studies have demonstrated the validity of co-citations analysis to understand the intellectual structure of a research area (Di Guardo and Harrigan 2012). Therefore, to verify the objectives of the study, we first carried out a descriptive analysis of the articles surfacing from the research. Subsequently, the bibliometric methodology of co-citation analysis mentioned in White and McCain's study (White and McCain 1998) was used to analyze the most cited publications addressing EU theory. The number of times that two documents or authors dealing with EU theories are quoted together in the resulting universe of publications was analyzed so as to obtain the relationships between quotations and map the dominant approaches to research on the subject.

Data were collected from the Science Citation Index Expanded (SCI-Expanded), the Social Science Citation Index (SSCI) and the Social Science Citation Index (A&HCI), compiled by

Clarivate Analytics online databases which contain bibliographic information about authors, affiliations, and citations of thousands of publications.

We chose the Web of Science database because it has been shown to be a reliable source for citation data processing (Chabowski et al. 2018; Dongmei Zha et al. 2020). Data retrieval was carried out by searching for those articles which had the term "Entrepreneur * Universit *" in the title, abstract, or keywords and had been published in journals in the categories of management, business, and economy, without applying any chronological filter. The unit of analysis of this study was the publications, and the variables collected were the authors and their affiliation, publication journals, number of citations, and references cited. The result was a total of 479 documents written in English, with publication dates between 1983 and 2018. Table 1 provides a summary of the documents included in the study.

Table 1 Summary of the 479 documents included in the study

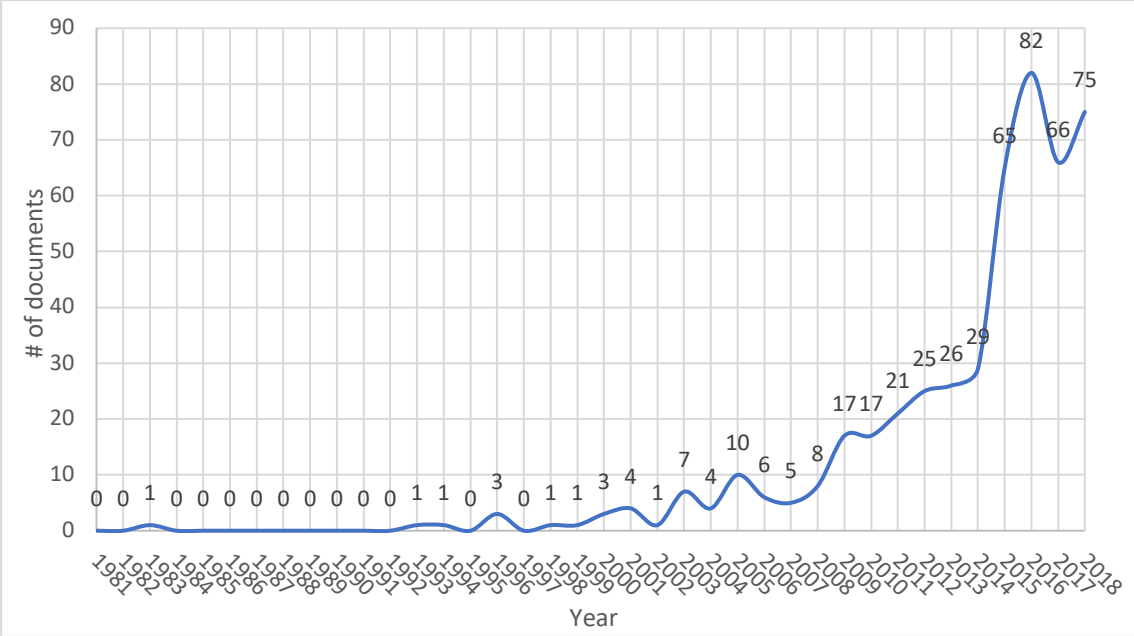
Description	**Results**
Documents	479
Sources (Journals, Books, etc.)	269
Keywords Plus (ID)	594
Author's Keywords (DE)	1208
Period	1983–2018
Average citations per document	15.89
Authors	933
Author Appearances	1167
Authors of single-authored documents	116
Authors of multi-authored documents	817
Single-authored documents	138
Documents per Author	0.513
Authors per Document	1.95
Co-Authors per Document	2.44
Document types	**Number**
Article	300
Article; Data paper	1
Article; Proceedings paper	13
Proceedings paper	165

4. Results

Next, the description and analysis of the results are divided into four sections. In the first section, the articles resulting from the research are characterized, namely the time evolution of the number of articles published, and the articles and journals in which they are published. In the second part, we analyze the most relevant authors together with their geographic location, as well as the transnational networks of co-authors. In the third section, keyword analysis is performed in order to study the conceptual structure of the articles. In the fourth section, analyses of bibliographic matching and co-quotations are carried out.

4.1 Time evolution of publications on EUs: most cited articles and sources

Documents were searched by writing the expression mentioned in Sect. 3 in the browser. The search yielded a total of 479 references, whose annual evolution can be seen in Graph 1. It is observed that the first published article dates back to 1983 and that it was not until a decade later that the next publication on this subject appeared (1993). In fact, it is only since the beginning of this century that the number of annual publications has begun to increase and since 2009 that the number of publications has been higher than or equal to 15 documents per year, with 2015 being the year in which this scientific field began to grow in importance (65 articles). 2016 and 2018 are the years in which the highest number of documents were published, with 82 and 75 respectively.



Graph 1 Number of articles by year of publication

In terms of citations, the 479 documents analyzed have a mean of 26.7 ± 78.9 citations, with 27 documents (16.7%) having no citation at all, and 48 articles (31.8%) being cited between one and five times. Table 2 shows the articles that obtained at least 100 citations.

Table 2 - Top of publications in the domain of Entrepreneurial Universities with more than 100 citations

	Article	**# of citations**
1	Etzkowitz, Webster, Gebhardt, & Terra (2000)	802
2	Etzkowitz (2003b)	531
3	Etzkowitz (1998)	476
4	Etzkowitz (2003a)	375
5	Deem (2001)	244
6	D'Este & Perkmann (2011)	205
7	Cooke (2005)	185
8	Etzkowitz & Klofsten (2005)	181
9	Etzkowitz (1983)	180
10	Bramwell & Wolfe (2008)	169
11	Jacob, Lundqvist, & Hellsmark (2003)	168
12	Rasmussen & Sorheim (2006)	164
13	Philpott, Dooley, O'Reilly, & Lupton (2011)	119
14	O'Shea, Allen, Morse, O'Gorman, & Roche (2007)	110
15	Guerrero, Cunningham, & Urbano (2015)	102
16	Martinelli, Meyer, & von Tunzelmann (2008)	102
17	Van Looy et al. (2011)	100

The five articles with the highest number of citations are:

1. Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy, 29*(2), 313–330. (802 Citations).
2. Etzkowitz, H. (2003b). Research groups as 'quasi-firms': The invention of the entrepreneurial university. *Research Policy, 32*(1), 109–121. (531 Citations).
3. Etzkowitz, H. (1998). The norms of entrepreneurial science: Cognitive effects of the new university–industry linkages. *Research Policy, 27*(8), 823–833. (476 Citations).
4. Etzkowitz, H. (2003a). Innovation in innovation: The triple helix of university–industry–government relations. *Social Science Information sur les Sciences Sociales, 42*(3), 293–337. (375 Citations).
5. Deem, R. (2001). Globalisation, New Managerialism, Academic Capitalism and Entrepreneurialism in Universities: Is the local dimension still important? *Comparative Education, 37*(1), 7–20. (244 Citations).

With regard to the sources, as a result of the analysis, we identified a total of 269 journals that have published work on the subject of the EU. Table 3 shows the ten journals with the highest number of articles. As for the number of articles each journal has published, we highlight the Journal of Technology Transfer (with 26 articles), Research Policy (16 articles), Higher Education (11 articles), and the International Journal of Technology Management (11 articles). The following stand out as the most cited journals: Research Policy (with 2800 citations), Journal of Technology Transfer (702 citations), Technovation (571 citations), and Higher Education (442 citations). The journals with the highest number of citations per article are Research Policy, with 175.0 citations per article published, Social Science Information sur Sciences Sociales, with 138.3 citations per article (this journal was not included in the table due to having published only 3 articles, corresponding to 415 citations), Technovation, with 71.4 citations per published article, and R&D Management, with 59.6 citations per article (not shown in the table due to having published only 5 articles, corresponding to 298 citations).

Table 3 - Top of sources with the highest number of publications, and respective citations, in the domain of Entrepreneurial Universities

Source	# articles	# citations	# citations/article
Journal of Technology Transfer	26	702	27.0
Research Policy	16	2800	175.0
Higher Education	11	442	40.2
International Journal of Technology Management	11	19	1.7
Industry and Higher Education	10	18	1.8
Small Business Economics	9	137	15.2
Technovation	8	571	71.4
Scientometrics	8	214	26.8
Journal of Management Development	8	13	1.6
European Planning Studies	7	112	16.0

4.2 Most relevant authors, countries, and collaborative networks

When analyzing the data of the 933 authors of the 479 documents published in the field of Entrepreneurial Universities and published in academic journals (see Table 4), we found that Etzkowitz, H (16 articles), Guerrero, M (11 articles), Urbano, D (11 articles), and Errasti, N (10 articles) are the authors with the most significant number of publications. Fractionalizing the articles by the number of authors, the most productive authors are Etzkowitz, H (12.75 articles), Meyer, M (4.37 articles), Guerrero, M (3.73 articles), and Urbano, D (3.73 articles).

Table 4 Top authors with publications in the field of Entrepreneurial Universities

Authors	Articles	Authors	Fractional-ized articles
Etzkowitz, H	16	Etzkowitz, H	12.75
Guerrero, M	11	Meyer, M	4.37
Urbano, D	11	Guerrero, M	3.73
Errasti, N	10	Urbano, D	3.73
Markuerkiaga, L	9	Mok, KH	3.00
Igartua, JI	7	Errasti, N	2.87
Meyer, M	7	Markuerkiaga, L	2.67
Cunningham, JA	6	Culkin, N	2.50
Klofsten, M	5	Knuuttila, T	2.50
Carayannis, EG	4	Tuunainen, J	2.50
Debackere, K	4	Cunningham, JA	2.08
Fayolle, A	4	Igartua, JI	2.08
Gaus, O	4	Baldini, N	2.00
Iscaro, V	4	Hassanin, M	2.00
Kirby, DA	4	Nikunen, M	2.00
Castaldi, L	3	Raymond, SU	2.00
Culkin, N	3	Styhre, A	2.00
Cuozzo, B	3	Wonglimpiyarat, J	2.00
El hadidi, H	3	Kirby, DA	1.83
Ganzarain, J	3	Iscaro, V	1.78

Figure 1 reveals the main countries with research competences in the subject area of Entrepreneurial Universities. The USA (with 89 publications), the UK (77 publications), Italy (66 publications), Spain (59 publications), and Germany (44 publications) are the countries with the highest number of publications in that field.

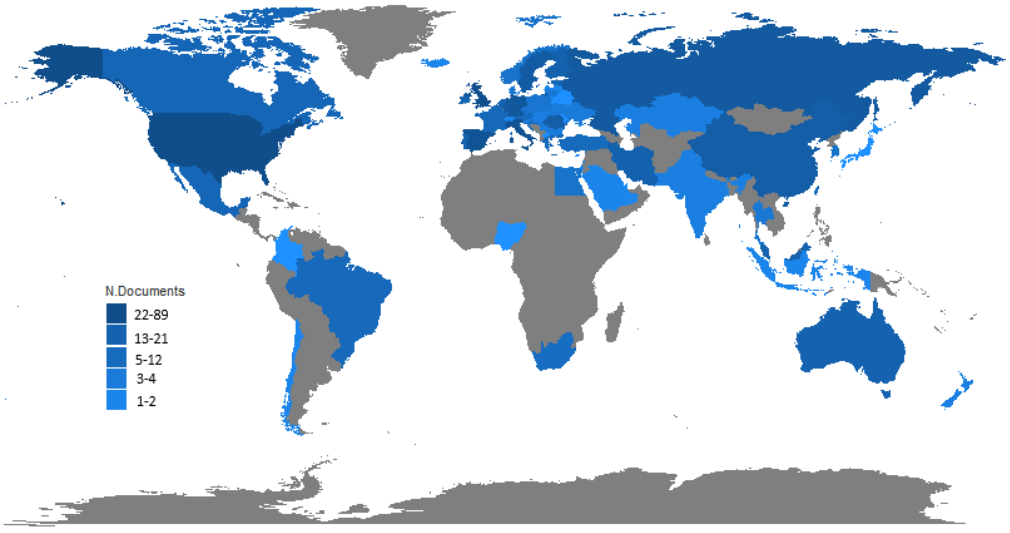


Fig. 1 Countries with publications in the field of Entrepreneurial Universities

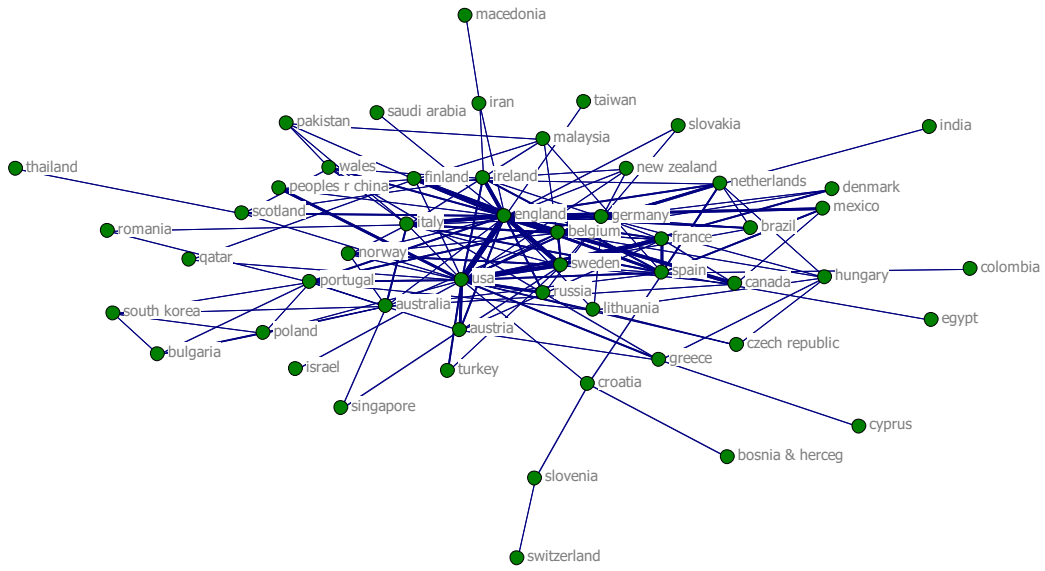
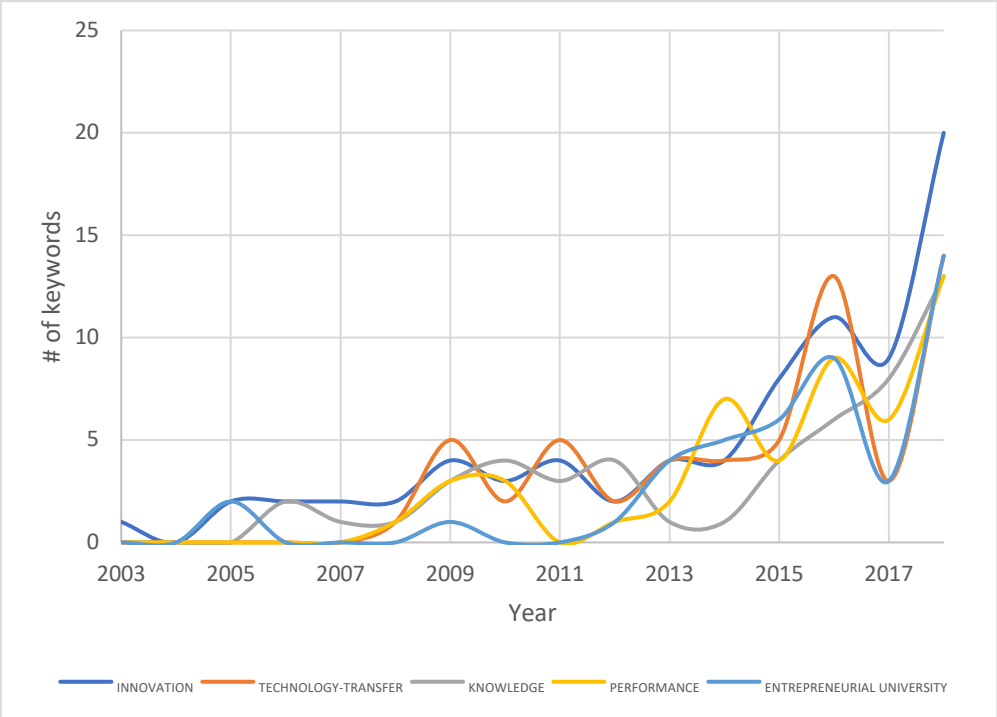


Fig. 2 Collaboration networks between countries

In terms of cross-country co-authoring, British authors have published seven documents together with authors from Belgium, as well as seven articles with US authors, six with Swedish authors, and four with authors from Canada, Finland, Ireland, and Italy. Belgian authors have published four articles with colleagues from Finland, which is the same number as the publications co-authored by Swedish and US researchers. Figure 2 shows the co-authorship networks among countries, where organizations belonging to the same country are grouped into one node, and the size of each node is proportional to the number of countries with which a co-authorship exists. If there is a link between different countries, this means that there is at least one co-authoring relationship between them.

4.3 Keyword analysis

The most common keywords are Innovation (78 publications), Technology transfer (58 publications), Knowledge (51 publications), Performance (49 publications), Entrepreneurial University (45 publications), Science (43 publications), Triple-helix (36 publications), and Industry (32 publications). In terms of the dynamics of keywords, it can be observed from Graph 2 that since 2016, the term Innovation has prevailed over other keywords. In recent years, however, the keyword Knowledge has also gained preponderance, currently showing a frequency similar to the keywords Technology Transfer, Performance, and Entrepreneurial University.



Graph 2 Keyword Dynamics (5 most frequently used keywords)

4.4 Bibliographic coupling analysis

The initial sample of 479 publications contained 14,540 references. According to the criterion of relevance, we only considered those articles with at least 30 citations (Ferreira et al. 2016; Fernandes et al. 2017). In this way, the sample was reduced to 54 publications containing 2472 references in total. Based on bibliographic coupling, a matrix of references that were common to 54 publications was calculated in order to establish the network of connections between the publications and group them into clusters (see Table 5).

Table 5 Clusters obtained from the cluster analysis based on the bibliographic coupling of 54 publications with at least 30 citations

Cluster 1	**Cluster 2**
Etzkowitz et al. (2000)	Guerrero et al. (2016)
Etzkowitz (2003b)	Audretsch (2014)
Etzkowitz (1998)	Harrison & Leitch (2010)
Etzkowitz (2003a)	Guerrero et al. (2015)
Cooke (2005)	Urbano & Guerrero (2013)
Etzkowitz & Klofsten (2005)	Guerrero & Urbano (2012)
Etzkowitz (1983)	Kirby et al. (2011)
Meyer (2006a)	Sidhu et al. (2011)
Ranga et al. (2003)	Colombo & Piva (2012)
Etzkowitz (2013)	Heffernan & Poole (2005)
Meyer (2006b)	Meoli et al. (2013)

Cluster 3	**Cluster 4**
Deem (2001)	
Stromquist (2007)	D'Este & Perkmann (2011)
Lam (2010)	Bramwell & Wolfe (2008)
Ylijoki (2005)	O'Shea et al. (2007)
Subotzky (1999)	Martinelli et al. (2008)
Tuunainen (2005a)	Van Looy et al. (2011)
Lazzeretti & Tavoletti (2005)	Chang et al. (2009)
Tuunainen (2005b)	Czarnitzki et al. (2009)
Yokoyama (2006)	Yusof & Jain (2010)
Hakala (2009)	Baldini (2010)
Hong & Walsh (2009)	

Cluster 5	**Cluster 6**
Jacob et al. (2003)	Philpott et al. (2011)
Rasmussen & Sorheim (2006)	Boardman & Ponomariov (2009)
Wong et al. (2007)	Ankrah et al. (2013)
Leydesdorff & Meyer (2010)	Kalar & Antoncic (2015)
Meyer et al. (2003)	Metcalfe (2010)
Sam & van der Sijde (2014)	

Multidimensional scaling (MDS) allowed us to produce a map with which to analyze the relationships among the articles. Figure 3 shows the network of articles obtained through this multidimensional analysis using data from the common reference matrix.

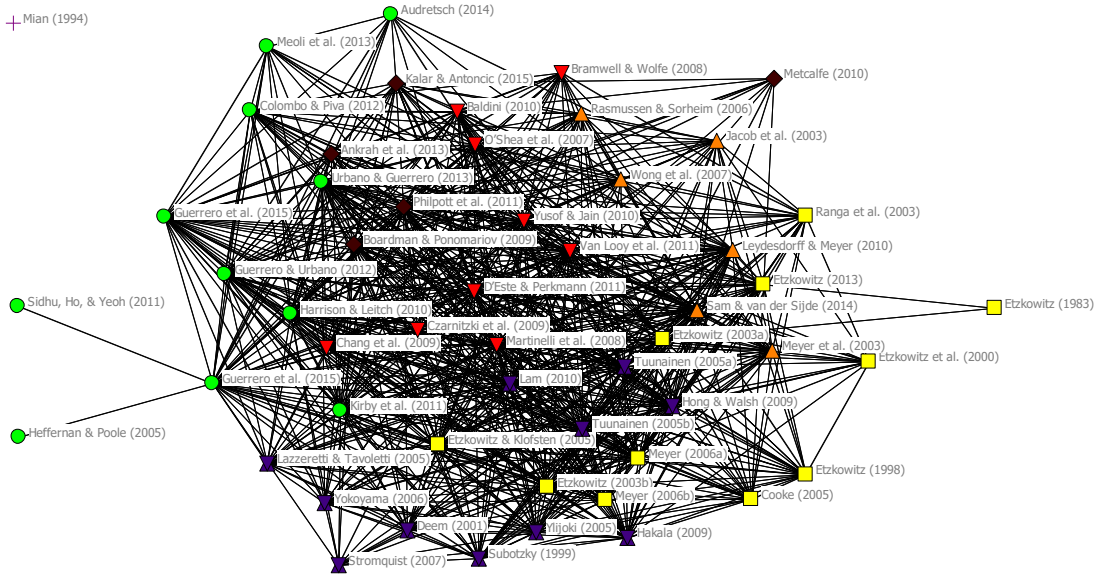


Fig. 3 Bibliographic coupling network of the 54 publications and their respective clusters

In this search we found that the article by Mian (1994) was isolated from the six identified clusters. A possible explanation for this may be that it was one of the first works published on

the subject. In his study, Mian (1994) highlighted the essential role that university-sponsored technology incubators (USTI) could play in the creation of new technology-based firms. After analyzing the practice of some 30 USTIs in the USA, this author proposed that universities designed specific programs for these incubators in order to establish objectives and management policies that were compatible with the new mission of the entrepreneurial university.

Next, we analyze the lines of research underlying each cluster.

4.4.1 Cluster 1: triple helix model

The key concept in the Triple Helix approach is precisely the EU and its role in the knowledge society (Etzkowitz 1983).

The transformation process, which many universities are currently undergoing, began at the end of the 19th century with the so-called first academic revolution that incorporated research as part of the university's mission, alongside teaching. At the end of the 20th century, the second academic revolution took place when the third mission emerged: the university's contribution to regional and national economic development (Etzkowitz 1983, 1998). Thus arose the idea of an entrepreneurial university (Etzkowitz 1983), which is integrated, together with industry and the government, into a complex and coherent system of relations that make innovation possible (Etzkowitz 1998). The coordinated effort of these three institutional spheres pursues regional and national progress through the development of innovative regions (Etzkowitz and Klofsten 2005). According to these authors, an innovative region is one that "… has the capability to move across technological paradigms and periodically renew itself through new technologies and firms generated from its academic base" (Ibid., 243).

In this innovation system, known as the triple helix model, all three helices (university, industry, and government) play an essential role not only because of the internal transformation each one has undergone, but also because of the transformation that has occurred in the type of relationships established among these three institutional spheres (Etzkowitz 1998; Etzkowitz et al. 2000). In contrast to the traditional, linear innovation model, where innovation firstly begins with the generation of knowledge which is put into practice in a second stage, in the triple helix model, innovation is seen as a systemic and networking process in which hybridization is fostered among the three helices or institutional spheres (Etzkowitz 2003a).

Under the triple helix model, each of the three spheres can take the role of the other two. For example, universities can assume the role of the industry by creating spin-offs as a way of exploiting the knowledge they generate, and in that way, they adopt a proactive behavior towards the practical application of their research. On the other hand, companies can also provide funding to the university through contracted research, thereby replacing the government in its role of a supplier of financial resources to the university. The government,

for its part, not only exercises its legislative power to work in favor of innovation, but can also act as a public entrepreneur or venture capitalist, thereby replacing industry (Etzkowitz 2003a). Nonetheless, although these three spheres may seem to overlap each other at some stage of the innovation process, an essential feature of this model is the relative independence of these organizations (Etzkowitz et al. 2000).

However, although the entrepreneurial orientation of universities is beneficial to the economy, some studies have raised concerns. In particular, Etzkowitz (2003b) questions the legitimacy of commercializing research results, and he goes on to argue that EUs manage to overcome possible tensions among entrepreneurship, research, and teaching by achieving feedback and positive synergies between the three missions (Etzkowitz 2013). Ranga et al. (2003) and Meyer (2006a; b) provide evidence of the existence of synergies between certain entrepreneurial activities and research. Ranga et al. (2003), for example, found that the number of publications on basic research by groups of academics carrying out entrepreneurial activities does not decrease in relation to the number of publications on applied research by these same groups. Furthermore, their study also showed that the number of basic research publications exceeds that of applied research publications by the same group of academics, both in the total number of publications and in their growth rate. In addition, Meyer (2006a; b) found that patenting does not appear to have a negative effect on the output of researchers involved in entrepreneurial activities in terms of the number of scientific articles they publish, nor in the number of citations they obtain from these publications.

Finally, the triple helix model, as a model that explains regional development, has been questioned by some scholars such as Cooke (2005). According to this author, regional innovation systems can be better explained by other models or theoretical approaches such as the Regional Knowledge Capabilities approach.

4.4.2 Cluster 2: knowledge society

The set of works that are framed within this second cluster explore the way in which EUs contribute to regional and national development. In this regard, Guerrero et al. (2015) argue that EUs contribute to the economic growth of their environment by generating human capital, knowledge capital, and entrepreneurship capital, these resources being the result of the teaching, research, and entrepreneurial activities they undertake.

Through education and training, EUs provide their environment with human capital in two forms. On the one hand, they produce graduates with the skills demanded by employers and, on the other hand, they train staff with the proper skills to become entrepreneurs and job creators (Urbano and Guerrero 2013), thereby also encouraging the surrounding society to become entrepreneurial (Audretsch 2014). The design of entrepreneurship training programs, the organization of business plan competitions, and the creation of business incubators and

technology transfer offices are some of the mechanisms used by EUs to foster entrepreneurship among their personnel and students (Guerrero et al. 2016).

Additionally, knowledge capital obtained as a result of research may be transferred through patenting and licensing or by launching spin-offs (Urbano and Guerrero 2013; Guerrero et al. 2015). With regard to spin-offs, however, several studies have suggested that these have a limited impact on regional and national economic growth. According to Harrison and Leitch (2010), this may be because these types of enterprises usually do not grow and remain small over time. Colombo and Piva (2012), for their part, point out that academic spin-offs perform poorly due to the fact that, although their founders have a high level of scientific-technical competence, they do not have the right managerial training, nor experience when it comes to industrial practice.

A few years later, and acknowledging the difficulty which spin-offs created by universities or public research centers have to grow and be sustainable in the long term, Meoli et al. (2013) proposed that it should not be taken for granted that the technology-transfer process ends with the creation of a spin-off, but rather that the final stage of the process should be that this technology is sold to a larger organization. The resources of the acquiring company (e.g., management skills, an appropriate distribution network, financial resources, etc.) can facilitate the development and growth of the spin-off. An important finding of their work is that the affiliation of firms with a university or public research center positively affects the decision of potential investors; that is, these investors are more willing to pay a higher amount for a share in these companies than for a share in those companies which are not associated to any university or public research organization. An important finding of their work is that the affiliation of firms with a university or public research center positively affects the decision of potential investors; that is, these investors are more willing to pay a higher amount for a share in these companies than a share in those companies which are not associated to any university or public research organization.

As a final point, it should be noted that in order to generate human capital, knowledge capital, and entrepreneurship capital, the EU must create a suitable atmosphere; that is, an environment where staff and students take a positive attitude towards entrepreneurship, and where the university establishes relations with the industry, adopts a flexible organizational structure, implements academic entrepreneurship programs, and creates the necessary support structures for technology transfer and start-ups (e.g., science parks, foundations, and specialized offices) (Kirby et al. 2011; Guerrero and Urbano 2012). Furthermore, Sidhu et al. (2011) suggest that EUs can increase and exploit their training capacities through agreements with foreign universities. In this regard, effective communication structures and frameworks, as well as trust and commitment, are factors that guarantee the success of these transnational agreements (Heffernan and Poole 2005).

4.4.3 Cluster 3: globalized perspective

Globalization is one of the factors that can help explain the transformation of universities into entrepreneurial organizations. This transformation requires a set of changes which involve searching for and using new ways of funding; implementing organizational and cultural changes; adopting managerial practices, values, and techniques from the field of business; competing to attract international students; and introducing changes in the rules and working practices of researchers, as well as new forms of teaching by means of ICTs (Deem 2001; Stromquist 2007; Lam 2010).

It is worth pointing out here that much of the specialized literature seems to have accepted that a certain convergence does exist in how universities respond to the pressures of globalization and, consequently, in the changes they introduce (Tuunainen 2005b). There are, however, some studies that question this convergence (e.g. Deem 2001; Tuunainen 2005b) since "the changes universities are living through are not uniform nor are they pervasive. Instead of being isomorphic with one another, there are, actually, different kinds of universities in the world just as there are different kinds of activities within each university…" (Tuunainen 2005b, p. 292). In this sense, Deem (2001) argued that local factors, such as culture, social relations, or the environment could influence the way in which universities from different countries respond to the pressures of globalization and, in particular, how each university approaches entrepreneurship. Following this reasoning, Yokoyama (2006) found that the history of each university, its institutional features, as well as the governmental policies of its country seem to be relevant antecedents of how each one will participate in entrepreneurial activities. The public or private nature of universities also seems to be another variable conditioning this response (Tuunainen 2005a).

Deem (2001) also argued that while globalization allows universities to produce knowledge anywhere in the world through taking advantage of their international networks, the exploitation of this knowledge tends to occur at the local level. These arguments are consistent with those of Lazzeretti and Tavoletti (2005), who provide evidence that the pursuit of international academic excellence and contributing to local economic development are compatible goals for EUs, even though they are often considered incompatible.

Conversely, other papers have focused on the negative consequences of the transformation into an entrepreneurial university. For example, Ylijoki (2005) argues that researchers feel that, to some extent, they have lost the freedom to choose the subject on which they would like to concentrate their research efforts. And this can lead to them feeling demotivated, which can have a negative effect on the performance of university–industry collaborations. These results are in line with those of Hakala (2009), who highlights the challenge faced by young researchers when deciding how to distribute their time and efforts between their dissertation, on the one hand, and research aiming to obtain marketable results, on the other.

Another undesirable effect is that researchers become increasingly competitive, which makes them share less and less of their knowledge and information (Hong and Walsh 2009).

Finally, Subotzky (1999) finds that although globalization has led to many universities adopting a market-oriented approach, an alternative university model characterized by its orientation towards social development and aiming for the common good is also possible, thereby fulfilling the broader purpose of higher education.

4.4.4 Cluster 4: researcher vs. entrepreneur

Most studies included in this cluster focus on the role of the researcher and analyze aspects such as the researcher's attitude towards entrepreneurship (Martinelli et al. 2008), the contextual factors that favor this attitude (O'Shea et al. 2007; Bramwell and Wolfe 2008; Chang et al. 2009; Baldini 2010; Yusof and Jain 2010), the tensions between research and entrepreneurship (Van Looy et al. 2011), and the researcher's motives for taking part in entrepreneurial activities (Czarnitzki et al. 2009; Baldini 2010; D'Este and Perkmann 2011).

Martinelli et al. (2008) report that faculties and schools differ in the way their researchers collaborate with industry and that these differences are more significant in terms of teachers' attitudes towards the transfer of knowledge and technology than in terms of the university's policy, regulations, and practice.

Knowledge transfer between university and industry requires that their relationship is set in the right context. This context should embrace aspects such as a highly developed industrial environment (Baldini 2010); informal as well as formal relationships among researchers and industry staff (Bramwell and Wolfe 2008); universities with an adequate organizational structure that implement the right policies to provide researchers with training programs that increase their entrepreneurial capabilities (Chang et al. 2009); an appropriate work climate (Yusof and Jain 2010) with an organizational culture geared towards entrepreneurial activities: a broad resource and knowledge base; a well-defined mission supported by key staff, and a high-quality research output (O'Shea et al. 2007).

As we pointed out above, one of the elements that favor knowledge transfer is precisely the quality of the research (O'Shea et al. 2007). In this respect, Chang et al. (2009) found that technology transfer through patenting and licensing or the participation in start-ups require that EUs are ambidextrous, i.e., EUs need to promote and facilitate among their staff both the pursuit of excellence in research and its commercialization. In fact, Van Looy et al. (2011) results suggest a positive relationship between the level of scientific productivity of universities (e.g., publications) and their level of entrepreneurial activities. Also, according to these authors, the positive relationship between scientific productivity and the number of patents can be explained because both entail similar knowledge-creation activities, and both are the result of the same research effort. The relationship between scientific productivity and the number of research contracts is positive because companies take into account the

university's reputation for quality scientific output as a criterion for choosing academic partners. Moreover, contracted research facilitates the creation of spin-offs, as it provides researchers with a better understanding of the market potential and the development of appropriate business models.

On the other hand, Czarnitzki et al. (2009) questioned whether the orientation of researchers towards entrepreneurial activities could negatively affect scientific productivity in terms of quantity and quality. Their work provides evidence that the relationship between patents and scientific productivity seems to be conditioned by patent ownership. Their results show that when patent ownership is assigned to the researcher, his or her university or the center in which the research has been carried out, both the number of publications and their quality augments (as measured both by the number of citations and by the impact factor of the journal in which they are published). However, they find a negative effect when patent ownership is assigned to the company. According to the authors, this diverse effect is due to the fact that when it is assigned to the researcher or his/her university or research center, the majority of research projects that lead to a patent grant are those related to basic research in contrast to those projects carried out with industrial partners which only pursue a practical application of the discovery.

Lastly, as to the reasons that lead academics to participate in different entrepreneurial activities, Baldini (2010) found that letting researchers and their departments share the royalties from patents from their research has proven to be an incentive that positively influences the number of patents. These findings are also supported by the work of D'Este and Perkmann (2011), who found that the reason why researchers undertake research contracts, consultancy activities, as well as joint research is because, through these activities, they can improve their performance in terms of the number of quality publications. This may be explained by the fact that entrepreneurial activities allow researchers to gain knowledge and also to have access to different types of resources, such as financial aid, equipment, materials, and data sources. Nonetheless, the main reason why researchers collaborate with the industry is because of the economic benefits they can obtain from the commercialization of their knowledge by filing a patent or launching a spin-off.

4.4.5 Cluster 5: dual personality

Both the incorporation of the third mission and the transition of the university towards an entrepreneurial model involve radical changes in its organization and management. However, these changes that affect their organizational culture, or the way they are managed, require several years to be completed and, in order for them to be fully accomplished by EU managers, governments need to legitimize them through public policies which focus more on innovation than on research. Then again, for research to be commercialized through business initiatives, the EU must maintain a balance between its knowledge exploration and creation activities and those activities that pursue knowledge exploitation (Jacob et al. 2003).

But despite the government support for university entrepreneurial initiatives, Leydesdorff and Meyer (2010) found evidence that, along the two decades previous to their research, the number of university patents had decreased in most advanced economies, which, according to these authors, was because university rankings do not regard patents and spin-offs as significant factors.

Many universities have evolved into what is known as an EU by adapting their organizational and national context to the Anglo-American model of higher education. Through this model, the EU not only aims to promote economic growth in its region as one more of its missions but also to link this new mission to the research and teaching as a way to maintain its academic identity (Sam and Van der Sijde 2014).

Indeed, this transformation of the university should also be reflected in the changes made in the curricula and teaching methodologies. As Rasmussen and Sorheim stated (2006), the third mission can also be achieved through teaching, i.e., through the design of training programs and active teaching–learning methodologies which foster an orientation towards innovation and entrepreneurship among students. In this sense, the provision of graduates with appropriate managerial and entrepreneurial skills is a prerequisite for the development of innovative and successful businesses that can contribute to regional economic development. In a similar vein, Wong et al. (2007) propose that in knowledge-based economies where labor markets are increasingly dynamic, even the curricula of technical degrees should include business and entrepreneurship training programs. Thus, it may be that the poor entrepreneurial education of researchers from technological backgrounds is yet another explanation for Meyer et al. (2003) results, since these authors found that only 10% of the patents produced in universities were later exploited through start-ups launched by academic entrepreneurs. In fact, most academic inventions, which are generally financed with public funds, are exploited by large companies.

4.4.6 Cluster 6: frenzy

Some of the works that we reviewed regarding this last cluster adopt a novel approach to the study of the university–industry relationship. For instance, they analyze this relationship from the perspective of industry personnel (Ankrah et al. 2013), the role of academic disciplines (Philpott et al. 2011; Kalar and Antoncic 2015), the personal characteristics of researchers such as age or gender (Boardman and Ponomariov 2009), or they emphasize that university staff are put under pressure to concentrate their efforts on seeking and obtaining funding (Metcalfe 2010).

For Philpott et al. (2011), the complexities underlying the development of a unified entrepreneurial character within the institution are increasingly leading to a "schizophrenic" split between the disciplines in the university. These authors question whether there is a single model or ideal for the EU, and suggest that when designing strategies to achieve the third

mission, university managers should take into account their university's particular capabilities and operational context. They argue that, apart from patenting, licensing, and spin-offs, there are other forms of knowledge transfer and wealth creation in the EU's economic environment, frequently ignored by the specialized literature. These other forms of knowledge transfer encompass, among other alternatives, training courses for industry personnel or consultancy services, which are often the mechanisms through which academics from the Arts, Humanities, and Social Sciences fields contribute to the third mission. In fact, these alternative ways of transferring knowledge sometimes provide universities with a major source of funding and can generate even more revenue than licenses and spin-offs. In this regard, the work of Metcalfe (2010) highlights that, in many countries, one of the consequences of the changes introduced by public policies in higher education is the greater pressure experienced by researchers to direct their efforts towards obtaining finance from alternative sources to public funding.

Kalar and Antoncic (2015) later explored possible differences among the disciplines regarding the participation of academics in business activities and found that academics belonging to natural science departments perceived a higher level of entrepreneurial orientation in their department than those belonging to social science departments. Their results point to a positive relationship between this perception and the willingness of academics to take part in entrepreneurial initiatives.

On the other hand, while most studies that revolve around university–industry relations have been conducted from the perspective of the university itself and/or of academics, Ankrah et al. (2013) take a dual perspective. These authors study the motives of industry personnel and academic staff alike for collaborating and building relationships. Their findings reveal that even though there are several differences between the motives of one group and another, because of the different organizational context they come from (with a different mission, practice, and organizational culture), in general, there is a high degree of coincidence in the motives of both groups. Another interesting finding of this work is that both academics and industry workers seek, through these collaborations, to benefit their respective organizations rather than to contribute to the economic and social impact generally referred to when justifying government support for such relationships.

Table 6 shows the main ideas of the works included in each cluster.

Table 6 Review of insights challenging the prevailing theoretical assumptions about the Entrepreneurial University

Prevailing Theoretical Approaches	**Review insights**
Cluster 1: Triple Helix Model Etzkowitz et al. (2000) Etzkowitz (2003b) Etzkowitz (1998) Etzkowitz (2003a) Cooke (2005) Etzkowitz & Klofsten (2005) Etzkowitz (1983) Meyer (2006a) Ranga et al. (2003) Etzkowitz (2013) Meyer (2006b)	• The industry begins its participation in companies created by university scientists to gain access to the new technology. • The university came to be regarded as a factor of production. • Economic and social development is part of the mission of universities. • The second revolution of the university emerges: the entrepreneurial university (UE). • The capitalization of knowledge is thus the heart of a new mission for the university. • New concept of Triple Helix: university-industry-government. • The university plays a greater role in technological innovation. • There is an impact of the Science-Industry relations on knowledge production of academic research groups. • The groups of scientists do not reduce the number of publications previously performed, in addition to maintaining this performance, they also produce applied research resulting from this relation. • It starts to operate an interactive model of innovation, abandoning the linear model. • The government starts acting as a public entrepreneur. • The EU is the result of developing an "internal logic" of academic development. • The Research University shares similar qualities with a start-up company. • A knowledge-based regional development model emerges: Initiation, Implementation, Consolidation and Renewal. • Bioregional Innovation Systems: lead to a new theory of economic geography in the knowledge economy, based on 'regional knowledge capabilities'.

Cluster 2: **Knowledge Society** Guerrero et al. (2016) Audretsch (2014) Harrison & Leitch (2010) Guerrero et al. (2015) Urbano & Guerrero (2013) Guerrero & Urbano (2012) Kirby et al. (2011) Sidhu et al. (2011) Colombo & Piva (2012) Heffernan & Poole (2005) Meoli et al. (2013)	• Establishment of offshore education partnerships. • Spin-off - Two visions: i) One of the EU's major challenges lies in its spin-offs. Most of these companies start small and remain small, reflecting the founders' aspirations, capabilities and resources. ii) High-tech academic start-ups exhibit peculiar genetic characteristics that characterize a lasting performance in the development of the company. • Establishing networks and collaborations with foreign universities is crucial for building knowledge and innovation centers. • An entrepreneurial society refers to places where knowledge-based entrepreneurship has emerged as a driving force for economic growth, job creation and competitiveness. • Entrepreneurial universities play an important role both in the production of knowledge and in its dissemination. • Entrepreneurial university - characteristics: (i) an important catalyst for regional economic and social development; ii) generates and exploits business opportunities; iii) an approach to the institutional economy, as well as the resource-based approach and approaches to endogenous growth, should be adopted; iv) The affiliation of companies to universities makes access to risk capital easier; v) The entrepreneurial university is a response to generate technology transfer and startups based on knowledge. • In the entrepreneurial economy, the dominant factor of production is knowledge. • In the new socioeconomic scenarios, the role of entrepreneurial universities not only generates / transfers knowledge but also contributes / provides leadership for the creation of entrepreneurial thinking, actions and institutions.

Cluster 3: **Globalized Perspective** Deem (2001) Stromquist (2007) Lam (2010) Ylijoki (2005) Subotzky (1999) Tuunainen (2005a) Lazzeretti & Tavoletti (2005) Tuunainen (2005b) Yokoyama (2006) Hakala (2009) Hong & Walsh (2009)	• Globalization has generated new forms and organizational practices in the production of knowledge in higher education. • The EU, characterized by growing market behavior and management. • Researchers have a sense of nostalgia, which translates into a loss of freedom and autonomy at work, can condition the success of collaborations between universities and business. • There are two frontiers: a boundary between the social roles of university researchers and private entrepreneurs, as well as a physical separation of work done by academics such as corporate development projects. • It will result in a hybrid research group in which the company will be "purified" in a private entity without direct links with the university. • Universities pursue one main goal: to transfer knowledge that is internationally relevant to all mankind. • Today, the most powerful socio-economic forces require universities to become involved in regional economic development: local employment, university spin-offs and economic growth. • Instead of internationalism, internationalization is found to mean predominantly a quest for student markets in the domestic and overseas markets. • Academic scientists are active agents who shape the relationships between science and business, thus showing the continuing diversity in their work guidelines. • Socioeconomic policies require universities to become involved in regional economic development: local employment, university spin-offs, and economic growth. • Instead of internationalism, internationalization is found to mean predominantly a quest for student markets in the domestic and overseas markets. • Academic scientists are active agents who shape the relationships between science and business, thus showing the continuing diversity in their work guidelines.

Cluster 4: **Researcher- Entrepreneur** D'Este & Perkmann (2011) Bramwell & Wolfe (2008) O'Shea et al. (2007) Martinelli et al. (2008) Van Looy et al. (2011) Chang et al. (2009) Czarnitzki et al. (2009) Yusof & Jain (2010) Baldini (2010)	• Leaders, administrators, and teachers seek to increase the propensity to engage in the marketing of research activities through the new spin-offs. • The spin-off generation is typically considered the result of: i) characteristics of individuals; ii) organizational policies and structures; iii) organizational culture; iv) external environment. • Universities produce knowledge transfer mechanisms, such as the generation and attraction of talent for the economy, and collaborate with the local industry by providing formal and informal technical services. • Ambidextria as an important feature in the EU. • In order to promote the commercialization of academic research, it is necessary to build a university as a dual structural organization that simultaneously allows the research of excellence and the commercialization of this research. • The growing commercialization of university discoveries has triggered a controversy over the impact of scientific research. • Researchers are giving more attention to activities that lead to patenting than to traditional academic research. • In many universities researchers are still awakened to the monetary rewards that collaboration between universities and companies can bring. • Policies to encourage this collaboration should refrain from concentrating excessively on monetary incentives for cooperation with industry and consider a broader range of incentives to promote interaction between the academy and industry. • Scientific productivity is positively associated with entrepreneurial effectiveness.

Cluster 5: **Dual Personality** Jacob et al. (2003) Rasmussen & Sorheim (2006) Wong et al. (2007) Leydesdorff & Meyer (2010) Meyer et al. (2003) Sam & van der Sijde (2014)	• The creation of an entrepreneurial university takes several years with various infrastructural changes in order to achieve success. • The commercialization and commodification of knowledge create a degree of uncertainty in the role of universities. • Most of the patented academic inventions are linked to the scientific research conducted by the inventors and tend to be used in large enterprises, not start-ups founded by academic entrepreneurs. • Innovation through the creation of new businesses and new business areas are key factors in achieving the company's economic goals at the regional and national levels. • A restrictive factor is the availability of competent people to manage projects and become entrepreneurs. • Entrepreneurship education has been pursuing increasingly action-oriented initiatives, emphasizing learning by doing. • The entrepreneurial university contributes to the competitive advantage of the industry with which it collaborates. • There is a new classification of universities: patents and spin-offs are not counted in university rankings committing new cooperations between university-industry-government relations. • Universities are very receptive to changes in their environments.
Cluster 6: **Frenzy** Philpott et al. (2011) Boardman & Ponomariov (2009) Ankrah et al. (2013) Kalar & Antoncic (2015) Metcalfe (2010)	• Factors that lead university scientists to work with private companies: i) sources of financing; ii) institutional affiliations; iii) possession status; iv) student support; v) scientific values; vi) demographic attributes. • The underlying complexities of developing a unified entrepreneurial character within the institution are increasingly leading to a schizophrenic split between disciplines within the university. • This division of attitudes can cause widespread disharmony between the academic community and impede progress towards the achievement of this new university mission: the ideal of the EU. • Academics in the natural sciences realize that their university department is highly entrepreneur-oriented. • The fact that researchers feel that a university department has a high or low entrepreneurial orientation can have a significant effect on whether or not an academic enters into some activities that are of a more entrepreneurial nature

5 Conclusions and future research agenda

Since the publication of the influential works by Etzkowitz (1983) and Etzkowitz and Leydesdorff (1997), there has been a large number of academic contributions that have focused on a wide range of aspects concerning the concept of the entrepreneurial university. To be able to systematize this literature and to find out how knowledge about this concept could be advanced, we carried out a co-citation bibliometric analysis, which allowed us firstly, to pinpoint the lines of research that make up the intellectual structure around this knowledge domain and secondly, to identify the key contributions, the most relevant authors, and the scientific journals with the greatest impact on this particular area.

Through the bibliometric analysis carried out, six major groups of studies on this topic were identified. The first one focuses on the triple helix model, i.e., on the bilateral and trilateral relations between industry, university, and government. These relations account for a new model of innovation, where the three actors can participate in the different phases of innovation processes and even assume the role traditionally held by any of the others. Public policies of many countries have supported and fostered these relations because of their role in knowledge transfer and innovation and, through the latter, in regional and national economic development. Recent studies have also included the fourth and fifth helix in the relations between university, industry, and government, i.e., models of innovation which incorporate the civil society and the university's environment in the analysis. But what remains to be explored is the stakeholders' influence on the EUs' performance regarding issues such as whether their interests are taken into account when defining objectives and strategic plans, and how these plans are managed.

A second large group of studies has paid attention to how universities can contribute with their different activities to social and economic development. However, researchers have neglected to study how EUs can also contribute to the environmental sustainability of the region in which they operate or to achieving the United Nations' Sustainable Development Goals (SDGs).

The transformation which many universities are undergoing in their endeavor to contribute to economic growth, as part of their mission, has opened a new debate among researchers, which is the focus of the third group of works. While some authors argue that this transformation is isomorphic, other scholars claim that each university's response is different and conditioned by contextual factors such as its condition as a public or private university, its organizational culture, the country's government policies, or the need to seek funding. Studying how other factors influence this transformation, e.g., the internationalization process many universities are undertaking, also opens up an interesting line of research. Additionally, it could also serve as a useful guide to management teams to find out whether certain practices and strategies implemented by EU universities and which have reached a

high level of entrepreneurial activity can be imitated by universities in other regions or countries and be successfully adapted to their particular contexts.

The literature contributions belonging to the fourth group have analyzed the entrepreneurial activities carried out at universities from the researcher's point of view. Results from some of these studies have revealed that the alleged negative relationship between the traditional academic activities and the entrepreneurial ones that characterize EUs is more theoretical than real. This group's contributions have also taken into account other factors, as for instance, the attitudes of academics who participate in university-firm collaborations and their reasons for doing so; the personal relationships that academics establish with the staff of firms with which they collaborate, or the organizational culture of the EU and its influence on its entrepreneurial performance, among others. Most works of this group, however, focus exclusively on the technology transfer to industry (i.e., patenting, licensing, and spin-offs). Thus, new research efforts could be directed at the analysis of the transfer of other types of knowledge, i.e., non-technological knowledge. For instance, in the social science field, consultancy services are another mechanism by which EUs transfer knowledge to the industry. This other type of non-technological knowledge can also help foster intra-entrepreneurship through the creation of new firms, innovation, or the strategic renewal of existing firms, and thereby generate economic growth.

The fifth group of research articles highlights the necessity to link entrepreneurship with teaching and research, as well as the need for EUs to maintain a balance between activities of knowledge exploration, creation, and exploitation. These studies advocate the need for training plans of different university degrees also to include education in both business and entrepreneurship, with the aim of promoting an entrepreneurial spirit among students and academics. In this regard, however, there is a lack of studies that measure the impact that this type of training has on firm creation, the intra-entrepreneurship of firms that hire graduates who have received this training, as well as its final impact on economic and social growth.

Finally, the last group of studies has considered the role of variables such as the researcher's discipline or gender in the development of entrepreneurial activities within the EU framework. Further research could also explore how the features of EU management team members are related to the way they make decisions and the success of university–industry relations.

Moreover, there are still issues that need to be examined in more depth to further our understanding of the EU. To this end, the EU could be studied from different theories and theoretical approaches, both from the field of management and from other areas such as psychology or sociology. Another line of research could analyze whether differences exist between the economic and social impact of the entrepreneurial university as opposed to the impact of traditional universities.

Finally, researchers have not considered the role that new information and communication technologies could play in the activities carried out by the EU and its functions, which provides another interesting line of research.

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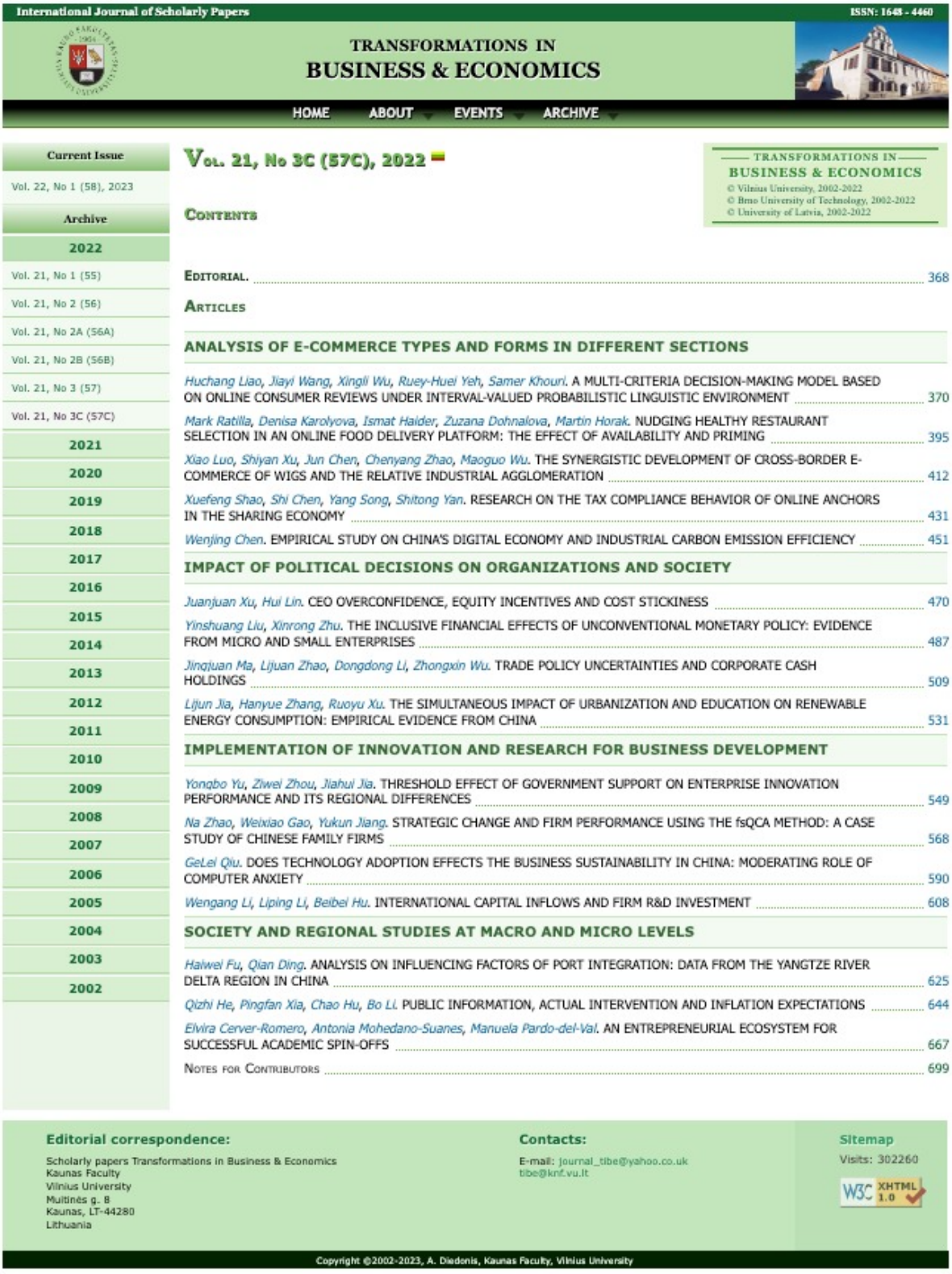
Artículo 3. An entrepreneurial ecosystem for successful academic spin-offs



International Journal of Scholarly Papers
ISSN: 1648 - 4460

TRANSFORMATIONS IN
BUSINESS & ECONOMICS

Vol. 21, No 3C (57C), 2022

Contents

Editorial correspondence:
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Contacts:
E-mail: journal_tibe@yahoo.co.uk
tibe@knf.vu.lt

An entrepreneurial ecosystem for successful academic spin-offs

Publicado en la revista *Transformations in Business & Economics***,** en 2022, Vol. 21, Nº 3C (57C), pp. 667-698.
ISSN 1648-4460

http://www.transformations.knf.vu.lt/57c/article/anen

Esta revista está incluida en los siguientes índices:

1. **Journal Citation Reports 2021**
   Social Sciences Citation Index (SSCI), Journal Impact Factor 1.824
   CATEGORY ECONOMICS Rank by Journal Impact Factor 220/381 (Q3); CATEGORY BUSINESS Rank by Journal Impact Factor 135/154 (Q4)

2. **SCOPUS 2021**
   CiteScore 2.6; Q1 81% 113/608 Political Science and International Relations; Q1 76% 100/426 Social Sciences (miscellaneous); Q2 58% 178/423 Business and International Management

3. **Scimago Journal Rank 2022**
   SJR 0.313; Q2 Political Science and International Relations; Q2 Social Sciences (miscellaneous); Q3 Business and International Management

JEL Classification M13, L26, I23

An entrepreneurial ecosystem for successful academic spin-offs

Elvira Cerver Romero[1] · Antonia Mohedano Suanes[1] · Manuela Pardo del Val[1]

[1]Facultat d'Economia - Department of Business Administration, Universitat de València

ABSTRACT. Academic spin-offs are a powerful channel for transferring the results of academic research to industry and society, thus providing significant contributions to economic development and generating skilled employment. The knowledge generated in universities and public research centers, however, is much greater than that which is actually transferred. Not many researchers have an entrepreneurial mindset and, when they do, they often lack the key skills to run a business successfully. Moreover, academia is not necessarily a breeding ground for start-ups. Based on case studies from academically diverse spin-offs, this paper aims to analyze the characteristics of an entrepreneurial ecosystem that favors the creation and the sustainable and successful development of academic spin-offs. Our results suggest that the political, cultural, financial, support, human capital and market dimensions require specific content and actors to complement the conventional start-up ecosystem and make it suitable for academic spin-offs.

KEYWORDS: academic spin-offs, entrepreneurial ecosystem, knowledge transfer, academic entrepreneurship, higher education, multi-case study.

JEL classification: M13, L26, I23

INTRODUCTION

Universities and public research entities have an important role in local and national economic development, both for their contribution to the development of human and entrepreneurial capital, and for the generation and transfer of knowledge (Cohen, 2006; Youtie, Shapira, 2008; Isenberg, 2011; Bischoff et al., 2018; Huang-Saad et al., 2018). One channel for transferring knowledge is through an academic spin-off, that is, a company with its own legal personality created by staff from universities and/or public research centers, possibly with other partners, with the aim of commercially exploiting the knowledge generated by their research in these institutions (Pardo et al., 2021).

The potential benefits of academic spin-offs have led governments and those responsible for the institutions behind them to design and implement policies that favor their creation (Wright et al., 2007; Nosella, Grimaldi, 2009; Mustar, Wright, 2010; Buenstorf, Geissler, 2013; Urbano, Guerrero, 2013; Fini et al., 2017). Some of the benefits of academic spin-offs highlighted in previous studies include their contribution to creating a strong link between industry and science (Debackere, Veugelers, 2005), to regional economic development (Mian, 1997; Nicolau, Birley, 2003) and to wealth creation (Roberts, Malone, 1996; Steffensen et al.,

2000; Pérez, Martínez, 2003; Walter et al., 2006). The explanation for such outcomes is that these companies, which are very active in R&D, drive economic activity (Roberts, Malone, 1996; Di Gregorio, Shane, 2003; Nicolau, Birley, 2003) and help to generate new jobs (Steffensen et al., 2000; Pérez, Martínez, 2003; Walter et al., 2006), in particular skilled positions for new graduates and PhDs (Rizzo, 2015; Dorner et al., 2017).

It is remarkable that the number of academic spin-offs is very small compared to the number of patents that universities obtain each year (Meyer et al., 2003; Pardo et al., 2021). Another of their characteristics is that spin-offs generally remain small over time (Colombo, Piva, 2005; Harrison, Leitch, 2010). For this reason, the literature has tried to identify the antecedents of spin-off creation and performance. Some antecedents are related to the characteristics of the founders or the founding teams such as, for example, their motivations (Fini et al., 2009; Hayter, 2011; Lam, 2011), their experience (Krabel, Müller, 2009; Clarysse et al., 2011; Miranda et al., 2017) and their educational background (Prodan, Drnovsek, 2010; Abreu, Grinevich, 2013). Others are related to characteristics of the academic spin-off, such as the reputation of the university from which it emerges (Di Gregorio, Shane, 2003; Gómez-Gras et al., 2008; Avnimelech, Feldman, 2015); and others are external, such as, for example, the regional context in which they grow (Fini et al., 2011; Sternberg, 2014; Davey et al., 2016).

However, as Prokop (2021) points out, there is still limited understanding of the role of the entrepreneurial ecosystem in both the creation and performance of academic spin-offs. Prokop (2021) finds that the difference between entrepreneurial ecosystems, in terms of the number of academic spin-offs and their survival, can be explained by differences in their configuration. It is important to consider configuration, since the concept of 'entrepreneurial ecosystem' captures the idea of a set of interconnected elements oriented toward an ambitious form of entrepreneurship (Isenberg, 2010), namely one focused on stimulating the growth of high value-added companies (Stam, 2015) such as academic spin-offs.

So far only a small number of researchers have examined the entrepreneurial ecosystem of academic spin-offs, and they have mainly focused on the success stories (e.g., Schaeffer, Matt, 2016; Miller, Acs, 2017; Huang-Saad et al., 2018). However, the characteristics an entrepreneurial ecosystem should have in order to help overcome the challenges facing academic entrepreneurship still remain to be studied.

Considering both the potential benefits of academic spin-offs stated above and the research gap previously explained, the main objective of this paper is to propose the 'ideal' ecosystem for the creation and growth of academic spin-offs, starting by identifying the main challenges they face. We approach this objective through a multi-case study and, based on the results obtained, we suggest a set of elements that should exist in such an ecosystem, and identify the actors responsible for them.

This paper is structured in four parts. In the first part, we review the literature and present the enablers of and challenges to creating and growing academic spin-offs; we then define the

entrepreneurial ecosystem and analyze its dimensions and main actors. This part concludes with a theoretical proposal of the entrepreneurial ecosystem for successful academic spin-offs. In the second part we present the methodological guidelines followed in this research. The third part presents the results of a study of multiple cases, which leads us to a new entrepreneurial ecosystem proposal. Finally, we close the paper by combining the theoretical and practical proposals to offer an entrepreneurial ecosystem model for academic spin-offs.

1. The Theoretical Framework

1.1 Academic Spin-offs: Creation and Growth

The literature on academic spin-offs identifies several enablers of these companies and the challenges they face, both at the time of their creation and in their subsequent development.

1.1.1 Factors Determining the Creation of Academic Spin-offs

Factors that influence the creation of academic spin-offs include the strength of the entrepreneurial culture in academic and research institutions, the resources allocated to research and transfer, the characteristics of academic entrepreneurs, their network of relationships, and the research fields. We take a closer look at them in what follows.

The promotion and development of an entrepreneurial culture is essential to stimulate and encourage researchers to create spin-offs (Grimm, Jaenicke, 2012; Huyghe, Knockaert, 2015) through activities such as holding ideas competitions and entrepreneurship projects, running entrepreneurship courses, or drawing attention to previous experiences, among others (Beraza, Rodríguez, 2011).

Several studies have found that the greater the volume of financial and human resources allocated to research, the greater the stock of knowledge that universities and other public research entities can potentially transfer to society, and the greater the probability of creating academic spin-offs (Lockett *et al.,* 2005; Rodeiro-Pazos *et al.,* 2010; Avnimelech, Feldman, 2015; Link, Scott, 2017). Moreover, this probability increases when research results respond to the real needs of industry or of the market in general (Di Gregorio, Shane, 2003; O'Shea *et al.,* 2005; Powers, McDougall, 2005; Rodeiro-Pazos *et al.,* 2010).

Furthermore, support resources for technology transfer, such as the availability of incubators, science parks, technology transfer offices (hereinafter, TTOs), and any other type of infrastructure that promotes and enables the creation of companies, have been considered fundamental elements for stimulating the creation of academic spin-offs (Lockett, Wright, 2005; Fini *et al.,* 2009). Among these support resources, several studies highlight the role that TTOs can play when universities provide them with enough staff with the necessary skills (Clarysse *et al.,* 2005; O'Shea *et al.,* 2005; Rodeiro-Pazos *et al.,* 2010; Clarysse *et al.,* 2011).

TTOs can stimulate the creation of academic spin-offs by training and mentoring academic entrepreneurs, providing support to identify market opportunities from research results, and/or advising researchers on the possible evaluation of research results, among other actions (Gómez-Gras *et al.,* 2008; Clarysse *et al.,* 2011; Fernández-Alles *et al.,* 2015; Rodríguez-Gulías *et al.*, 2016; Slavtchev, Göktepe-Hultén 2016).

With regard to the characteristics of academic entrepreneurs, many of the motives that drive them are common to non-academic entrepreneurs (Morales-Gualdrón *et al.,* 2009) such as, for example, the desire for independence and achievement, self-fulfillment or self-esteem. But, in addition, academic entrepreneurs are driven by their own motivations: the need to apply knowledge to practical uses and the satisfaction of being able to do so (Chiesa, Piccaluga, 2000), the need to be socially responsible or to serve society, in order to improve people's living standards (Morales-Gualdrón *et al.,* 2009), the possibility of obtaining new resources, both financial (scholarships, public subsidies, etc.) and non-financial (new infrastructures and facilities, etc.) to continue their research through the new venture (O'Gorman *et al.,* 2008), academic recognition, reputation or promotion (Stuart, Ding, 2006; Fini *et al.,* 2009; Hayter, 2011; Lam, 2011; Hayter, 2015), the absence of academic career opportunities, and/or the identification of personal development prospects outside academia (Horta *et al.,* 2016), although the desire for wealth is rare (Shane, 2004).

On the other hand, academic entrepreneurs with previous business experience, such as entrepreneurship experience and work experience in industry (Krabel, Müller, 2009; Clarysse *et al.,* 2011; Miranda *et al.,* 2017) are more likely to exploit their research output through a spin-off. In the same vein, the probability of establishing second-generation spin-offs may improve when academics have previously had entrepreneurial intentions and entrepreneurial behavior (Hossinger *et al.,* 2020).

Academics' relationship networks can also stimulate entrepreneurship. According to Prodan, Drnovsek (2010), academics who maintain personal contacts and relationships in the business world and perceive that, on a personal level, they have entrepreneurial skills, are easily motivated to create a spin-off once they see an opportunity. Moreover, the frequency or length of interactions between academics and industry increases the possibility of opportunity recognition, which favors the creation of spin-offs (Bourelos *et al.,* 2012).

Finally, the researcher's field or area of knowledge also influences their propensity to create a spin-off, since academic spin-offs are generally founded by academics working in areas of applied research, engineering, and physics (Prodan, Drnovsek, 2010; Abreu, Grinevich, 2013). In turn, academics in social science disciplines are generally involved in soft transfer activities (Philpott *et al.,* 2011) such as consulting and contracted research (Prodan, Drnovsek 2010; Abreu, Grinevich 2015; Fini, Toschi, 2016).

1.1.2 Factors Determining the Success of Academic Spin-offs

The growth of academic spin-offs is conditioned by the context in which they are developed and the availability of funding, their relationship with the parent institution (where the innovation was conceived), and by certain characteristics of their founders and management team, as described below.

In addition to the relevant role of the entrepreneurial ecosystem as a determinant of academic entrepreneurship success (Franco-Leal *et al.,* 2020; Prokop, 2021), other external factors such as the regional context (Fini *et al.,* 2011; Sternberg, 2014; Davey *et al.,* 2016) or the presence of agglomeration economies in a region (Conceiçâo *et al.,* 2017) have also been shown to have an influence. In particular, the availability of financing (Munari *et al.,* 2018; Wright *et al.,* 2006) is a major challenge.

The spin-off's relationship with its parent institution has been considered as one of the determinants of its innovative capacity (Ferri *et al.,* 2018; Helm *et al.,* 2018). In addition, the institution's reputation gives academic spin-offs credibility in the market, favoring their performance by attracting investors and by presenting them as reliable partners to potential alliances (Di Gregorio, Shane, 2003; Gómez-Gras *et al.,* 2008; Avnimelech, Feldman, 2015).

Furthermore, certain characteristics of the entrepreneurs, such as their entrepreneurial experience, their personal motivation to see the company grow and their approach to entrepreneurship as a team, have also been identified as conditioning factors for academic spin-off performance.

Having entrepreneurial experience, in addition to the obvious knowledge about the entrepreneurial process and business management, allows the academic entrepreneur to develop a network of relationships that may include, among other relevant agents, potential investors and/or experienced managers. This network of relationships can subsequently be leveraged to the spin-off's benefit and be one of the determinants of its success (Mosey, Wright, 2007).

The entrepreneurs' motivation or intentions to grow their company are also critical to business development (Knockaert et al., 2015). This motivation is not always present in the case of academic entrepreneurs because they often remain attached to the scientific institution they work for and do not take on the risk associated with the spin-off (Hesse, Sternberg, 2017). Moreover, academic entrepreneurs often have the 'spirit' of a researcher more tan an entrepreneur, so that their intrinsic and reputational motivations, as noted above, are more relevant than purely economic ones (Lam, 2011).

Academic spin-offs founded by a team perform better than those founded by a single individual (Roberts, 1991). Huynh (2016) argues that the greater endowment of human capital contributed by all the members of the founding team, compared to that contributed by a single entrepreneur, is positively valued by potential investors and increases the likelihood

that the spin-off will raise the funds it needs, thus favoring its success. Knockaert *et al.* (2011) provide evidence that the diversity of training and experience of founding team members increases the probability of survival of academic spin-offs.

Finally, the right combination of scientific and managerial profiles among the members of the management team of an academic spin-off seems to be a major guarantee of its success (Lundqvist, 2014). To ensure a good balance, Franklin *et al.* (2001) advise hiring experienced managers when none of the founders has a profile with management skills, thus allowing the academic founders to focus their efforts on areas related to technological development.

1.2 Entrepreneurial Ecosystem

1.2.1 The Concept

The entrepreneurial ecosystem concept was first introduced as a biological metaphor (Moore, 1993) to explain how companies emerge in a context in which they interact with one another and with other agents. Although most definitions in the literature consider this interaction (Malecki, 2018), there is still no widely accepted definition (Stam, 2015).

Among the various definitions of an entrepreneurial ecosystem (e.g., Cohen, 2006; Isenberg, 2011; Mack, Mayer, 2016; Audretsch, Belitski, 2017; Theodoraki, Messeghem, 2017), in our opinion, Mason, Brown's (2014, p.5) is one of the most comprehensive. These authors define an entrepreneurial ecosystem as "*a set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organisations (e.g. firms, venture capitalists, business angels, banks), institutions (universities, public sector agencies, financial bodies) and entrepreneurial processes (e.g. the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sellout mentality within firms and levels of entrepreneurial ambition) which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment.*"

The idea of an entrepreneurial ecosystem has three main underlying elements (Brown, Mason, 2017): its objective is companies' success, it is located in a specific geographical area, and it is rooted in the interactions between its components.

The first of these three elements refers to the ecosystem's aim to stimulate 'ambitious' entrepreneurial activity; that is, not only does it focus on creating new companies but also on their success (Isenberg, 2010) and especially high-growth companies (Brown, Mason, 2017).

In terms of location, an ecosystem is confined to a specific geographic area. This geographic proximity is precisely what stimulates the interaction between its agents, thus favoring knowledge exchange (Mason, Brown, 2014). However, an entrepreneurial ecosystem can be specific to an industry in a given territory, or it can include several industries (for example, the case of Silicon Valley) (Audretsch, Belitski, 2017) and, although they are usually restricted to a particular geographic area, entrepreneurial ecosystems are not defined by having a certain

dimension or scale (for example, a university campus, a city or a region), nor are they associated with a particular size of city (Mason, Brown, 2014). Some may take shape at the regional level, or exceptionally, at the national level, and even form part of more complex structures involving relationships between actors at different territorial levels, both nationally and internationally (Brown, Mason, 2017).

Thirdly, the entrepreneurial ecosystem concept is based on the important role of the interactions between its components, the framework conditions and the local and/or regional environment. The perspective of specific and complex interactions also points to the idiosyncrasies of each ecosystem. Each entrepreneurial ecosystem emerges and develops under unique conditions and circumstances (Feldman, Braunerhjerlm, 2006), so each has its own distinctive characteristics and idiosyncrasies that are geographically, relationally and socially embedded (Brown, Mason, 2017). There are no universal formulas, nor can a successful ecosystem be replicated elsewhere, as the nature of each element is tied to a particular territory (Hospers *et al.,* 2008), so time, the efforts of key actors, and the resources allocated will shape a unique and unrepeatable ecosystem. The historical evolution and the agents' accumulated experience and learning will determine the entrepreneurial ecosystem of each territory (Isenberg, 2010; 2011).

The implications of this third element are often overlooked when analyzing how to favor entrepreneurship in a territory. Specifically, ecosystems are not designed, created, or built, but can be influenced, facilitated, and sometimes restored (Isenberg, 2016). This is not semantic nitpicking, because relying on an external influence in the ecosystem is tantamount to jeopardizing its equilibrium and ignoring its self-sufficient and self-regulating character.

1.2.2 Dimensions and Key Actors

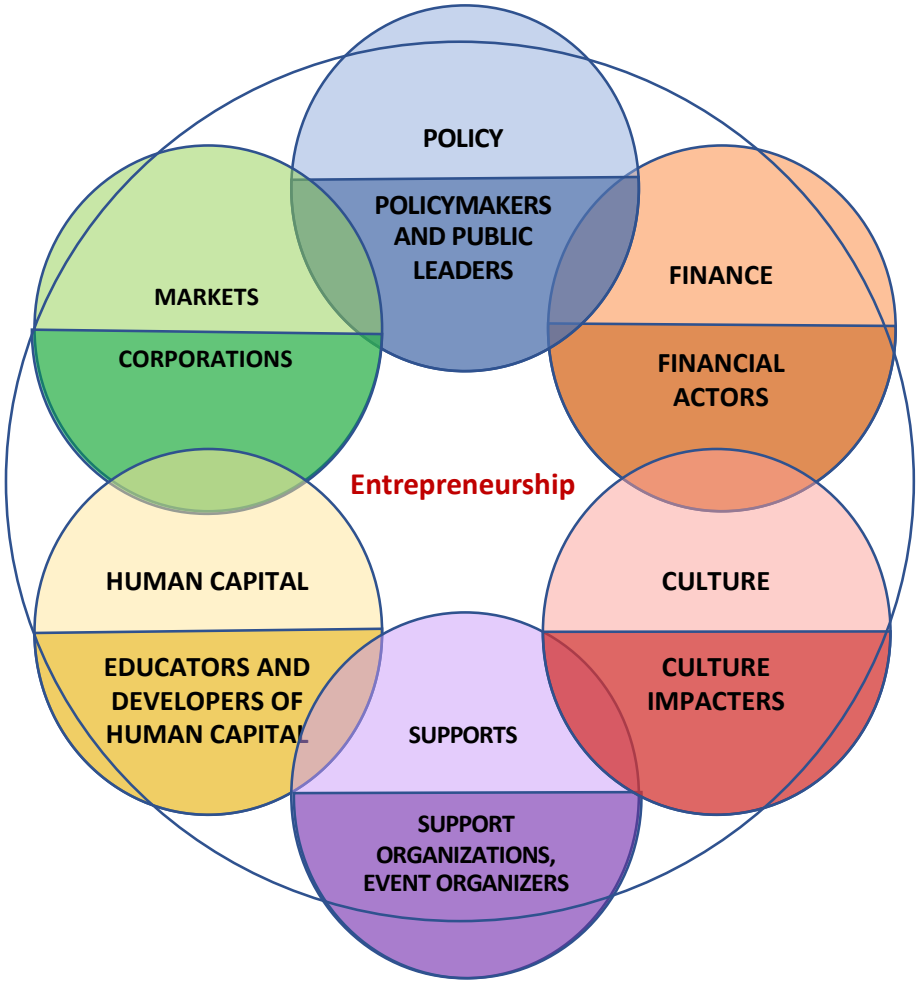
One of the most frequently cited models when listing the components of an entrepreneurial ecosystem is that of Isenberg (2011). This author proposes, from an overall perspective, six dimensions, composed of various elements, which interact with each other in a complex and particular way, reinforcing the intensity of the ecosystem without advocating cause–effect relationships between them. In a subsequent paper Isenberg, Onyemah (2016) posit that each of these dimensions has a set of key agents. *Figure 1* shows a combination of the two proposals.

The suitability of this model lies in its ability to structure all the elements that make up a healthy entrepreneurial ecosystem into six dimensions, with their corresponding key players. Although all of them interact according to the ecosystem concept described above, an approach that splits the ecosystem into dimensions and assigns responsibility for each of them is more accessible and easier to understand.

There is no doubt about the importance of the policy dimension in an entrepreneurial ecosystem. This dimension includes both the public institutions associated with

entrepreneurship and the regulations governing it, and the interaction between entrepreneurship and public leaders. The actors are governments, at the local, regional, or even national level, but also those in charge of education and research centers. The regulatory framework is fundamental to sustain entrepreneurship, whereas bureaucracy is usually one of the obstacles most cited by entrepreneurs in any ecosystem (Isenberg, 2014) and it is clearly the responsibility of public administrations to prevent it. Moreover, the role of public administrations should not stop at legislating; they should also confront 'softer' challenges, such as breaking down cultural barriers or promoting entrepreneurship training. In any case, the ultimate goal of the political dimension is to observe where the ecosystem is heading and facilitate its evolution, rather than to create new directions (Isenberg, 2010).

Figure 1. **Dimensions and Actors of an Entrepreneurial Ecosystem**



Source: own elaboration, based on Isenberg (2011) and Isenberg, Onyemah (2016)

The finance dimension includes the elements that fund ventures, whether through investments, grants, awards, loans or subsidies. The key players here are investors in the broadest sense of the term, as well as project and award sponsoring organizations.

The cultural dimension of a healthy entrepreneurial ecosystem shows social norms with a high tolerance for failure and that reward innovation and creativity, and accord entrepreneurs high social status. These values are achieved by drawing attention to success stories that serve as motivation for others (Isenberg, 2011) and are disseminated by the key cultural players—mainly the media (Isenberg, Onyemah, 2016).

In the support dimension, Isenberg (2011) includes the services and infrastructures that support entrepreneurship, from legal, accounting, investment, or technical advice, to conferences and contests for entrepreneurial ideas or projects, including telecommunications, logistics and, of course, incubators and accelerators. As Mason, Brown (2014) note, entrepreneurial ecosystems are characterized by being rich in information and availability of knowledge and resources to be exploited. The figure of the "deal-maker" (Napier, Hansen, 2011) also emerges here, experienced professionals with vast relational capital that they put to the service of new companies. The key agents in this dimension are all professionals working in the aforementioned areas: lawyers, accountants, investment advisors, event organizers, incubators, accelerators, science parks, and so on.

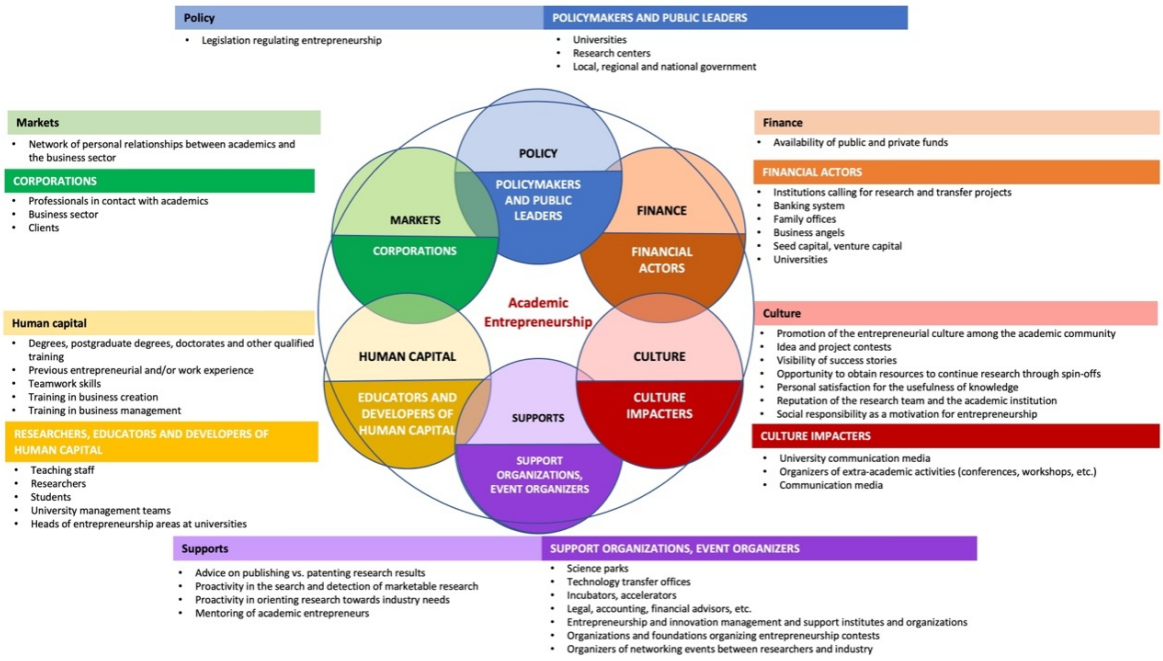
For the entrepreneurial ecosystem to do its job, it must have the necessary human capital to provide new companies with the workforce they need in sufficient numbers and with the appropriate qualifications. This dimension also includes the competencies of entrepreneurs, namely their ability to succeed thanks to their previous experiences and knowledge. The key players are closely related to the academia and are the teaching staff and management teams of educational institutions (Isenberg, Onyemah, 2016).

In the market dimension, companies and clients stand out as key agents. In a developed entrepreneurial ecosystem, consolidated companies are essential as natural allies of entrepreneurship, not only as its customers, but also because talent from both sides—corporations and start-ups—interacts and moves, feeding the success of the ecosystem (Isenberg, 2014; Mason and Brown, 2014).

1.3 Theoretical Proposal of the Entrepreneurial Ecosystem for Successful Academic Spin-offs

The factors identified from the literature review that determine the creation of academic spin-offs and those that help them to develop and become successful are incorporated into the model of Isenberg (2011) and Isenberg and Onyemah (2016), as shown in *Figure 2.* This model presents an initial proposal of the contents of each dimension of the entrepreneurial ecosystem for academic spin-offs, as well as its actors.

Figure 2. **Theoretical Proposal of the Entrepreneurial Ecosystem for the Creation and Success of Academic Spin-offs**



Source: created by the authors

2. Methods

The objective of this study is to identify what an entrepreneurial ecosystem that favors the creation and success of a greater number of academic spin-offs would look like. To this end, we carried out a multi-case study that allowed us to test the suitability of the entrepreneurial ecosystem shown in *Figure 2* and build on it, if necessary. According to Scuotto *et al.* (2020), qualitative methods allow a deep understanding of entrepreneurship as a systemic phenomenon, so they are particularly recommended to address the objectives set out in this research.

2.1 Case Selection

In Spain, according to the latest data published by the IUNE observatory (IUNE, 2019), during the period 2010–2019, 96.46% of academic spin-offs have their origin in public universities; we therefore focus on the cases linked to public universities.

Our initial focus is the Miguel Hernández University (UMH), which is the university in Spain with the most spin-offs created per 100 professors (0.95 for the period 2010–2019) (IUNE, 2019), despite being one of the smallest in the country and the smallest in the autonomous community in which it is located, with an average number of professors of 458.2 in the period 2010–2019.

To expand the number of cases to be analyzed, we turned to the spin-offs of two other public universities located in the same administrative region as the UMH and which, therefore, are subject to the same legislative and institutional framework. We selected cases of spin-offs from the University of Valencia (UV) and the Polytechnic University of Valencia (UPV). These are the two largest universities in the Valencian Community, and are among the 10 largest in Spain. The average number of professors at the UV and UPV during the period 2010–2019 was 2,181.1 and 1,823.0, respectively. However, the number of spin-offs created per 100 professors during the same period was 0.02 and 0.10, respectively (IUNE, 2019), far behind those of the UMH.

The heads of the science parks of the three universities put us in touch with a selection of spin-offs linked to their respective universities which, due to their characteristics, offer a high potential for learning (Stake, 1994). Some can be considered successful cases and others, failures, thus providing us with a heterogeneous composition of cases (Eisenhardt, 1989). Applying the criterion of theoretical saturation during the data analysis phase (Strauss, Corbin, 2015), the research is based on the analysis of 16 academic spin-offs, whose main characteristics are summarized in *Table 1*.

Table 1. **Basic characteristics of the cases analyzed**

Spin-off[a]	Foundation year	Sector	Number of employees	University of origin
SpO-01	2006	Agri-food/auxiliary industry	6	UV
SpO-02	2007	Information technology	6	UV
SpO-03	2014	Medical biotechnology	7	UV
SpO-04	2012	Medical technology	5	UPV
SpO-05	2019	Medical technology	1	UPV
SpO-06	2019	Industrial design	1	UPV
SpO-07	2013	Psychology	12	UMH
SpO-08	1999	Cosmetic biotechnology	12	UMH
SpO-09	2014	Medical biotechnology	2	UMH
SpO-10	2015	Medical biotechnology	11	UMH
SpO-11	2016	Medical biotechnology	5	UMH
SpO-12	2019	Medical biotechnology	3	UV
SpO-13	2013	Medical biotechnology	3	UMH
SpO-14	2004	Agri-food biotechnology	10	UMH
SpO-15	2013	Agri-food biotechnology	0	UMH
SpO-16	2011	Photonic technology	18	UPV

Notes: (a) To ensure the confidentiality of the participating companies, their names have been replaced by a code.

Source: created by the authors.

2.2 Data Collection

The information was obtained mainly through semi-structured interviews conducted in October and November 2020. The interviews had previously been reviewed by the head of the UV science park. In addition, we conducted a pilot interview, which allowed us to improve some of the questions raised without making significant changes, so this case is also included in the study.

The interviews lasted an average of ninety minutes and were conducted by videoconference, due to the restrictions in place resulting from the Covid-19 pandemic. Some of the interviews involved more than one member of the founding team of the same spin-off. Most of the interviewees were academics and some had created more than one spin-off.

All interviews were recorded, with the consent of the informants, and subsequently transcribed.

We also used secondary sources of information for each case, such as information published on their web page, economic-financial data from the SABI database, as well as press reports. The triangulation of information between the different sources used guarantees a high degree of consistency (Yin, 2003).

Following the methodological guidelines suggested by Yin (2003), to reinforce the reliability of the research we created a file for each case containing the recording and transcript of each interview, the evidence obtained from secondary sources of information, and the individual case report with a summary of the implications of the case with respect to the research question.

2.3 Data Analysis

Finally, through content analysis, each of the co-authors of this paper conducted her own analysis and interpretation of the information. Once the report was written, the interviewees had the opportunity to review it and make their own contributions. The triangulation of the analysis among researchers and with the interviewees also ensures a high degree of consistency (Yin, 2003).

3. Results and Discussion

Below we present the main barriers, challenges and facilitators faced by the spin-offs studied. From our analysis of these factors, we attempt to identify the elements that make up an entrepreneurial ecosystem favorable to spin-off creation and success.

Complexity of the academic entrepreneur's motivations

Entrepreneurial academics are first and foremost academics and therefore their motivation for entrepreneurship will be conditioned by the type of incentives associated with their professional career. According to many of the interviewees, the low entrepreneurial orientation among their colleagues is explained by their need to focus their efforts on publishing their research results as the means to advance their professional careers within their university or public research entity (SpO-1, SpO-04, SpO-05, SpO-6, SpO-12, SpO-13, SpO-16).

These results suggest the desirability of a change in the incentive system to favor the creation of a greater number of academic spin-offs, especially considering that academic excellence and entrepreneurship are compatible, since scientific productivity is a necessary precondition for entrepreneurship to exist (Clarysse *et al.*, 2011; Huyghe *et al.*, 2016a). Therefore, academic entrepreneurship requires ambidextrous universities and public research entities, that is, oriented both to the pursuit of excellence in research and to its commercialization (Chang *et al.*, 2009). Legislation that regulates academic entrepreneurship and that, in particular, provides an adequate arrangement of incentives can stimulate and motivate academics both to publish and to undertake entrepreneurship.

...Internally, the university makes it easier for faculty members to take the step, based on regulations that allow us to make our work compatible with being the administrator of the company and having a percentage of the capital [...] This is fantastic; it is one of the barriers that exist to entrepreneurship (SpO-09).

What motivates academics to be entrepreneurial, according to the cases studied, is to see that the knowledge their research generates is beneficial to society (SpO-07) or simply that it has a practical application and is useful, for example, in terms of treating diseases (SpO-08, SpO-09, SpO-10, SpO-12). Another reason valued positively by some academic entrepreneurs is that a spin-off can provide a professional opportunity for members of the research team who find it difficult to continue in the academic institution (SpO-2, SpO-08, SpO-09, SpO-10, SpO-16) or in some cases it is even seen as a form of self-employment (SpO-12).

The number of people with PhDs is increasing and there are fewer and fewer grants or projects to apply for, and there are no vacancies either. After 12 years doing basic research, I wanted to change and start doing other things. I saw the creation of the spin-off as a job opportunity (SpO-12)

Our results are compatible with those of previous studies that have also identified such motives as drivers of entrepreneurship among academics (e.g. Chiesa, Piccaluga, 2000; Morales-Gualdrón *et al.*, 2009). Additionally, in some cases (SpO-07) the informants considered the spin-off as a way of giving back to society in return for what society had done

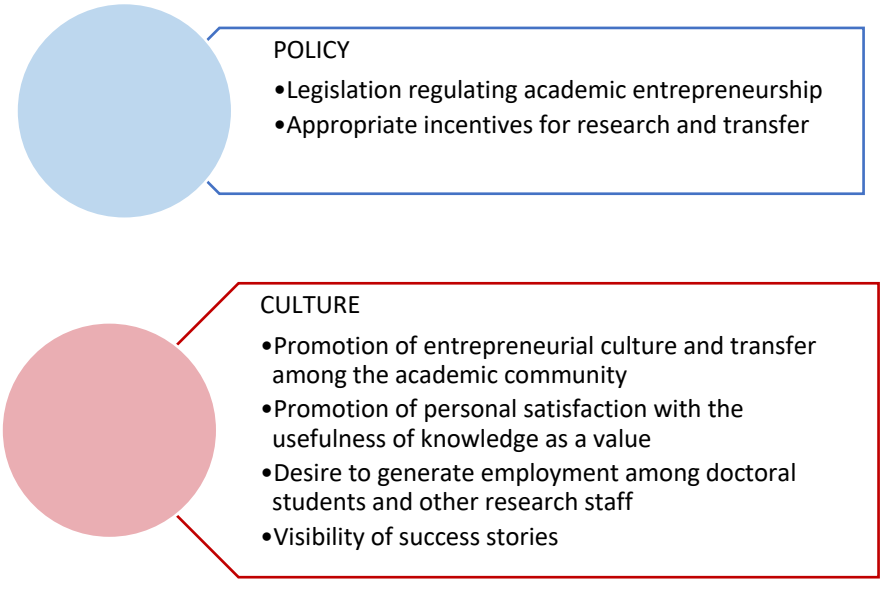
for researchers (in the form of scholarships and public aid to finance their studies, international training programs, etc.).

The motivation for turning our research into a business project is very intrinsic. We felt the need for our research achievements not to remain on paper; we wanted to give back to society what it had invested in us (SpO-07)

Motivations related to some form of contribution to society could be encouraged by actively promoting socially shared values as part of a local culture oriented toward entrepreneurship. In turn, universities and public research entities can also strengthen the entrepreneurial culture by highlighting 'role models'. In fact, several entrepreneurs also mention that they feel a certain 'duty' to appear as references or models, that the creation of spin-offs should be made visible to arouse interest and motivate professors and researchers, as well as to publicize what is being done at the business and technological level (SpO-07, SpO-08, SpO-09, SpO-10, SpO-16). The visibility of success stories motivates other academics to undertake entrepreneurial ventures and helps to shape an entrepreneurship-oriented culture (Huyghe, Knockaert, 2015). Having peer referents can persuade other academics that entrepreneurship is not only possible but also desirable (Audretsch *et al.*, 2000; Feldman *et al.*, 2001). In a university context, examples of success provide reassurance to those academics who want to imitate known cases, because the example of peers is a signal that academic entrepreneurship is accepted as a legitimate activity, which reduces concern about possible social repercussions (Stuart, Ding, 2006).

These findings suggest certain characteristics to be included in an entrepreneurial ecosystem favorable to academic spin-off success, as shown in *Figure 3*.

Figure 3. **Characteristics of an Academic Entrepreneurial Ecosystem According to the Motivations of the Entrepreneur**



Source: created by the authors.

The importance of market orientation

Teams that have founded academic spin-offs agree that the decision to take the leap from research to entrepreneurship hinges on having a product that meets market needs in an innovative way (SpO-02, SpO-12, SpO-08, SpO-09, SpO-10, SPO-13). However, we also found evidence that scientists often 'fall in love' with their research results and ignore, deliberately or unconsciously, whether their commercialization will actually be viable (SpO-09).

Scientists create a company with the dream that their results are the most perfect in the world (SpO-09)

Previous literature suggests that, on many occasions, academics focus their research on issues that lack business interest or simply have no practical applicability (Debackere *et al.*, 2005; Neves, Franco, 2016). Graduate and doctoral programs could therefore encourage research toward a practical market orientation, supporting the effectiveness of the incentives already mentioned.

Some entrepreneurial academics (SpO-02, SpO-03) acknowledged that they had been overly optimistic both in evaluating the attractiveness of their product to the market and in estimating the time to market. In order to continue operating successfully, others were forced to admit that their initial idea was not viable, and had to redefine the business, restructure the company and the team, and above all focus on the market (Sp0-02, SpO-08, SpO-09).

R&D [...] has to be driven by the market and the customer [...]. The route must be market–science–product (SpO-01)

However, in cases where the CEO was a professional manager, or a scientist with previous experience in entrepreneurship, the business idea hit the market target, the product was marketable, and good project management led to success (SpO-01, SpO-04, SpO-05, SpO-06, SpO-10, SpO-11, SpO-12, SpO-13, SpO16). These results suggest that a CEO with a background in business management and leadership brings the market perspective, less considered by many academic entrepreneurs when creating a spin-off. This finding corroborates those of Visintin, Pittino (2014), who state that one of the most important challenges for an academic spin-off is indeed the need to combine technological orientation with market orientation.

These results highlight that the absence of a commercial and economic viability analysis can have negative consequences for spin-off performance. Creating academic spin-offs driven by technology rather than by the market is risky (Druilhe, Garnsey, 2004). Therefore, academics should be advised on the appropriateness, or otherwise, of taking research results to the market through a spin-off.

In addition to the advice TTOs could provide on this issue (e.g., Siegel *et al.*, 2003; Phan, Siegel, 2006; Siegel, Wright, 2015), researchers should ideally have some training in entrepreneurship and business management, which could allow them to participate in identifying, evaluating and searching for opportunities, thus having a more active and informed role in the decision

to commercialize their findings through a spin-off (Duval-Couetil *et al.*, 2021). Some interviewees' conviction of the importance of such training led them to take a postgraduate course in entrepreneurship prior to creating the spin-off (SpO-03); others felt the need for such training after its creation (SpO-02); and others received this training as part of an entrepreneurship program or an ideas contest in which they participated (SpO-12).

On the other hand, some of the spin-offs analyzed have benefited from the existence of a business network able to take advantage of their innovations (SpO-2, SpO-6, SpO-15, SpO-16).

A large company in the area was interested in our research. As they provided infrastructure when they joined [...] we didn't have to look for machinery (SpO-15)

These results indicate that academic spin-offs need the companies in their environment to be able to absorb their technological advances.

We also observed that interaction with industry allows academics to modify their research lines in an attempt to adapt them to the needs of the local business environment.

Our original research was in the area of food from animal sources, but we are in an agricultural area, [...] so we are shifting direction toward the valorization of co-products from the agri-food industry (SpO-14)

As Mansfiel (1995) points out, incorporating the market perspective into academic research requires greater interaction with industry through collaborative actions such as contracted research, consulting agreements, and joint participation in research projects, among others. Moreover, such interaction can also give academics access to cutting-edge research being conducted by firms, so that the research groups they lead can focus and shape their own research agendas and better integrate them within the relevant R&D community (Debackere, Rappa, 1994; Van Looy *et al.*, 2004).

Researchers learn a lot from the research teams in large companies, who know a lot, a lot, a lot... although they don't publish because they're not in the same world; but they have the same level of knowledge. Scientists are being trained in that mindset (SpO-06)

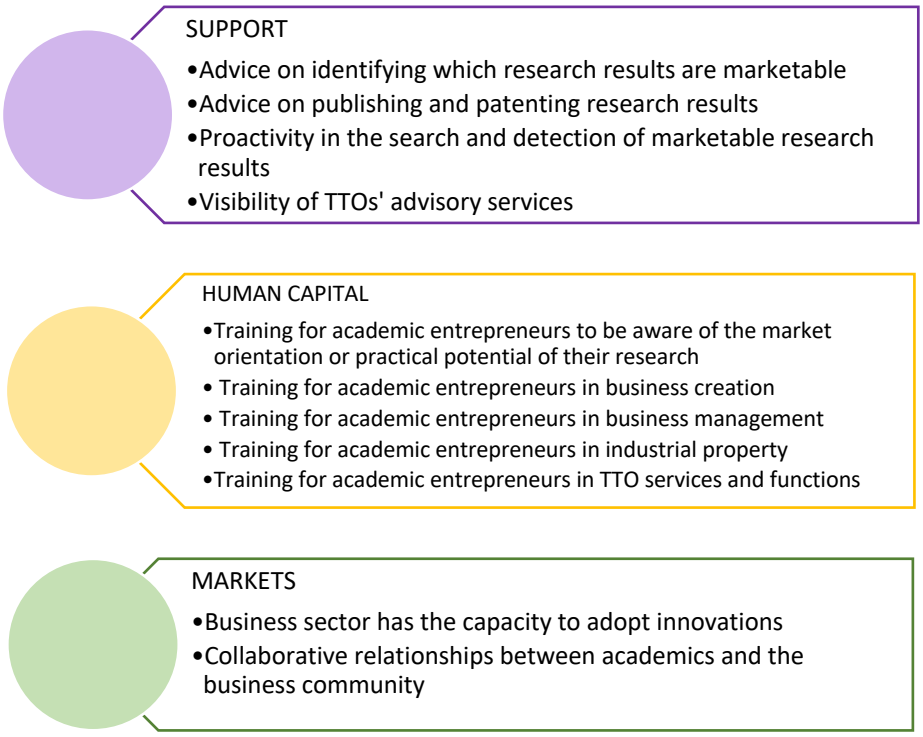
Another interviewee (SpO-01) highlighted the vast amount of knowledge generated by universities and public research entities that is never exploited.

[...] a lot of knowledge is just lying in cupboards, a lot of finished research that the university doesn't even know it has, and that, properly assessed and documented, could be offered to the business community; we don't even know the potential value of what we know we have, never mind what we don't even know we have (SpO-01)

Similarly, Kessels, Kwakman (2006) point out that, despite being made public in scientific journals, often this knowledge never reaches society, even when it contains a solution to real problems. TTOs should therefore be more proactive in the search for and detection of marketable research.

Lack of knowledge about industrial property regulations is another problem that can hinder market launch. In the case of SpO-13, the founder recounted a previous experience in which the research team published their results before obtaining patent ownership because they were unaware of the legislation; by doing so, they were unable to protect their findings and exploit them commercially. Training in industrial property could help researchers avoid this type of problem. Indeed, as Huyghe *et al.* (2016b) point out, researchers are sometimes unaware of the considerable support and advice available from TTOs, and some are even unaware of their existence. The TTOs' advisory services should therefore be promoted and made visible in order to encourage entrepreneurship among academics.

Figure 4. **Characteristics of an Academic Entrepreneurial Ecosystem According to the Need for Market Orientation**.



Source: created by the authors.

Lack of awareness about university transfer

Businesses are often unaware that they can enter into various types of transfer agreements with a university or public research entity (patent licenses, contracted research, consultancy, etc.), and even participate as partners in an academic spin-off, together with academics and the university itself, as in the cases of SpO-01 and SpO-13.

Fortunately, there are also exceptions. In the case of SpO-01, an entrepreneur looked at the technological options the university had for a solution to take advantage of a market opportunity and they jointly create a spin-off to apply the technology previously generated by the academic founder in a new field.

Similarly, in SpO-13, a non-academic entrepreneur with work experience in the management of biotechnology projects looked for a patent filed by Spanish universities to cover a need he had identified in the market.

Raising awareness in industry, and society in general, about the possibility of jointly creating a spin-off with academics, and even having the university as a partner, could be another way of encouraging more academic spin-offs. To this end, actions are needed to draw attention to the potential for collaboration between companies and universities and public research organizations and, especially, to the portfolio of technologies that they have to exploit. The two groups should also be encouraged to meet and interact together through actions promoted and facilitated by support organizations such as TTOs, incubators, accelerators, and science parks (e.g., Siegel *et al.*, 2003; Becheikh *et al.*, 2010; Simith, Bagchi-Sen, 2012).

Our interviewees also emphasized the important role of science parks in facilitating the visibility, relationship and contacts between spin-offs and the agents located in them (SpO-01).

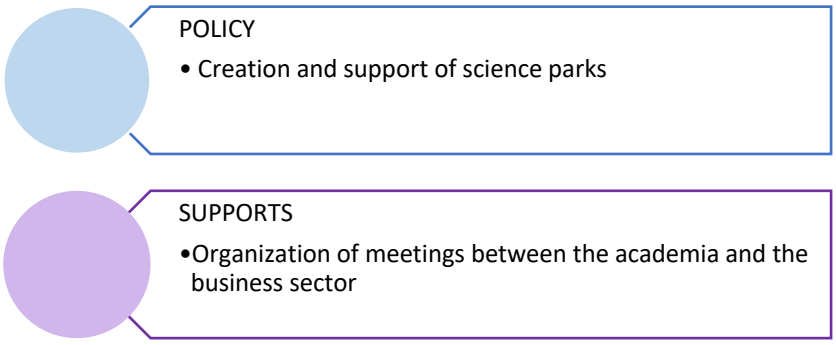
The science park in the entrepreneurial ecosystem plays a good role in terms of relationships. As for improvements, we could do with a direct channel to strengthen networking within the park (SpO-01)

Science parks play a critical role in the initial promotion of academic spin-offs since they facilitate the relationship with other entrepreneurs, expert advisors, potential clients, as well as investors (Rodeiro-Pazos *et al.*, 2008); they also provide other services such as entrepreneurship training, or specialized advisors in areas such as finance, among others (Rodeiro-Pazos, Calvo-Babio, 2012).

The science park gives you the most support, not only with space; you can approach the science park with an idea and you have people who help you transform it into a business plan, and provide you with all the necessary tools to generate a company realistically (SpO-10)

Therefore, an entrepreneurial ecosystem that supports the creation and success of academic spin-offs by actively publicizing transfer from universities should include the elements shown in *Figure 5*.

Figure 5. **Characteristics of an Academic Entrepreneurial Ecosystem that Actively Publicizes Transfer from Universities**



Source: created by the authors.

The value of awards and contests

Most of the interviewees recognize the importance of participating in entrepreneurship or idea competitions, calls for proposals to support entrepreneurship in general, and attending events specialized in their sector. In particular, they highlight the importance of contests that include, in addition to the prize money, some type of training or mentoring (SpO-03, SpO-07, SpO-12, SpO-13), since both are necessary at the beginning. This training or mentoring goes some way to remedying the lack of advice that many academics have pointed out.

We were selected by the Foundation for Innovation and Prospective Healthcare (FIPSE) to receive a six-month mentorship at the Massachusetts Institute of Technology (MIT) with experts in the American healthcare sector. The American experience was very valuable in terms of learning (SpO-03)

Likewise, these programs require participants to prepare a business plan, which helps them to evaluate what stage the project has reached and to identify the needs they will have during its life (SpO-15).

Furthermore, participation in these competitions makes the spin-off visible (SpO-13), allows founders to present the project to investors (SpO-12) and even, on occasions, to complete the financing from the cash prize included in some calls for proposals (SpO-03, SpO-07, SpO-13).

… we won a prize ... of 25,000 euros and a mentoring program, which allowed us to meet people in the ecosystem and raised awareness of the company (SpO-12)

These results are consistent with those of Parente *et al.* (2015), who also find that competitions raise the profile of the winning projects in particular and give them legitimacy in the eyes of stakeholders such as investors.

Additionally, contests have also allowed founders to interact with researcher-entrepreneurs from other universities (SpO-12, SpO-13), and with other companies in the ecosystem (SpO-13), thus facilitating networking. This networking is highly valued by the entrepreneurs, as it allows them to share experiences and identify solutions to shared problems.

… from the beginning, we relied heavily on the Caixa program, which helped us make contact with many companies in the sector. (SpO-13)

Based on these results, we suggest that in order to optimize the positive role of awards and competitions in the creation and success of academic spin-offs, the elements shown in *Figure 6* should be present in the entrepreneurial ecosystem.

Figure 6. **Characteristics of an Academic Entrepreneurial Ecosystem to Leverage the Value of Awards and Contests**

Source: created by the authors.

Need for support and advice

The demand for more advice is very common among scientific partners (SpO-02, SpO-07, SpO-08, SpO-09, SpO-12). Many feel that they would have benefited from a prior evaluation of their idea to identify the target market, market size, define the business model and so on, similarly to what investors would later demand of them, but in this case before deciding to create the spin-off.

… technically, we were failing and with the help of two entrepreneur friends, we redesigned the business plan, [which was] totally unfocused and out of touch with reality [...] and the company started to do well. (SpO-8)

Even basic questions about the normal operations of a company become a challenge for those who have never carried them out (opening a bank account in the name of the company, knowing the procedures for registering the company in the social security system, etc.) (SpO-12). While these academics are obviously great scientists, this does not mean that they are comfortable with the administrative processes involved in creating a company.

… Someone should provide the advice that we didn't have at the beginning. It doesn't necessarily have to be something the university does. The fact is that someone should guide you through the process (SpO-12)

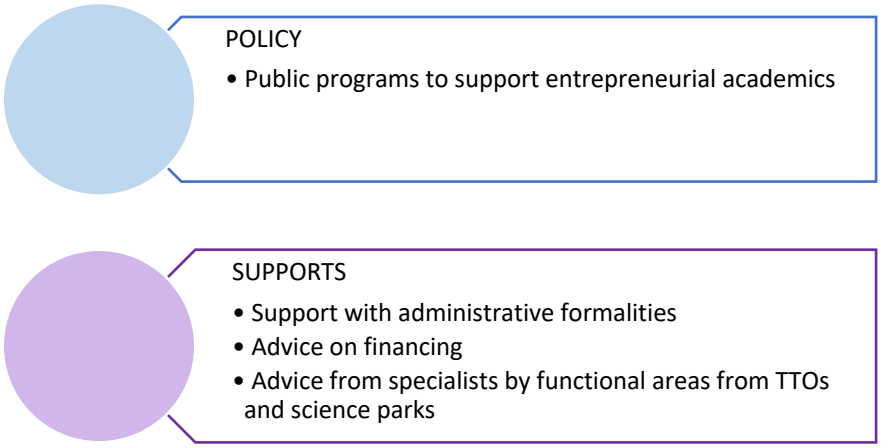
Some of the cases in which all members of the founding team are academics faced a further obstacle: knowing what sources of funding are available, which one is the most appropriate at any given time, how to plan the resource needs of their project over time (SpO-02, SpO-12), how to present the project to potential investors, and how to contact them (SpO-12). In some cases, external advice was sought to fill these and other knowledge gaps in business management. Cases SpO-02 and SpO-03 were obliged to hire industrial property advisory services, and consultants to prepare their business plan and elevator pitch.

Previous literature suggests that TTOs can play an important role in providing advice and support on all these issues, either through direct technical assistance when they have the staff with the necessary skills (Lockett *et al.*, 2003; Clarysse *et al.*, 2005; Lockett, Wright, 2005), or by facilitating contact with experienced managers or entrepreneurs who can provide such specialized advice (Mosey, Wright, 2007), or by referring researchers to local or regional public agencies that can provide it. According to Rodeiro-Pazos, Calvo-Babio (2012), some science parks can also provide such advice.

Therefore, even though as they evolve spin-offs will naturally incorporate professionals into their management structure when needed, it would be beneficial to have the support of public programs to guide entrepreneurship, advice from TTOs and/or science parks on the administrative procedures involved in creating the company, and advice from specialists in the company's different functional areas, and in particular, in the area of finance.

Figure 7 shows the elements that an entrepreneurial ecosystem favoring academic spin-offs should have to guarantee the availability of support and advice for researchers who decide to become entrepreneurs.

Figure 7. **Characteristics of an Academic Entrepreneurial Ecosystem that Offers Support and Advice to Academic Researchers**



Source: created by the authors

Professionalism in research and in management

Academic spin-offs are idiosyncratic in that they have their origins in research results. The research prestige of the team members can therefore be leveraged as a key variable to boost the new company's reputation in the eyes of potential investors, strategic partners, and other agents.

In the case of SpO-12, an internationally recognized researcher with extensive experience in the sector joined the board of directors as an independent director. This director has facilitated contact and relations with other companies in the sector. Similarly, in SpO-13, the academic founder's international reputation as a researcher also facilitated interaction with investors.

Thus, as Mustar *et al.* (2008) argue, an academic spin-off's ability to attract investors depends on the credibility and prestige of the research group behind it, as well as on its ability to integrate the members of the group into its workforce, as a means of maintaining this prestige. These findings prompt us to reflect on how important it is for universities and public research organizations to value and draw attention to the scientific achievements of their researchers, so their reputation and prestige go beyond the academic sphere and attract the attention of investors and other strategic partners. Therefore, guiding researchers' efforts toward the pursuit of scientific prestige should form part of a culture that aims to favor the creation and success of academic spin-offs.

With regard to the professionalization of company management, we observed three configurations in the founding teams of the academic spin-offs analyzed:

(a) Teams initially formed only by academics (SpO-02, SpO-03, SpO-07, SpO-12, SpO-14, SpO-15, SpO-16). Practically from the beginning, these teams remark on the complexity of managing a company. In some cases, they define their learning in this area as "trial and error" and illustrate that scientists can also learn to be managers, although they admit that it involved a huge effort:

I'm a telecommunications engineer [...] I've learned how to manage this through sweat and tears (SpO-02)

(b) Teams that combined members with academic and business profiles from the outset (SpO-04, SpO-05, SpO-6, SpO-08, SpO-09, SpO-10, SpO-11). A clear example of this type of team is the case of SpO-08, whose academic founder explains:

The first time, taking the decision to start a business is complicated, but also if you're a scientist and you want to take on the management of the company, you need a lot of time and you don't do it well, because you don't know how [...] you have to look for the best managers, get them involved, support them 100% and delegate (SPO-08)

(c) Businesspeople with an entrepreneurial vocation who look to science for a business idea in which to invest (SpO-13), or who have a specific concern, seek an answer in science (SpO-01) and incorporate researchers into their business project.

Teams made up exclusively of academics quickly detect shortcomings and lack of skills, especially in the areas of finance and marketing. In some cases, they soon incorporate a new partner with training and experience in business management who also assumes the role of CEO. In the case of SpO-07, managers at the science park of the spin-off founders' university provided the initial contact with someone with the potential to take on this role. In other cases (SpO-12) professionalizing management is a condition the investors impose to get to the next round of funding. In the cases where the founding team also includes members with management profiles, the academic founders prefer to focus on technology and delegate management to an experienced partner.

…all this business management part really bores them... but if you take it away, they are delighted… (SpO-04)

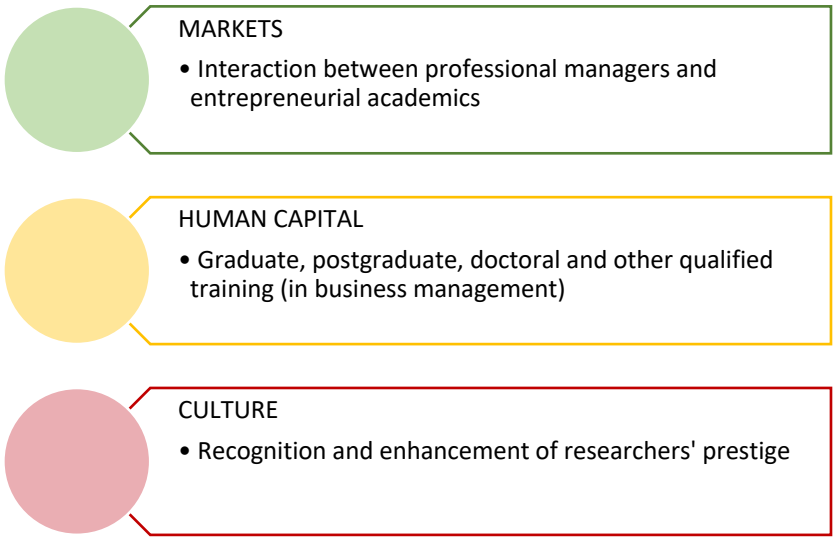
According to Vohora *et al.* (2004), when the academic founders of a spin-off lack the appropriate skills themselves, they should entrust its management to people who do have managerial skills, whether or not they are business partners. Indeed, in all the cases studied, an appropriate combination of technical and business skills among those who will assume managerial functions was identified as a key factor, both for the initial impulse required by an academic spin-off and for its survival and success. These results suggest that the cognitive diversity of the teams formed by academics who control the technological side and by professionals who provide the managerial skills, favors the performance of academic spin-offs.

Therefore, initiatives should be in place to facilitate contact between academic entrepreneurs on the one hand, and potential partners and/or employees with management skills on the other. In addition, the market must be able to supply professionals trained in business administration and management who can join the founding and/or management teams of academic spin-offs, as well as the complementary training in these areas that, as mentioned above, is recommended for academic entrepreneurs qualified in other disciplines.

Our results are compatible with those of previous studies that find academic spin-offs founded and/or managed by both academics and non-academics perform better than those founded and/or managed only by academics (e. g., Lundqvist, 2014; Visintin, Pittino, 2014). Hambrick, Mason (1984) argue that the diversity of experiences, knowledge and approaches among the members of the founding and/or management team leads to better decisions, which in turn explains their superior performance. The poorer performance of academic (compared to non-academic) spin-offs has been explained by the high levels of R&D expertise in their founding teams, which in many cases have no commercial experience (Ensley, Hmieleski, 2005).

Figure 8 shows the elements an entrepreneurial ecosystem favoring academic spin-offs should have in order to ensure that these companies have professionals with the appropriate competencies both in their workforce and in the management of the company.

Figure 8. **Characteristics of an Academic Entrepreneurial Ecosystem to Ensure Professionalization in Research and in Management**



Source: created by the authors.

The financing challenge

In general, the great challenge for the spin-offs analyzed lay in obtaining the necessary financing, both in quantity and at the right time, until they started to see a return on their investment.

Only a few of the cases analyzed had any revenue at the time of their creation (SpO-02, SpO-03, SpO-16); however, all the informants reported that they had accessed public funding at some point, through grants, loans on favorable terms, or other forms. Huggins (2008) and De Cleyn, Braet (2009) argue that public funding is an important support for the creation and success of academic spin-offs. In particular, informants mentioned the importance of support to hire PhDs and other research personnel (SpO-03), which also implies that the ecosystem must have qualified personnel in a range of scientific disciplines.

However, in some cases, the conditions of the support programs were mismatched with the peculiarities of the spin-off or the sector in which it operates. For example, the non-academic founders in cases SpO-04, SpO-05 and SpO-6 explained that they were not entitled to support from a certain public program because they did not meet the condition that the company hold 50% of the funds requested at the time of application. This condition is difficult to meet, considering that some companies experience periods of negative net cash flows, given the investment in materials, rentals, supplies, certifications, tests and so on involved in developing the technology, before the project generates any income.

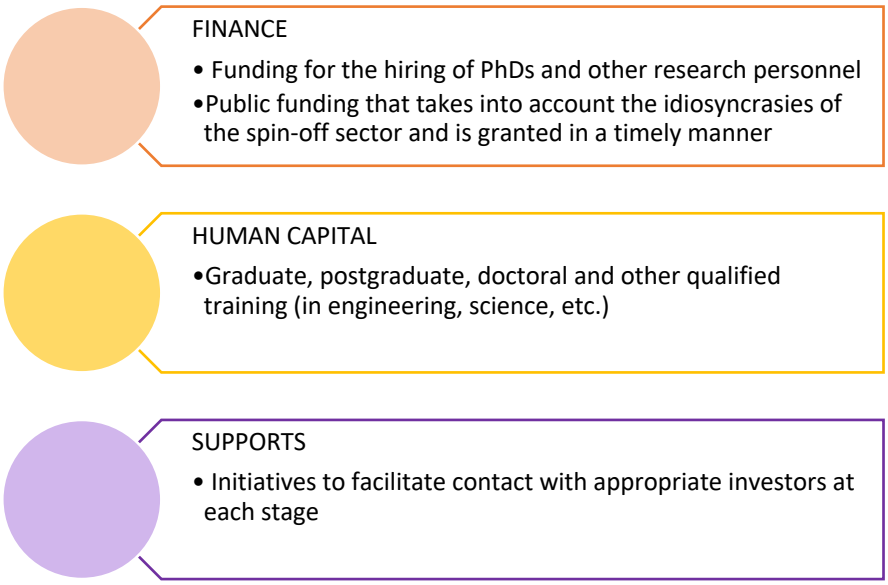
In other cases (SpO-01, SpO-03) the public financing programs were well suited to their particular needs, but the time between the subsidy's approval and receiving the money is also a drawback (SpO-16, SpO-12). Another common problem associated with public funding is that the capital granted is transferred once payments have been justified, but if the spin-off does not have the capital to make the initial payments, these schemes are of no use to them.

Financing follows very different patterns depending on the sector. Because they face long product development processes resulting in high-risk activities, spin-offs in the biotechnology and pharmaceutical industry (SpO-03, SpO-08, SpO-09, SpO-10, SpO-11, SpO-12, SpO-13) require large amounts of long-term investment, which is sometimes not available locally or nationally. This situation forces them to seek US or Asian venture capital funds if they want to compete globally. Another problem detected was that, at a certain stage, the investment required was too large for some of the local funds but at the same time, too small for the international funds (SpO-03).

These results reveal the need for initiatives that facilitate contact between academic spin-offs and the right investors at each stage of their development.

The characteristics of an entrepreneurial ecosystem favoring academic spin-offs to ensure that these companies have the necessary funding for their creation and growth are shown in Figure 9.

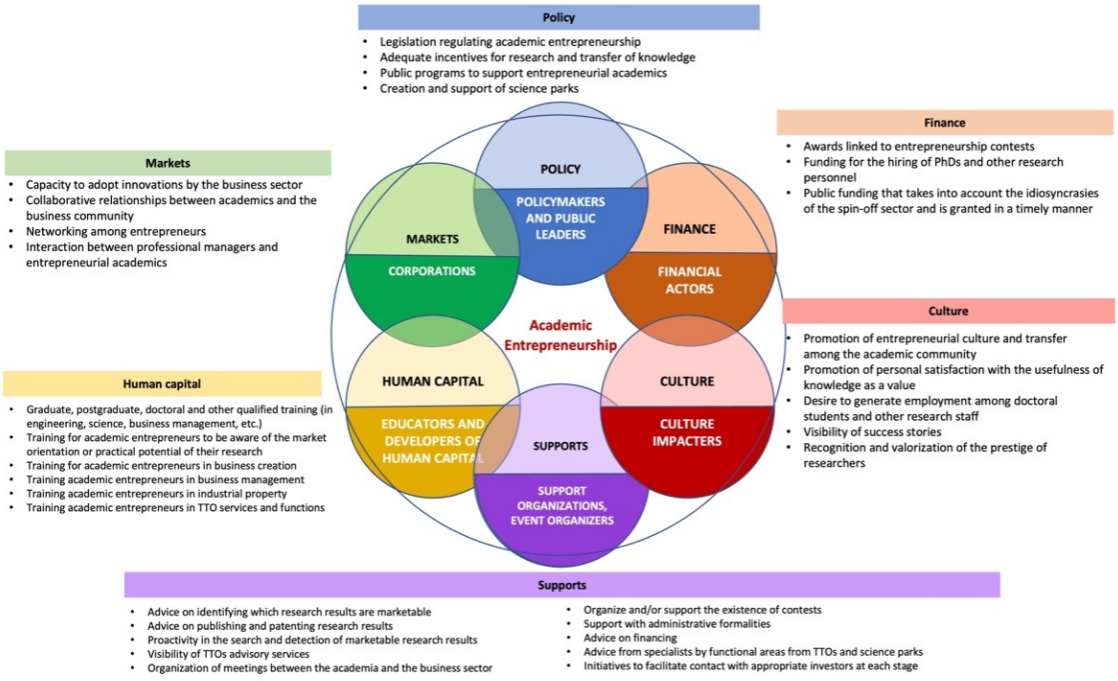
Figure 9. **Characteristics of an Academic Entrepreneurial Ecosystem that Facilitates Financing**



Source: created by the authors.

Our analysis of the interviews has identified the most relevant contents of the dimensions, as well as their agents, to consolidate an entrepreneurial ecosystem that supports both the creation and development of academic spin-offs, as shown in *Figure 10*.

Figure 10. **Empirical Proposal of the Entrepreneurial Ecosystem for the Creation and Success of Academic Spin-offs**



Source: created by the authors.

Finally, and importantly, it is not always a simple matter to associate the evidence with a specific dimension. Thus, the idea follows that the elements of each dimension are interrelated and, in line with the theoretical approach of the ecosystem as a set of elements that is balanced on the basis of their complex relationships, this research shows that interactions exist between elements of the same dimension, as well as between those of different dimensions, which contribute to the balance and reinforcement of the ecosystem's components.

Some of these interactions are summarized in *Table 2*, although this is not an exhaustive list.

Table 2. **Interactions between the dimensions of the academic spin-off entrepreneurial ecosystem**

	P	F	C	S	HC	M
Policies that support both research and transfer (policy) favor an entrepreneurial culture (culture), as well as the orientation of research to the market and the needs of industry (support).	X		X	X		
Policies that support the creation of educational institutions and curricula in all areas (policy) contribute to the availability of graduates with the necessary technical and managerial competencies (human capital).	X				X	
Policies that support R&D activities (policy) provide funding for research that can be commercialized, as well as for the hiring of PhDs by academic spin-offs (finance).	X	X				
Policies to create and support science parks (policy) provide academic entrepreneurs with facilities and services at a reduced cost (finance), as well as access to other support services (support) such as advice, training (human capital), contact and networking between entrepreneurs (markets), companies (markets), and investors (support).	X	X		X	X	X
The organization of idea or entrepreneurship competitions (support) helps to reinforce the culture of entrepreneurship (culture). If they involve cash prizes, they supplement financing (finance) and if they involve training and/or mentoring programs, they improve the qualification of the founding team (human capital). They facilitate networking among entrepreneurs and/or with companies (markets) and even contact with investors (finance).		X	X	X	X	X
The visibility of success stories reinforces the entrepreneurial culture (culture) and makes industry aware of the possibility of establishing collaboration agreements with universities and public research centers (markets), which in turn motivate academics to participate in these agreements and reorient their research to the market and the needs of industry (support), thus feeding back into the entrepreneurial culture (culture).			X	X		X
Researcher prestige (culture) helps to attract investors (finance).		X	X			
Providing resources to TTOs (policy) allows them to offer advice (support) and to be proactive in making industry aware of opportunities to collaborate with academia (markets).	X			X		X
Highly qualified personnel (human capital) can be recruited with support for PhDs (finance) from public programs (policy).	X	X			X	

Legend: P=Policy; F= Finance; C=Culture; S=Support; HC= Human Capital; and M=Markets

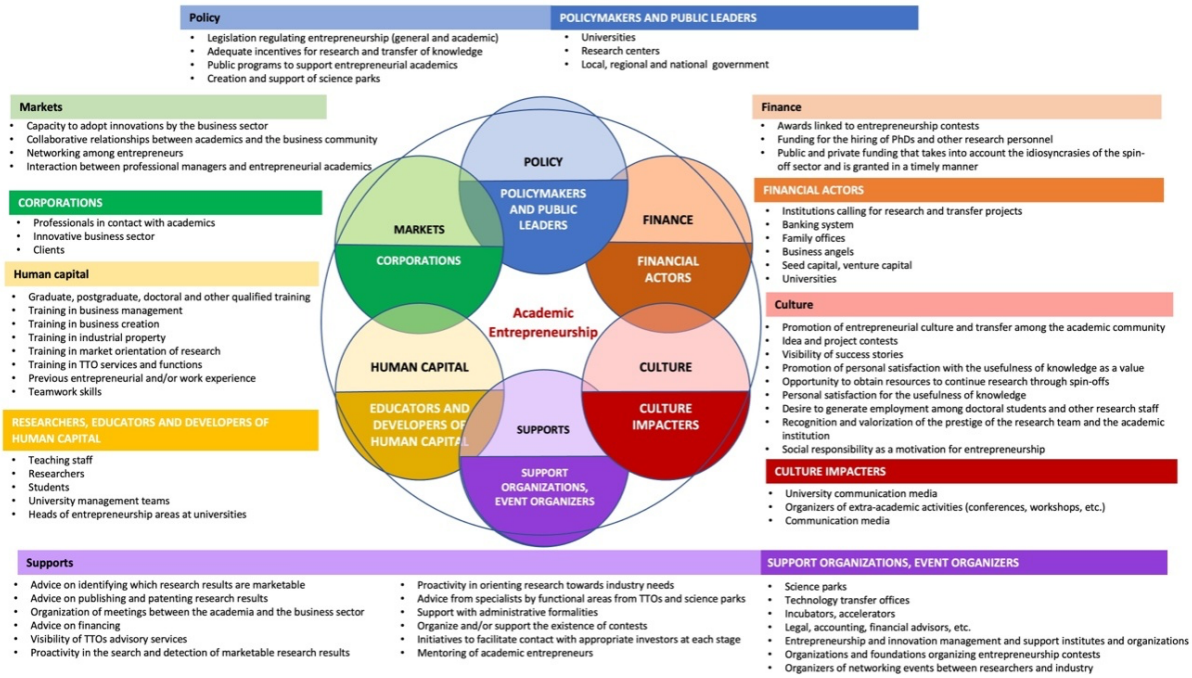
Source: created by the authors.

4. Proposal for an Entrepreneurial Ecosystem for Academic Spin-offs

If we compare *Figure 10* with *Figure 2*, resulting from the theoretical review on the determinants for the creation and success of academic spin-offs, our empirical analysis substantially confirms the content of the proposed entrepreneurial ecosystem and expands it with some elements that give greater consistency to its dimensions.

The model resulting from the theoretical review (*Figure 2*) is combined with the findings of this empirical research (*Figure 10*) to yield the entrepreneurial ecosystem favorable to academic spin-offs as shown in *Figure 11*.

Figure 11. **Entrepreneurial Ecosystem for the Creation and Success of Academic Spin-offs**



Source: created by the authors.

In what follows we describe each dimension and its key actors.

Policy: policymakers and public leaders

In an ecosystem favorable to academic spin-off creation and success, the policy dimension encompasses the development of regulations governing entrepreneurship –both in the general and academic sense– and public policies that encourage research and transfer from universities and public research entities. It also ensures there are public programs to support academic entrepreneurs and backs the creation and support of science parks.

The agents responsible for ensuring that the policy dimension contains these elements are universities, public research entities, and governments, especially at the local and national levels.

Finance: Financial actors

The finance dimension is related to obtaining the necessary capital to undertake the project in each of its stages, and comprises the funds from public or private calls, some of them specifically aimed at hiring research and doctoral staff, and cash prizes.

In addition to the usual investors (banks, family offices, business angels, venture capital funds, etc.) the financial actors are all the entities that organize competitions and offer grants for research and transfer projects.

Culture: Culture impactors

The culture dimension of the entrepreneurial ecosystem favorable to academic spin-off creation and growth is based on the need to foster a culture of entrepreneurship and knowledge transfer in the academic community, and should be complemented by contests and actions designed to publicize success stories and highlight the values that support entrepreneurship among researchers, such as personal satisfaction, social responsibility, reputation, and the generation of jobs for the research team.

The actors responsible for achieving this culture dimension are the universities' communication services and entities that organize extra-academic activities, with the media also playing an outstanding role.

Supports: Support organizations, event organizers

The support dimension should offer advice on when to publish and when to patent research results, help identify marketable research, and orient research toward the needs of industry. This dimension includes actions such as setting up meetings between the academic community and the business sector, organizing entrepreneurship competitions, helping with administrative procedures, providing specialist advice in each of the functional areas, particularly in financing, as well as facilitating contact with potential investors. Actions drawing attention to TTOs' mentoring and advisory services should also be considered in this dimension.

Science parks and TTOs have a long tradition of acting as support agents, but their work can be complemented by institutes and organizations that manage and support entrepreneurship, as well as by bodies that organize competitions and events to facilitate networking between the business community and researchers.

Human capital: Researchers, educators, and developers of human capital

In an entrepreneurial ecosystem favorable to academic spin-offs, the human capital dimension must ensure an extensive educational offer at all levels, to guarantee the availability of both a technically and an entrepreneurially qualified workforce. In particular, academic entrepreneurs themselves need basic training in business management, business creation and industrial property, as well as knowledge to orient their research to the market and information about the services and functions available to them through TTOs. The theoretical review completes this picture with the importance of previous work experience and the ability to work in teams of academic spin-off members.

The actors responsible for generating this dimension of the ecosystem are, of course, university agents: teaching staff, researchers, management, students and those in charge of entrepreneurship areas.

Markets: Corporations

The market dimension encompasses all aspects associated with the business environment in which the spin-off develops its activity. The creation and success of these companies requires the support of a business network in which to establish initiatives from companies that, as academic spin-offs, enjoy the differential advantage of innovation. Likewise, academic entrepreneurs need to maintain and formalize relationships with this business network, as well as networking relationships with other entrepreneurs. This dimension could also favor interaction between business management professionals and academic entrepreneurs.

The actors in this markets dimension are professionals of all kinds who wish to maintain contact with academics, as well as a business network able to take advantage of the innovations made by academic spin-offs.

Conclusions

One way universities and public research entities fulfill their mission to transfer the knowledge they generate to society is by creating spin-offs. The potential benefits of academic spin-offs for regional, social, technological, and economic progress have been the focus of much research that has identified the factors behind their creation and success. However, to date, the role of the entrepreneurial ecosystem in which they emerge has attracted limited research attention.

Through a multi-case analysis, we have identified elements and actors that should be present in an entrepreneurial ecosystem helping academic spin-offs overcome the challenges they face, favoring their creation and, especially, their performance. We also provide evidence of the complex web of interactions between the elements that make up this ecosystem.

Nevertheless, our proposal does not ignore the self-sufficient and self-regulating nature of each entrepreneurial ecosystem. As Isenberg (2014, 2016) states, relying on an external influence in the ecosystem is tantamount to putting its equilibrium in jeopardy. Any action on the entrepreneurial ecosystem should consider its systemic nature and, therefore, take into account that trying to improve one of its dimensions may be ineffective if its interrelation with other dimensions or between elements of the same dimension is ignored. In this sense, focusing efforts exclusively on policies to support the creation of infrastructure for the incubation and support of academic spin-offs, such as science parks and TTOs, for example, may be ineffective if they are not accompanied by other policies that establish a career path for researchers in universities and public research entities that values both their research and their entrepreneurial achievements.

The academic contribution of this research lies in the special nature of the ‘ideal’ entrepreneurial ecosystem of academic spin-offs, as opposed to that of general entrepreneurship. While maintaining the dimensions of a ‘conventional’ entrepreneurial

ecosystem, in the academic entrepreneurial ecosystem the emphasis is placed on policies and incentives for research and transfer, on the importance of a culture that values them, and on the existence of highly qualified human capital, in addition to the necessary adjustment of the dimensions of markets, support and finance to these companies. As for the specificity of the support dimension, our results point to the importance of TTOs in guaranteeing, prior to creating the spin-off, the correct definition and protection of intellectual property. Subsequently, TTOs and science parks, together with other support infrastructures, provide assistance in launching the activity. With regard to the financial dimension, public funds are needed in the ecosystem to hire highly qualified personnel, such as PhDs and other researchers, to advance research, and to generate innovations from universities and public research entities. Cooperation between researchers and companies under different types of agreements is another necessary and specific element of the academic spin-off ecosystem.

This study is not free of limitations. First, our research focuses on academic spin-offs arising from universities located in a specific geographic context; this context should be expanded in future studies. Second, the information obtained comes mainly from the founders of the spin-offs analyzed. Given the systemic nature of entrepreneurial ecosystems, future studies could enrich their results by considering the perspective of other stakeholders such as, for example, public policy makers, science parks, TTOs, and investors. Future lines of research could also advance in the measurement of each of the dimensions, and propose systemic actions to improve the entrepreneurial ecosystem for academic spin-offs.

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