

**UNIVERSIDAD COMPLUTENSE DE MADRID**  
FACULTAD DE CIENCIAS DE LA DOCUMENTACIÓN



**TESIS DOCTORAL**

**LA CAPACIDAD DE ABSORCIÓN Y APROPIACIÓN DEL CONOCIMIENTO.  
DISEÑO DE UN MÉTODO DE MEDICIÓN PARA EL ANÁLISIS  
COMPARATIVO ENTRE PAÍSES: UN ESTUDIO DE CASO EN COLOMBIA**

MEMORIA PARA OPTAR AL GRADO DE DOCTOR  
PRESENTADA POR

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LA CAPACIDAD DE ABSORCIÓN Y APROPIACIÓN DEL CONOCIMIENTO.  
DISEÑO DE UN MÉTODO DE MEDICIÓN PARA EL ANÁLISIS COMPARATIVO  
ENTRE PAÍSES: UN ESTUDIO DE CASO EN COLOMBIA

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## **Resumen**

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La tesis que se presenta en “formato publicaciones” (Real Decreto 99/2011, de 28 de enero (BOE 10/02/2011) ) es el resultado de una investigación profunda sobre la relación entre dos elementos clave para la generación de innovación: la capacidad de absorción y la apropiación del conocimiento. Los resultados de esta investigación se desarrollaron en tres artículos científicos publicados en revistas de alto impacto.

La capacidad de absorción es fundamental para la generación de innovaciones, ya que permite a las empresas y organizaciones asimilar y procesar nuevo conocimiento para su posterior aplicación en el desarrollo de nuevos productos y servicios. Por su parte, la apropiación del conocimiento es esencial para recuperar la inversión realizada en el desarrollo de las innovaciones y generar valor a partir de ellas, así como para crear exclusividad en el mercado. El objetivo final de esta tesis fue desarrollar un método de medición de estos conceptos en conjunto a nivel país.

Para llegar a este objetivo, en primer lugar, se llevó a cabo un estudio bibliométrico de textos completos en las bases de datos de artículos científicos Scopus, Science Direct y Lens, en el que se examinaron tanto la literatura sobre la capacidad de absorción como la de apropiación del conocimiento. El principal objetivo de este estudio fue analizar las similitudes y diferencias entre ambos campos y el análisis de sus interrelaciones (Cuéllar et al., 2022).

Asimismo, se llevó a cabo un análisis de convergencia entre los dos temas para identificar los elementos de mayor relación y su relevancia en cada uno de estos campos. Para ello, se utilizaron datos bibliográficos provenientes de Web of Science y Scopus (Cuellar et al., 2023a).

A partir de toda la información obtenida en el artículo 1 y el artículo 2, se diseñó un método para medir la capacidad de absorción y la apropiación en los países.

La metodología fue diseñada fundamentándose en elementos convergentes, tales como las patentes, la investigación y desarrollo, la transferencia de conocimiento y la innovación. Dicha metodología permite analizar los flujos de conocimiento entre artículos fundamentales, en este caso la producción científica colombiana, y los artículos citados por esta literatura, así como las patentes que hacen referencia a dichos trabajos científicos. La metodología implementada permite estimar el nivel de apropiación local del conocimiento, así como las fugas de conocimiento a nivel nacional e internacional, y determinar qué tipo de organizaciones explotan dicho conocimiento. Adicionalmente, facilita la comprensión de los procesos de adquisición, asimilación, transformación y explotación del conocimiento y su efecto en la generación de beneficios de la innovación, en un tema trascendental como lo es la transformación de la ciencia en prototipos y tecnologías que generen impacto (Cuéllar et al., 2023b).

Las principales implicaciones de esta investigación radican en la generación de política pública, pues evidencia los aspectos que deben reforzarse para generar un mayor número de innovaciones que potencien la competitividad. La herramienta presentada brinda a gobiernos, profesionales y académicos la capacidad de medir la absorción y apropiación del conocimiento, dos elementos cruciales en la competitividad de los países. Además, dicha herramienta es aplicable en cualquier tipo de país, lo que la vuelve versátil.

Por otra parte, se desarrolló una metodología para medir la convergencia entre campos, la cual puede ser aplicada a otros casos de estudio. Este aporte resulta valioso para bibliotecólogos y expertos en estudios bibliométricos.

## **Resumen en ingles**

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The thesis presented “Thesis based on publications” ((Real Decreto 99/2011, de 28 de enero (BOE 10/02/2011) ) is the result of an in-depth investigation into the relationship between two key elements in innovation performance: absorptive capacity and appropriation. The outcomes of this research were developed into three scientific articles published in high-impact journals.

Absorptive capacity is fundamental for generating innovations, as it enables companies and organizations to assimilate and process new knowledge for subsequent application in the development of new products and services. On the other hand, knowledge appropriation is essential for recovering the investment made in the development of innovations, generating value from them, and creating exclusivity in the market. The ultimate goal of this thesis was to develop a method for measuring these concepts at the country level.

To achieve this goal, a bibliometric study of full-text articles in Scopus, Science Direct, and Lens was conducted, examining both the literature on absorptive capacity and knowledge appropriation. For this purpose, a comparative analysis of the similarities and differences between both terms was carried out, and their interrelationships were studied (Cuéllar et al., 2022).

Furthermore, a convergence analysis between the two topics was conducted to identify the binding elements and their relevance, using bibliographic data from Web of Science and Scopus (Cuéllar et al., 2023a).

Based on the collected information, a method was designed to measure absorptive capacity and appropriation in countries. The methodology was grounded in convergent elements, such

as patents, research and development, knowledge transfer, and innovation. This methodology enables the analysis of knowledge flows between fundamental articles, in this case, Colombian scientific production, and the articles cited by this essential literature, as well as the patents referring to these scientific works. The implemented methodology allowed for estimating the local appropriation level of knowledge, as well as knowledge leakages at the national and international level, and determining which type of organizations exploit this knowledge.

Additionally, it facilitates understanding of the processes of acquisition, assimilation, transformation, and exploitation of knowledge and its effect on generating innovation benefits, on a crucial issue such as the transformation of science into prototypes and technologies that generate impact (Cuéllar et al., 2023b).

The main implications of this research lie in public policy, as they demonstrate which aspects need to be reinforced to generate a greater number of innovations that enhance competitiveness. The tool presented provides governments, professionals, and academics with the ability to measure absorptive capacity and knowledge appropriation, two crucial elements in countries' competitiveness. Moreover, this tool is applicable to any type of country, making it versatile.

On the other hand, a methodology for measuring convergence between fields was developed, which can be applied to other case studies. This contribution is valuable for librarians and experts in bibliometric studies.

## **PARTE I. FUNDAMENTOS DE LA INVESTIGACIÓN**

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## Capítulo 1. Introducción general

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### 1.1. Introducción

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La innovación desempeña un papel fundamental en el progreso social, económico y tecnológico de los países, permitiendo a los gobiernos adaptarse a cambios y generar valor. Es una herramienta esencial para aquellos que buscan mejorar la calidad de vida de sus ciudadanos y fomentar la creación de riqueza.

Mediante la investigación y el desarrollo, los gobiernos pueden hallar soluciones innovadoras a los desafíos que enfrentan sus comunidades y estimular el crecimiento económico. Además, la innovación conlleva beneficios derivados de la investigación y el desarrollo, resultando en productos, servicios y procesos más eficientes y rentables.

La innovación constituye una herramienta esencial para lograr diferenciación en las empresas y obtener mayores ventas en comparación con la competencia. Al innovar, las compañías crean productos y servicios exclusivos que satisfacen las necesidades de sus clientes de manera más eficiente y se distinguen de sus competidores.

Asimismo, la innovación posibilita a las empresas recuperar la inversión realizada en desarrollo tecnológico, dado que, al concebir productos o servicios innovadores, pueden obtener una ventaja competitiva y generar mayores ganancias.

Hay dos elementos clave que influyen significativamente en la generación de innovaciones para que estas alcancen el mercado y generen retorno, así como para que los procesos de investigación y desarrollo sean eficientes. Estos elementos son la apropiación del conocimiento y la capacidad de absorción.

La apropiación de conocimiento ha sido definida por diferentes actores según su alcance. Hurmelinna-Laukkanen y Yang (2022) desarrollaron un concepto específico de apropiación que definieron como apropiación realizada que lo entienden como la capacidad de generar valor y rentas a partir de las innovaciones desarrolladas. Por otro lado, existen factores contextuales y situacionales que son clave en la disponibilidad y viabilidad de los instrumentos de apropiabilidad y en los procesos de apropiación de una empresa. Estos factores incluyen el entorno legal y regulatorio, el mercado, la competencia, y las características de la innovación misma. Al evaluar estos factores, es posible determinar la capacidad de un país o una organización para obtener una recompensa por el uso de una innovación y para aprovechar los beneficios de esa innovación. Esto es conocido como las condiciones de apropiación (Hurmelinna-Laukkanen & Yang, 2022). De igual modo, la apropiación también ha sido reconocida como una capacidad de las organizaciones para proteger bajo modelos de propiedad intelectual sus desarrollos (Leiponen & Byma, 2009; Reitzig & Puranam, 2009).

Hurmelinna-Laukkanen y Yang (2022) también desarrollaron un concepto específico de apropiación, el cual definieron como el potencial de un innovador de beneficiarse de la innovación a partir del uso de los mecanismos de apropiación como la propiedad intelectual, el ser el primer jugador que desarrolla una innovación, entre otros.

Otro concepto relacionado con la apropiación es el régimen de apropiabilidad. Este concepto fue desarrollado por Teece (1986) y consiste en la habilidad de las empresas para obtener beneficios de las innovaciones que generan. Según Teece (1986) existen dos mecanismos de apropiación que se pueden utilizar para proteger el conocimiento: (1) instrumentos legales relacionados con la propiedad intelectual, como patentes, marcas y secretos comerciales, y (2) adquisición de conocimiento basada en la naturaleza de la tecnología, que puede ser un producto, proceso, conocimiento tácito o conocimiento codificado. Estos mecanismos se utilizan para garantizar que una empresa pueda captar los beneficios económicos de sus innovaciones y evitar que otros roben o repliquen sus ideas. Milesi et al. (2013) consideró las patentes, las marcas, los secretos y dos dimensiones adicionales (estrategias de primer jugador y participación y control de redes de distribución) para medir la apropiación del conocimiento. Colombelli et al. (2020) emplearon un enfoque basado en la propiedad

intelectual, añadiendo el tiempo en que se es líder en una industria y los activos complementarios (que incluyen activos comerciales y de producción) a su medición. Benedicto et al. (2014) y Rubira-García et al. (2018) clasificaron las dimensiones de apropiación en mecanismos directos (propiedad intelectual) e indirectos (como redes, alianzas, incubadoras de negocios, spin-offs y colaboraciones universidad-industria).

Torres de Oliveira et al. (2021) recurrieron a los mecanismos tradicionales de propiedad intelectual e incorporaron indicadores adicionales, tales como la complejidad del producto, el diseño del proceso, los contratos laborales, la ventaja en el tiempo de liderazgo, la fabricación complementaria y las habilidades en marketing y servicio.

En esta tesis, abordamos los diversos tipos de apropiación y régimen de apropiabilidad los sintetizamos bajo el término "apropiación del conocimiento".

Sobre el otro elemento clave, la capacidad de absorción es definida como la habilidad de escanear el entorno, asimilar el conocimiento, transformarlo y explotarlo (Cohen & Levinthal, 1990).

El concepto de capacidad de absorción fue propuesto por Cohen y Levinthal (1989) es un proceso multidimensional que comienza con la capacidad de adquirir conocimiento, refiriéndose a la habilidad de buscar y explorar fuentes de información externas. La segunda dimensión es la capacidad de asimilar el conocimiento, que implica entrenar al personal para que pueda integrar el nuevo conocimiento en los procesos internos de la empresa. Los autores también mencionan dos conceptos más: la capacidad de transformar y la capacidad de explotar el conocimiento.

La primera se refiere a la capacidad de generar nuevo conocimiento a partir del ya existente, mientras que la segunda se refiere a la capacidad de generar nuevos productos y servicios a partir del conocimiento transformado.

El vínculo entre la apropiación del conocimiento y la capacidad de absorción se observa desde los autores seminales de la capacidad de absorción. Cohen y Levinthal (1990) mencionan el régimen de apropiación como un elemento clave para la capacidad de absorción.

Sobre la relación de la capacidad de absorción y la apropiación, los autores identifican que regímenes de apropiación bajos pueden tener un impacto negativo en la capacidad de absorción de conocimiento por parte de las empresas. Esto se debe a que las empresas con bajos regímenes de apropiación obtienen menores retornos de sus innovaciones, lo que les incentiva a invertir menos en investigación y desarrollo. Además, estos regímenes también pueden reducir la cantidad de conocimiento compartido entre las empresas, Las empresas suelen ser menos proclives a compartir sus innovaciones si no pueden asegurarse una porción sustancial de los beneficios económicos derivados de estas. Por otro lado, los regímenes de apropiación robustos pueden dar lugar a una mayor inversión en la protección de las innovaciones, pero también pueden reducir la cantidad de conocimiento disponible y, por lo tanto, afectar la capacidad de absorción de las empresas.

Zahra y George (2002) revisaron el concepto de capacidad de absorción (AC) y lo dividieron en dos etapas principales: capacidad de absorción potencial y capacidad de absorción realizada. La capacidad de absorción potencial incluye la adquisición y la asimilación del conocimiento, mientras que la capacidad de absorción realizada implica la transformación y utilización de este conocimiento. La capacidad de absorción potencial implica encontrar conocimientos que puedan ser beneficiosos para una empresa y compartirlos dentro de la organización. Este nuevo conocimiento se puede combinar con el conocimiento existente de la organización para crear innovaciones, nuevos procesos o modelos de negocio a través de la capacidad de absorción realizada. Sobre la capacidad de absorción Zahra y George (2002) la definen como una capacidad dinámica o un conjunto de rutinas y procesos. “Las rutinas son actividades organizativas que facilitan el trabajo a través de recursos y habilidades organizativas”.

Zahra y George (2002) definen el régimen de apropiación como las "dinámicas institucionales e industriales que afectan la capacidad de una empresa para proteger y beneficiarse de nuevos productos o procesos". También discutieron el concepto de derrame de conocimiento, que ocurre cuando una empresa pierde el control de sus innovaciones debido a una baja inversión en capacidad de absorción. Ellos establecen que un régimen de apropiabilidad robusto puede ayudar a generar la apropiación de conocimiento y evitar las fugas del conocimiento.

La apropiación en este modelo juega un papel clave. Parafraseando a Zahra y George (2002): “Si una empresa tiene un régimen de apropiabilidad robusto, es probable que pueda captar los beneficios económicos de sus nuevos productos o procesos. Esto puede ayudar a la empresa a aprovechar su capacidad de absorción y transformar el nuevo conocimiento en innovaciones, nuevos procesos o modelos de negocio”. Por otro lado, si una empresa carece de un régimen de apropiabilidad robusto, se le dificultara utilizar y beneficiarse del nuevo conocimiento, lo que puede limitar su capacidad de absorción realizada”. Como se observa en el párrafo anterior los autores incluyen a la apropiación en la última parte del modelo de capacidad de absorción. Los autores también presentan el concepto de capacidad de apropiación de la industria. Aunque no lo definen explícitamente, sostienen que en industrias donde resulta difícil proteger las innovaciones y obtener los beneficios económicos completos derivados de los esfuerzos en I+D, las empresas deben enfocarse en desarrollar sus capacidades internas de innovación en lugar de depender de fuentes externas de conocimiento. Adicionalmente, Zahra y George (2002) identifican que una baja capacidad de apropiación también se refleja en una baja capacidad de absorción potencial.

Todorova y Durisin (2007) reconceptualizaron el concepto de la capacidad de absorción haciendo énfasis en la fase de reconocimiento del valor y las fases de adquisición, asimilación, transformación y explotación. Ellos definen tres factores críticos como contingentes: los mecanismos sociales (relaciones sociales o redes con el entorno), las relaciones de poder (relaciones entre los actores en un ecosistema) y el conocimiento previo. Su modelo considera los regímenes de apropiación como elementos relevantes tanto al inicio como al final del proceso de absorción (es decir, en las primeras y últimas etapas de la capacidad de absorción).

Todos estos modelos seminales demuestran la importancia de la apropiación como un elemento clave en la absorción del conocimiento, lo que refleja el estrecho vínculo entre ambos campos.

La importancia de la apropiación de conocimiento y de la capacidad de absorción en la innovación también ha sido un fenómeno estudiado. La apropiación del conocimiento genera beneficios o rentas de la innovación por lo que la apropiación cuenta con un vínculo directo con el impacto de las innovaciones. Por otro lado, la capacidad de absorción tiene como fin

el aprovechar el conocimiento externo y generar innovaciones de este, por lo que ambos temas están estrechamente ligados con el desarrollo y la rentabilidad de las innovaciones.

Uno de los estudios desarrollados en la tesis reconoció que las principales áreas en donde se ha identificado este impacto son la innovación abierta y el rendimiento de la innovación (Cuéllar et al., 2022). La innovación abierta, según Chesbrough (2006), es un enfoque colaborativo en el que las ideas, prototipos, necesidades y capacidades fluyen y se generan entre diferentes actores de la quíntuple hélice -empresas, universidad, gobierno, sociedad, ambiente- (Carayannis & Campbell, 2010). Esta colaboración permite a las empresas aprovechar al máximo su conocimiento y recursos para impulsar la innovación. Con relación al desempeño de la innovación busca entender el impacto y comportamiento de las innovaciones desde su ideación hasta su lanzamiento al mercado. Una definición clara este concepto es la dada por Ottenbacher y Gnoth (2005) que la define como el proceso de crear e implementar nuevas ideas, productos, servicios, procesos y políticas en todos los niveles de la organización.

Algunos estudios específicos muestran el impacto y la relevancia de la capacidad de absorción y la apropiación del conocimiento en la innovación. Por ejemplo, Thomas y Wood (2014) señalan que la apropiación del conocimiento es la última dimensión de la capacidad de absorción. Ellos hicieron este análisis en la industria del turismo, y destacan la importancia de la capacidad de absorción en el proceso de innovación. Bahl et al., (2021) encontraron que la apropiación del conocimiento debilita la relación entre la internacionalización y la innovación. Estos autores también encontraron sinergias entre la capacidad de absorción y la apropiación del conocimiento, demostrando la importancia de explorar y explotar el conocimiento. Además, identificaron que la capacidad de absorción y la apropiación del conocimiento actúan como desencadenadores en los procesos de innovación.

La magnetorresistencia gigante es una innovación importante que ha revolucionado la industria de los discos duros y ha sido explotada en Estados Unidos y Japón gracias a la capacidad de absorción de estos países. Sin embargo, Dedrick & Kraemer (2015) encontraron que los primeros innovadores obtuvieron una baja rentabilidad debido a un régimen de apropiabilidad débil sobre esta tecnología.

Por otro lado, Hurmelinna-Laukkanen y Olander (2014) señalaron la falta de información sobre la capacidad de absorción y la apropiación del conocimiento y tras evaluar la apropiación del conocimiento mediante mecanismos formales e informales, encontraron que estos elementos tienen un efecto positivo en el rendimiento de innovación de las organizaciones.

Los resultados presentados anteriormente solo son una muestra que demuestra que la capacidad de absorción y la apropiación del conocimiento son temas muy afines, que han evolucionado en conjunto y que tienen un alto impacto en el desarrollo económico, social y tecnológico de los países y juegan un rol clave en la generación de innovaciones.

Esa afinidad se evaluó en esta tesis utilizando una metodología desarrollada en los análisis tecnológicos y de industrias, pero muy poco utilizada en el área de la gestión, conocida como los análisis de convergencia (Cuellar et al., 2023a). La convergencia es definida como la aplicación de una tecnología de un área en otra área (Curran et al., 2010) o la convergencia industrial, que se define como el resultado de los vínculos de las agrupaciones industriales (Chen et al., 2022).

La convergencia ha sido estudiada en diferentes áreas como la industria farmacéutica, los nutraceuticos y una subárea de esta, la de los alimentos funcionales (Bornkessel et al., 2016; Curran et al., 2010; Curran & Leker, 2011). Otros autores han estudiado este tema en las tecnologías de la información y comunicación -TICS- (Hacklin et al., 2021), tecnologías en el almacenamiento de energía (Sick et al., 2019) en industria 4.0 y transformación digital se ha estudiado la convergencia para digitalización en el sector financiero y Fintech (Pietronudo et al., 2021; A. Thomas, 2019) y en la industria 4.0, robótica, digitalización, big data y analítica (Sick & Bröring, 2022).

A pesar de ser un tema muy popular en el análisis tecnológico e industrial, la convergencia no ha sido muy estudiada en ciencias administrativas y en la revisión de literatura que se hizo en la tesis no se encontraron estudios de convergencia entre la apropiación y la capacidad de absorción.

En esta tesis se realizó un análisis de convergencia que permitió confirmar que ambos temas están estrechamente relacionados y se complementan entre sí (Cuéllar et al., 2023a). Este

estudio reconoció las áreas en las que ambos campos generan un mayor impacto. Así mismo, se identificaron los elementos clave de convergencia, que permiten vincular a ambos temas, que son la innovación abierta y la performance de la innovación. De igual manera, otras áreas de convergencia son el emprendimiento y los derrames de conocimiento. Los principales elementos de unión de ambos temas son las patentes, la investigación y desarrollo, la gestión del conocimiento, Pymes (pequeñas y medianas empresas) y la internacionalización.

La convergencia entre ambas temáticas ha aumentado considerablemente en el tiempo, basándose en el número de palabras clave que ambos temas han tenido en común en un análisis de series temporales. Así mismo, se encuentra que ambos temas generan efectos positivos o moderadores sobre los temas en los que generan mayor impacto, aumentando, incrementando y mejorando la innovación abierta, el rendimiento de la innovación, los derrames del conocimiento y el emprendimiento.

Los análisis de convergencia permitieron identificar los elementos clave que unen a ambas temáticas. Con base en estos elementos se diseñó una metodología para medir la apropiación de conocimiento y la capacidad de absorción ( Cuéllar et al., 2023b).

La metodología desarrollada en esta tesis permite analizar ambas temáticas a diferentes niveles (macro, meso, micro). La metodología desarrollada tiene en cuenta los elementos de convergencia clave identificados que se presentaron anteriormente. En primer lugar, se identificaron los artículos que han sido desarrollados por organizaciones colombianas. Para esto se buscó en dos bases de datos que fueron Lens y Scopus. Con base en esta literatura se identificaron las citas dadas en artículos científicos y las citas recibidas en patentes. Ambos indicadores tuvieron en cuenta dos elementos clave en la convergencia entre la capacidad de absorción y la apropiación que son la investigación y desarrollo y las patentes.

A partir del análisis de la literatura, se compararon las distintas etapas de la capacidad de absorción y, además, se consideró la apropiación del conocimiento como una fase final en este proceso. Así mismo, la metodología permitió medir que tanto conocimiento se fuga en patentes solicitadas por solicitantes diferentes a los que hicieron el desarrollo científico base es decir cuanto conocimiento no es apropiado por los desarrolladores del conocimiento

científico y así mismo cuanto de ese conocimiento es tomado por otras organizaciones locales o por extranjeros como una medida para reconocer la apropiación y los derrames de conocimiento.

## **1.2. Objetivo general**

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Definir un método que permita reconocer cuantitativamente y cualitativamente que proporción se está absorbiendo y apropiando la ciencia y tecnología generada en Colombia

### **1.2.1. Objetivos específicos**

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- Reconocer las similitudes y diferencias que existen entre la capacidad de absorción y la apropiación de conocimiento a partir de una revisión sistemática de la literatura
- Reconocer los elementos de convergencia clave entre la capacidad de absorción y la apropiación del conocimiento
- Definir y analizar las diferentes metodologías que existen para evaluar la capacidad de absorción y el grado de conocimiento apropiado

## **1.3. Justificación de la tesis**

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La innovación es esencial para el desarrollo de un país. Se ha demostrado tanto empíricamente como teóricamente que la capacidad de absorción y apropiación del conocimiento son factores que promueven el rendimiento de la innovación, el emprendimiento y otros aspectos clave como la internacionalización y los derrames de conocimiento. Esta tesis propone un método de medición de la capacidad de absorción y apropiación del conocimiento para el análisis de países. Aunque se ha estudiado en profundidad la medición individual de cada uno de estos conceptos, la medición conjunta de ambos no ha sido un tema desarrollado a fondo. Adicionalmente, las mediciones se han realizado principalmente a nivel empresa, pero no a nivel país.

La creación de una técnica de medición de la capacidad de absorción y apropiación del conocimiento tiene un impacto directo Para la **comunidad académica en:**

Brindar a los académicos que estudian la medición de estos conceptos una nueva metodología de medición a partir de información científica y tecnológica con fuentes de acceso abierto.

Así mismo, la tesis desarrollada brinda a los **investigadores** que estudian individualmente cada uno de estos conceptos un avance en el análisis del estado del arte de estos campos, ya que proporciona una revisión sistemática y rigurosa de cada una de las literaturas, presentando las principales tendencias de cada tema y un análisis profundo de los artículos más representativos.

Adicionalmente, esta tesis facilita la comprensión de la relación entre estos dos conceptos y sus vertientes a partir del análisis de textos completos que muestran lo que se ha investigado en los estudios que analizan ambas literaturas.

Por otro lado, esta investigación hace también un gran aporte a los **académicos** que estudian la innovación abierta, el rendimiento de la innovación, el emprendimiento y los derrames de conocimiento (*knowledge spillovers*) al proporcionar elementos clave para impulsar estos temas.

**Para los gestores de políticas públicas:**

Permite diagnosticar la situación actual de un país en términos de flujos de conocimiento en términos de adquisición de conocimiento científico, asimilación y transformación en forma de generación de artículos científicos, explotación en forma de generación de patentes y apropiación también en esta última forma.

Permite hacer comparaciones con otros países y regiones mediante análisis de benchmarking.

Puede ser utilizado para generar nuevos modelos de medición de la innovación.

Permite generar políticas públicas para mejorar el entorno de innovación y fomentar el flujo de conocimiento.

**Para las empresas:**

La metodología permite a las empresas diagnosticar su propia capacidad de absorción y apropiación del conocimiento y compararla con otras empresas del mismo sector o país. Así

mismo les brinda a las empresas herramientas para tomar decisiones estratégicas en cuanto a cómo maximizar el uso del conocimiento externo y promover la innovación.

Como conclusión esta investigación sobre la medición de la capacidad de absorción y apropiación del conocimiento a nivel país, tiene un impacto significativo en la comunidad académica, los gestores de políticas públicas y las empresas, ya que proporciona una herramienta valiosa para diagnosticar y mejorar el rendimiento de la innovación.

#### **1.4. Estructura de la tesis y resumen de las contribuciones**

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La tesis se ha estructurado en base al modelo de formato de publicaciones (Real Decreto 99/2011, de 28 de enero (BOE 10/02/2011)). En la Parte I, se abordan los fundamentos de investigación. El Capítulo uno, "Introducción general", describe el propósito, la justificación, los objetivos y el resumen de las contribuciones de la tesis. El Capítulo dos, "Metodología", detalla el proceso de recolección, tratamiento y análisis de información desarrollado en la tesis. El Capítulo tres, "Revisión de la literatura", examina cómo se ha medido la capacidad de absorción y la apropiación de conocimiento en la literatura.

La parte II se centra en el desarrollo de tres artículos científicos con el objetivo de explorar la relación entre la capacidad de absorción y la apropiación del conocimiento y en generar una metodología de medición que pueda ser aplicable a grandes volúmenes de información para el análisis de estos elementos en países. En el primer trabajo (capítulo cuatro), se examinaron los orígenes, definiciones, modelos y objetivos de ambos temas para determinar el grado de vinculación entre ellos. En la segunda investigación (capítulo cinco), se identificaron las áreas donde ambos campos convergen y los elementos clave que contribuyen a esta convergencia. Con base en lo estudiado en los dos primeros artículos, se construyó una metodología (capítulo seis) para medir la capacidad de absorción y apropiación del conocimiento a nivel nacional, utilizando indicadores bibliométricos, de análisis de patentes y de análisis de redes sociales como base.

Finalmente, en el capítulo siete se presentan los resultados no publicados que se consideraron relevantes para la tesis y en el capítulo ocho las conclusiones y recomendaciones del estudio.

Las publicaciones en las que se desarrolla esta tesis Doctoral son las siguientes:

Artículo 1: Cuéllar, S. D., Fernandez-Bajón, M. T., & Moya-Anegón, F. de. (2022). *Similarities and differences between absorptive capacity and appropriability: A bibliometric perspective. Benchmarking: An International Journal.* <https://doi.org/10.1108/BIJ-12-2021-0773>

El objetivo de este estudio fue analizar las similitudes y diferencias entre la capacidad de absorción y la apropiación del conocimiento. Para ello, se examinaron textos completos de 681 artículos sobre apropiación y 431 sobre capacidad de absorción procedentes de Scopus, Science Direct y Lens. Se analizaron las definiciones y modelos de cada tema y se identificaron definiciones que incluyeran ambos temas. Además, se analizaron las citas seminales de cada tema y se observó si eran citadas por autores de ambas literaturas. Se profundizó en la literatura que trabajó conjuntamente ambos campos y se identificaron los temas y subtemas que analizaron a través de un análisis de modelamiento temático (LDA) y una técnica de coocurrencia utilizando modularidad (Vosviewer).

El estudio concluye que la capacidad de absorción y la apropiación del conocimiento están estrechamente vinculadas. En los modelos fundamentales sobre capacidad de absorción, la apropiación es siempre un componente crucial. Además, algunos autores presentan definiciones parecidas de ambos términos, y en ciertos casos, las etapas de cada uno resultan ser análogas.

Ambos temas tienen como principal objetivo mejorar el rendimiento de la innovación y tienen un impacto en modelos de innovación como la innovación abierta. Además, ambos temas están muy relacionados con otros campos, como la gestión del conocimiento.

Artículo 2: Cuellar, S., Fernandez Bajón, M. T., & De Moya-Anegón, F. (2023). *Convergence between absorptive capacity and knowledge appropriation: A new methodology Mapping the hidden links—ScienceDirect. Journal of Open Innovation: Technology, Market, and Complexity, 10(1).* <https://www.sciencedirect.com/science/article/pii/S219985312300272X?dgcid=author>

En este estudio se analizó información bibliográfica de 3412 artículos sobre capacidad de absorción y 368 sobre apropiación del conocimiento. El objetivo del trabajo fue identificar elementos de convergencia entre ambos campos.

Para ello, se utilizó una técnica de clusterización de modularidad a partir de la herramienta Vosviewer y se analizaron los índices H, CAGR y términos que han experimentado un alto crecimiento en los últimos periodos de tiempo.

La investigación muestra que las principales áreas de convergencia entre la capacidad de absorción y la apropiación del conocimiento son la innovación, especialmente la innovación abierta y el rendimiento de la innovación, el emprendimiento y los derrames de conocimiento.

En el estudio identificaron más de 20 elementos clave que contribuyen a la sinergia entre ambos campos, llamados "*building blocks*". Algunos de estos elementos destacados fueron la investigación y desarrollo, las patentes y la gestión del conocimiento. Todos estos fueron analizados por indicadores de redes sociales como la centralidad de grado y la centralidad de intermediación para determinar su importancia.

Este estudio presenta un enfoque original para analizar la convergencia entre dos áreas y es uno de los primeros trabajos que lleva a cabo este tipo de análisis en ciencias administrativas.

Artículo 3: Cuéllar, S., Fernandez-Bajón, M. T., & de Moya Anegón, F. (2023). *A New Approach to Measure Absorptive Capacity and Appropriability: A Case of Study in Emerging Markets. Journal of the Knowledge Economy.*  
<https://doi.org/10.1007/s13132-023-01646-6>

Con base en los dos primeros artículos y en una revisión detallada de la literatura de medición de capacidad de absorción y de la apropiación del conocimiento, se desarrolló una metodología para la medición de estos elementos a nivel de países específicamente en Colombia utilizando las capacidades científicas del país como base. Se analizaron los registros de literatura científica colombiana y las citas de estos trabajos para identificar los flujos de citas hacia adelante y hacia atrás entre países. Además, se analizaron las organizaciones involucradas en el proceso de apropiación del conocimiento y se examinó cuándo se producían fugas de conocimiento.

Para llevar a cabo este estudio, se recopilaron varios datos estadísticos. Primero, se identificaron 1680 registros de literatura científica desarrollada por colombianos en la base de datos Lens. Además, se encontraron 3066 registros de patentes que citaban al menos una vez a la literatura científica colombiana, y se identificaron 50697 trabajos que fueron citados por la literatura científica colombiana.

Se encontró que la apropiación del conocimiento y las últimas etapas de la capacidad de absorción normalmente no se da por solicitantes colombianos y por lo mismo ocurren fugas de conocimiento.

A continuación, se presenta el árbol de citas, que es un esquema que muestra cómo los distintos artículos de la tesis se interrelacionan y contribuyen a la unidad temática general de la investigación.

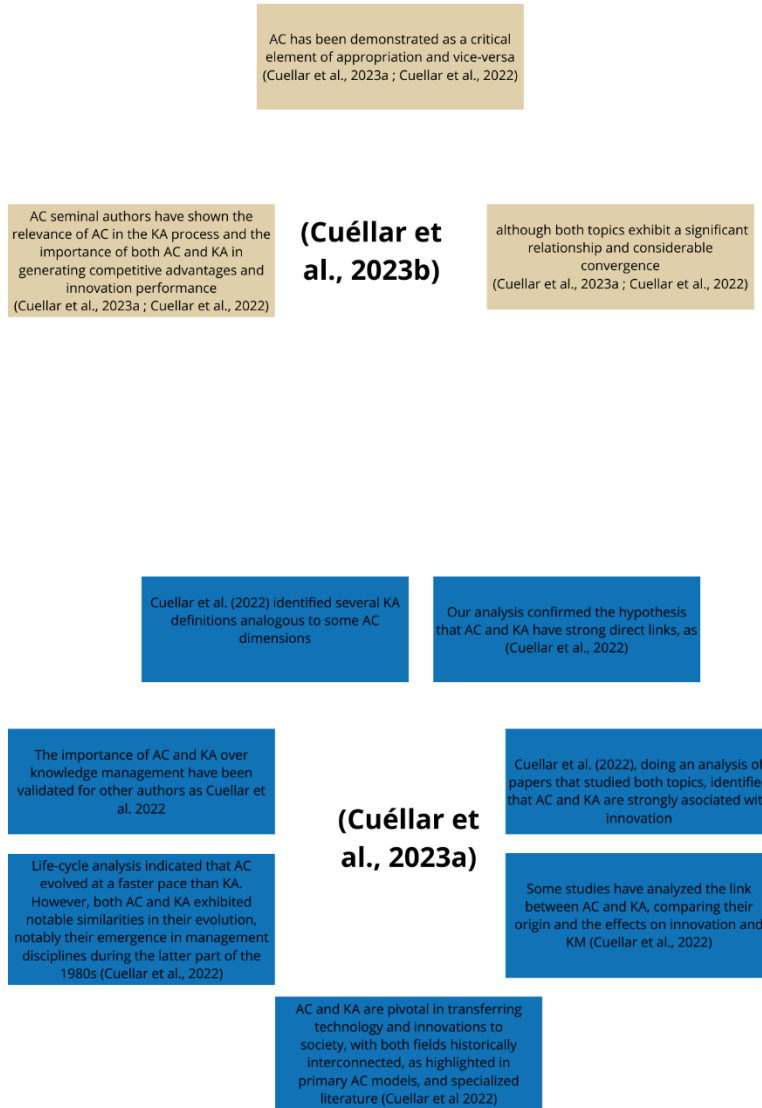


Ilustración 1 Árbol de citas de los documentos publicados que constituyen esta tesis

## Capítulo 2. Metodología

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En esta sección de la tesis se presenta las diferentes metodologías y herramientas tecnológicas y bases de datos utilizados para esta tesis.

Metodológicamente esta tesis se desarrolló usando las etapas de un ciclo de inteligencia tecnológica , en el que se sigue un proceso de análisis desde la desde la definición de la necesidad y objetivos, búsqueda de la información, normalización , análisis y presentación de la información (Mortara et al., 2009).

En la fase de definición de la **necesidad** se definieron los objetivos de la tesis que se presentaron anteriormente en sección anterior.

En la fase de coordinación se definieron las diferentes fuentes de información utilizadas en cada uno de los documentos. En la siguiente tabla se presentan las diferentes bases de datos utilizados en cada uno de los artículos.

Tabla 1 Fuentes de información utilizadas en cada uno de los estudios

Artículo	Fuentes de información
(Cuéllar et al., 2023b)	Scopus y Lens
(Cuéllar et al., 2023a)	Web of Science, Scopus
(Cuéllar et al., 2022)	Scopus, Science Direct y Lens

### 2.1. Fase de búsqueda

---

En la fase de búsqueda se ejecutaron las estrategias de recuperación de la información para cada uno de los estudios.

La siguiente tabla presenta un resumen de estas estrategias para cada uno de los estudios

Tabla 2 Estrategias de búsqueda de información utilizadas en la tesis

Artículo	Fuente de información	Estrategia de búsqueda	Objetivo
(cuéllar et al., 2022)	Scopus, lens science direct	“absorptive capacity” Or appropriability or “knowledge appropriation”	Recuperar la literatura científica sobre apropiación y capacidad de absorción en textos completos
(cuéllar et al., 2023a)	Scopus	Title-abs-key ( appropriability or "knowledge appropriation" )and ( limit-to ( subjarea , "busi" ) orlimit-to ( subjarea ,"econ" ) )	Recuperar la literatura sobre apropiación
(cuéllar et al., 2023a)	Web of science	Appropriability or "knowledge appropriation" (topic) and management or business or economics (web of science categories)	Recuperar la literatura sobre apropiación
(cuéllar et al., 2023a)	Scopus	Title-abs-key ( "absorptive capacity" ) and ( limit-to ( subjarea , "busi" ) orlimit-to ( subjarea ,"soci" ) )	Recuperar la literatura sobre capacidad de absorción
(cuéllar et al., 2023a)	Web of science	(ts=("absorptive capacity")) and (tasca==( "management" or "business"))	Recuperar la literature sobre

			capacidad de absorción
(cuéllar et al., 2023b)	Lens	Author.affiliation.grid.address.country_code:"c.o."	Recuperar la literatura científica desarrollada por organizaciones colombianas
(cuéllar et al., 2023b)	Lens api	Se usaron los lens id de los artículos descargados	Enriquecer la información con los campos de país y organización

Nota: para la recuperación de las patentes en S. Cuéllar, Fernandez-Bajón, et al., (2023) se hizo una búsqueda por el ID de la patente que se obtuvieron utilizando `author.affiliation.grid.address.country_code:"C.O."`. Esto mismo se hizo para recuperar los artículos citados por estos artículos.

Para la recuperación de textos completos en Cuéllar et al., (2022) se utilizó la herramienta (Open web Scaper, 2021) una herramienta de *web scraping* que permitió recuperar los diferentes PDF que se necesitaban para el análisis de texto completo.

En esta fase de búsqueda también fue necesario hacer una transformación de PDF a textos completos. Para eso el siguiente Script de R fue utilizado. En Cuéllar et al., (2023a), se utilizó información bibliográfica, proporcionando dentro del artículo un enlace directo a la base de datos completa. De manera similar, en Cuéllar et al., (2023b) se recurrió al uso de información bibliográfica; sin embargo, en este caso, la base de datos no se hizo disponible al público.

```

library("tabulizer")

CantDeArchivos <- length(list.files())

Urls <- c()

for (i in 1:CantDeArchivos) {
  Urls[i] <- list.files()[i]
}

Resultados <- data.frame("Nombre"="A", "Contenido"="B")

Resultados = Resultados[-1,]

for (i in 1:CantDeArchivos) {
  Temp<-data.frame(Urls[i],tabulizer::extract_text(Urls[i]))
  names(Temp)<-c("Nombre","Contenido")
  Resultados <- rbind(Resultados, Temp)
}

write.csv(Resultados,"ARTWOS.csv")

```

*Ilustración 2 Script de R utilizado para la descarga de textos completos*

## **2.2. Fase de normalización y enriquecimiento**

---

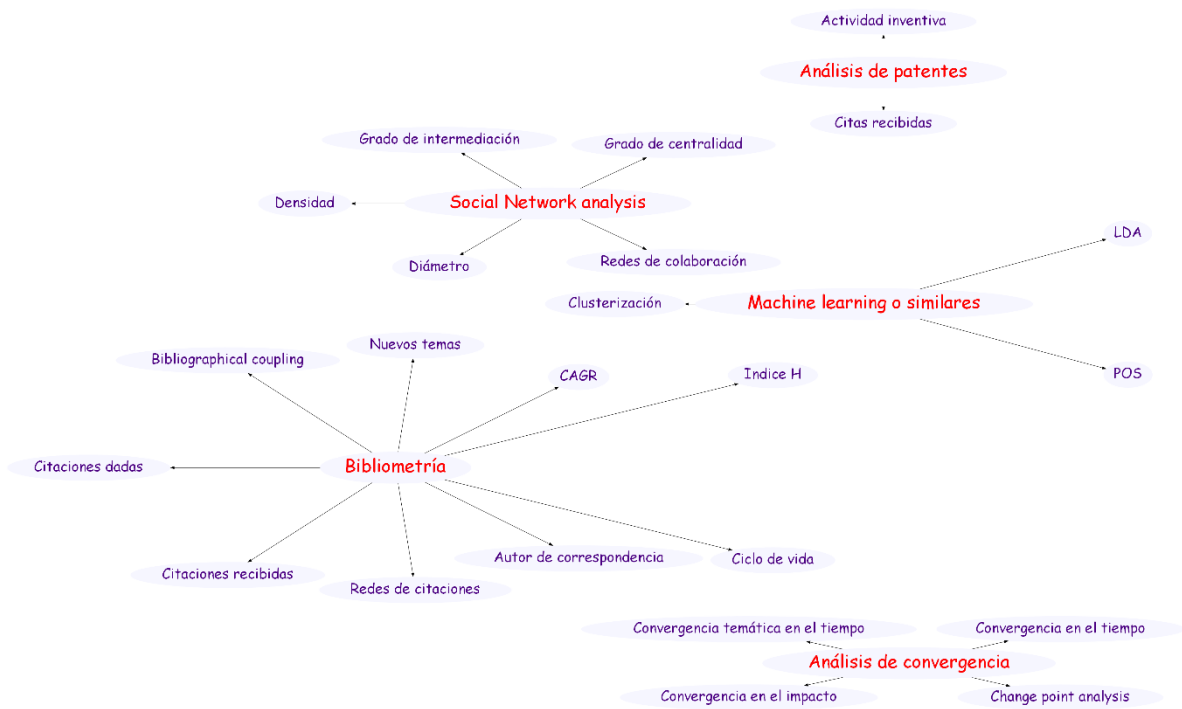
En la siguiente fase se normalizó y enriqueció la información. Para este proceso se utilizaron diferentes herramientas. Knime (Tursi & Silipo, 2019) fue utilizado en los tres artículos para enriquecer y depurar la información. Para la detección de duplicados y registros similares se utilizaron los nodos “Duplicate row filter” y el nodo “string matcher”. De igual modo, para normalizar las organizaciones se utilizó la herramienta Tableau Desktop la cual permite hacer fusión de cadenas manualmente.

En el trabajo de textos completos dos metodologías fueron clave para los análisis temáticos. Estas fueron la identificación n-gramas y el procesamiento de textos a partir de procesamiento de lenguaje natural para identificar efectos positivos o negativos en las oraciones. Los n-gramas son una herramienta de procesamiento de lenguaje natural que permiten identificar una secuencia elementos siendo los más comunes los bi-gramas y los tri-gramas de dos y tres palabras (Chen & Goodman, 1996). Los análisis de n-gramas se utilizaron en Cuéllar et al. (2022) para identificar tendencias temáticas en la literatura que desarrolló en conjunto la apropiación del conocimiento y la capacidad de absorción y en Cuéllar et al., (2023a) para hacer la comparación entre ambas literaturas.

## **2.3. Fase de análisis de la información**

---

En la tesis se utilizaron diferentes metodologías de análisis las cuales pueden ser vistas en la siguiente figura.



*Ilustración 3 Metodologías de análisis utilizadas en la tesis*

A continuación, se hace una explicación de cada una de estas metodologías.

### **2.3.1. Bibliometría**

Una de las metodologías que más se utilizaron en esta tesis fue la bibliometría. Esta herramienta se utilizó en todos los artículos que componen la tesis y fue estratégica para las revisiones de literatura, las metodologías de análisis de convergencia y para la metodología de análisis de capacidad de absorción y apropiación en países.

La bibliometría es una disciplina que busca medir y analizar la producción científica, tecnológica y comercial. La bibliometría fue definida por Pritchard (1969) como la aplicación de “estadística y matemática a libros y otras formas de comunicación escrita”.

Sus orígenes se remontan al siglo XIX, donde se utilizó para medir la producción literaria basándose en la estadística (Sanz Valero, 2022). A lo largo del tiempo, la bibliometría ha evolucionado y se ha utilizado para medir y evaluar todos los niveles de información.

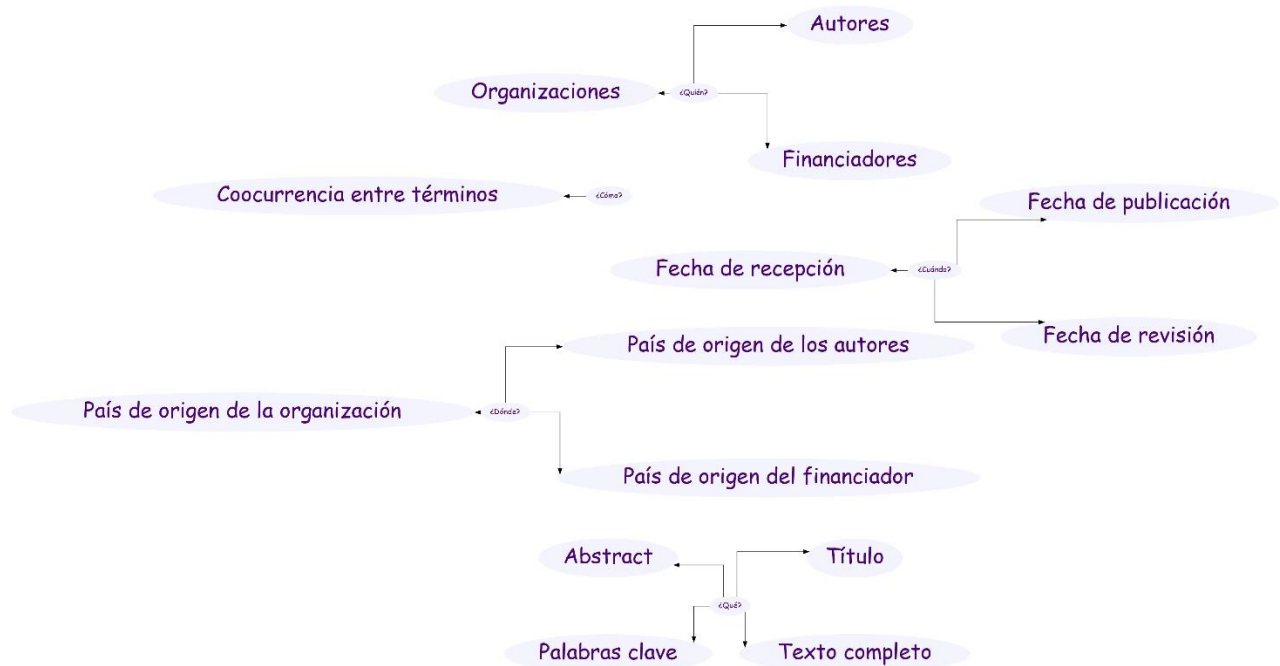
La bibliometría responde a preguntas como quién, qué, cuándo, dónde y cómo (Fu et al., 2021). Para responder a la pregunta del qué, la bibliometría utiliza campos de análisis temático como el título, el resumen y las palabras clave. Para responder a la pregunta del cuándo, se utilizan los campos de fecha de recepción del documento, fecha de revisión y fecha de publicación.

Para responder a la pregunta de dónde, se utilizan campos como el país de origen de los autores, el país de la organización que es filial de los autores y el país de origen del financiador de la investigación. En cuanto a la pregunta de quién, la bibliometría utiliza principalmente los nombres de los investigadores que han participado en los desarrollos.

Por último, para responder a la pregunta de cómo, la bibliometría utiliza enfoques como la relación entre términos, basándose en herramientas que miden la coocurrencia entre las palabras, y más recientemente, enfoques que utilizan el procesamiento de lenguaje natural con este fin.

Cada una de estas preguntas se puede responder mediante el análisis bibliométrico, con el fin de medir la productividad y calidad de cada uno de estos elementos. La productividad se mide basándose en el número de documentos desarrollados en alguno de estos elementos (Ridzuan et al., 2019) y la calidad se mide a partir del número de citas que reciben por otros documentos científicos o de otro tipo de literatura, como por ejemplo las patentes (Olensky et al., 2016) o las menciones en redes sociales (Shakeel et al., 2022).

En la siguiente ilustración se presentan los campos utilizados en los análisis bibliométricos.



*Ilustración 4 Campos utilizados para desarrollar análisis bibliométricos*

### **2.3.2. Análisis bibliométricos aplicados a análisis de textos completos**

Los enfoques bibliométricos han evolucionado a estudiar textos completos para tener mayor alcance y precisión en los análisis. Uno de los primeros autores que empezaron a mirar este enfoque fue Snizek et al., (1991) haciendo análisis de citas en el área de la biotecnología.

Los avances en metodologías de minería de datos especialmente en metodologías de análisis de texto no estructurado específicamente en procesamiento de lenguaje natural (Gomez et al., 2022) , en gestión de grandes volúmenes de información o big data (Ding et al., 2014) y en la recuperación de texto con robots o los procesos automatizados con robots han impulsado este tipo de estudios. En esta tesis fue llevado a cabo un análisis de textos completos para analizar los documentos que se enfocaron en estudiar la capacidad de absorción y la apropiación social del conocimiento.

### **2.3.2.1. Citaciones**

---

Las citaciones son un tipo de indicador bibliométrico muy utilizado para medir el impacto que tiene una investigación científica, una patente y en otros ámbitos hasta un tweet. La citaciones pueden ser dos tipos las dadas que hacen referencia a los documentos que son citados por un documento x (Reyes-Gonzalez et al., 2016) y las citaciones recibidas que hace referencia a los documento que citan este documento x (Og et al., 2020) . En la tesis, las citaciones de artículos fueron utilizadas para analizar las similitudes entre la capacidad de absorción y la apropiación del conocimiento haciendo una comparación entre los documentos que referenciaban los artículos científicos que investigan sobre la capacidad de absorción y los artículos científicos de apropiación (Cuéllar et al., 2022) y en los análisis de flujo de conocimiento en el ecosistema colombiano de I+D en Cuéllar et al. (2023b).

### **2.3.2.2. Redes de citaciones**

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Los análisis de redes de citaciones estudian la estructura y los cambios evolutivos de la relación entre artículos y los documentos que estos citan (Bu et al., 2019) . Estas redes permiten visualizar las relaciones entre la publicación analizada y las publicaciones que se citan. Las redes de citación pueden ser utilizadas con cualquiera de los campos bibliométricos presentados anteriormente para responder las preguntas del que, quien , cuando, donde y como y pueden ser utilizadas para analizar un mismo tipo de literatura o para analizar la relación entre diferentes niveles de innovación, por ejemplo la relación entre ciencia, tecnología e innovación como se hizo en una de las publicaciones de este documento de tesis (Cuéllar et al., 2023b) en donde se analizó la relación entre ciencia y tecnología.

Las redes de citación pueden ser divididas en:

Redes de citas directas: estas redes muestran las relaciones directas entre la referencia de un artículos y el artículo y las relaciones entre ese mismo artículo y los otros documentos que lo citan (Bu et al., 2019).

Redes de co-citación: Estas redes analizan los documentos que son citados en conjunto por una publicación o un grupo de publicaciones (Edge, 1979).

Redes de acoplamiento bibliográfico: Este tipo de red permite identificar la relación entre dos elementos basado en la cantidad de citas que comparten entre sí. Este análisis permite entre otras cosas reconocer la relación entre dos documentos por la cantidad de documentos referenciados que comparten (Kessler, 1963).

En esta tesis se utilizaron las redes de citas en el documento Cuéllar et al. (2023b) en el que se analizó la relación entre los artículos científicos desarrollados por autores y/o organizaciones colombianas y los documentos que estos citan y los documentos tecnológicos que los citaron utilizando con base a la información de patente.

Este análisis permitió identificar los flujos de conocimiento que permitieron hacer un análisis en profundidad del proceso de adquisición, asimilación, transformación, explotación y apropiación del conocimiento científico (Cuéllar et al., 2022). Para este análisis dos tipos de redes fueron utilizadas las redes directas y las redes de acoplamiento bibliográfico.

### **2.3.3. Análisis de patentes**

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Las patentes son un tipo de documento jurídico que le otorga a la persona natural o jurídica que la solicita, un derecho de explotación y una protección legal sobre el activo protegido por este mecanismo (Jin et al., 2011). Una de las metodologías utilizadas en este estudio fue los análisis de patentes. Los análisis de patentes son reconocidos como la utilización de métodos bibliométricos utilizando como base la información de patentes (Narin, 1994). La información de patentes cuenta con campos bibliográficos estructurados que permiten analizar diferentes elementos relacionados con diversos elementos como alianzas estratégicas (Di Guardo & Harrigan, 2016), actores clave, impacto de las patentes, panorama y tendencias tecnológicas (Cuellar et al., 2021) , entre otros.

La siguiente figura presenta los diferentes campos de las patentes que son utilizados para los análisis de patentes.



*Ilustración 5 Campos utilizados en los análisis de patentes*

En el desarrollo de la tesis diferentes indicadores de las patentes fueron utilizados. Por ejemplo, Cuéllar et al (2023b) se utilizaron para reconocer los flujos de conocimiento entre ciencia y tecnología, específicamente para identificar quienes han transformado y explotado el conocimiento. De estas patentes se analizó la apropiación por colombianos y por otros países, reconociendo la nacionalidad de los solicitantes y el tipo de organización (empresa, gobierno, académico o persona natural). Estos solicitantes se analizaron utilizando dos indicadores, la actividad inventiva un indicador que mira la productividad y que a su vez puede ser utilizado para la medición de la inversión en investigación y desarrollo de cada solicitante y se utilizaron las citas recibidas para medir la calidad de las patentes que han desarrollado estos solicitantes (Cuellar et al., 2021). De igual manera, se midió el alcance tecnológico de los solicitantes, es decir la amplitud de las patentes que desarrollan basándose en las clasificaciones cooperativas de patentes que están relacionadas con sus tecnologías (Ernst, 2003).

#### **2.3.4. Análisis del ciclo de vida**

Otro análisis que se desarrolló en la tesis fue el análisis del ciclo de vida. Dos metodologías fueron utilizadas para esto. El análisis de la Curva S, una metodología que mide a partir del

acumulado de una medida de performance (artículos científicos, patentes) y su evolución en el tiempo para identificar como ha sido el desarrollo o crecimiento del mismo en el tiempo (Ngwenyama et al., 2007). La curva S está conformada por las siguientes etapas. Una fase emergente caracterizada por una baja performance, una fase de crecimiento caracterizada por un crecimiento exponencial en la performance, una fase de maduración caracterizada por una performance más lenta que en la fase de crecimiento y una fase de saturación en la cual la performance disminuye como a la fase o emergente y desaparece (Ernst, 1997). En la tesis este análisis se utilizó para estudiar la apropiación del conocimiento por locales y el grado de fuga de conocimiento (Cuéllar et al., 2023b).

De igual manera, la curva s fue utilizada para analizar la convergencia entre la capacidad de absorción y la apropiación del conocimiento, basándose en la identificación de palabras que convergieron entre la literatura de ambas temáticas en un análisis temporal.

Adicionalmente, otro análisis de ciclo de vida fue desarrollado en la tesis fue basado en una metodología desarrollada por Chanchetti (2016) en la que utilizando dos indicadores que fueron el número de artículos por año y el número de investigadores por año, y con la que se identificó como había sido la evolución de la apropiación del conocimiento y de la capacidad de absorción en el tiempo y se hizo una comparación de ambos campos (Cuéllar et al., 2022).

### **2.3.5. Análisis de redes sociales**

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Los análisis de redes sociales buscan entender la relación que existe entre diferentes elementos que pueden ser actores -países, organizaciones, inventores y palabras clave (Hu et al., 2014). En el análisis de redes sociales los elementos son representados por los nodos y la relación entre los elementos que son representados por los enlaces (Hu et al., 2014). Los análisis de redes sociales permiten reconocer la importancia de cada elemento en la interacción, las subcomunidades o clústeres dentro de la comunidad (Lee & Wilkinson, 2018). Los indicadores utilizados en esta tesis fueron la centralidad de grado que mide la importancia de un nodo por la cantidad de enlaces que recibe, y la centralidad de intermediación que permite identificar los nodos que sirven como puentes entre subcomunidades (Wandelt et al., 2020). Así mismo, se midió la densidad de la red que permite reconocer la proporción de enlaces que existen entre los nodos de una red en

comparación con el número total de enlaces posibles en la red (Duch & Arenas, 2005). Es decir, es la medida de cuánto está conectada una red en relación con su tamaño y capacidad potencial. Por otro lado, se utilizó el diámetro de la red para medir la distancia amplia que existe entre cualquier par de nodos en la red (Marklof & Strömbergsson, 2013). Así mismo, otro aspecto clave en los análisis de redes sociales es la detección de comunidades. Un algoritmo de aprendizaje no supervisado muy utilizado para este aspecto es el modularidad, es decir la detección de módulos dentro de la red por los enlaces que los conectan (van Eck & Waltman, 2009).

En esta tesis los análisis de redes sociales fueron usados en varios elementos del desarrollo de la investigación. En Cuéllar et al., (2022) se utilizaron los análisis de redes sociales para identificar los temas más importantes en los textos completos de artículos que discutían la apropiación del conocimiento y capacidad de absorción en conjunto, utilizando algoritmos de modularidad de Vosviewer (van Eck & Waltman, 2009). De igual manera, los análisis de modularidad se utilizaron para analizar la convergencia entre la capacidad de absorción y la apropiación del conocimiento haciendo un análisis individual de cada literatura (Cuéllar et al., 2023a). Los indicadores de centralidad e intermediación fueron utilizados para reconocer los temas de mayor convergencia entre ambas literaturas (Cuéllar et al., 2023a). Finalmente, los análisis de redes sociales fueron utilizados para visualizar los flujos de conocimiento entre las citas dadas, la literatura core y las patentes en (Cuéllar et al., 2023b) y para reconocer el grado de colaboración entre países de la literatura core en el mismo artículo.

### **2.3.6. Otras metodologías**

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Otras metodologías que fueron utilizadas en esta tesis fueron una herramienta de modelamiento temático llamada LDA “Latent Dirichlet Allocation” la cual es un algoritmo de modelado temático, basado en modelos probabilísticos en el que se asume que los documentos son una mezcla de temas y estos están compuestos por palabras. LDA busca identificar la distribución de palabras que se relacionan en mejor medida con los temas utilizando una asignación que el algoritmo hace y basado en esa probabilidad agrupa los términos en los temas principales (Yang & Li, 2015).

De igual modo, se utilizó el análisis de *change point analysis* para analizar cambios significativos en los datos analizando la media y las varianzas con este fin. Esta metodología permite reconocer un punto o varios puntos de cambio en una serie de datos (Killick et al., 2012). En la tesis fue utilizado para comparar los puntos de cambio entre la literatura de apropiación del conocimiento y la literatura de capacidad de absorción para analizar la convergencia entre ambas (Cuéllar et al., 2022).

Por otro lado, en la información no publicada de la tesis o inédita se hizo un análisis de frases que fueron obtenidas utilizando la librería Spacy de Python (Yanti et al., 2021). De estas frases se reconoció la similitud semántica entre ellas (*embeddings*) en inglés, utilizando la librería Bert desarrollada por Google, específicamente la función *sentence Transformers* (Reimers & Gurevych, 2019) y que luego fueron clusterizadas utilizando *K-means* (Jain, 2010) y ChatGPT. Este análisis se hizo de los textos completos que contenían información de la capacidad de absorción y la apropiación del conocimiento. Este análisis permitió tener otra mirada complementaria de la literatura que ha estudiado ambos temas en conjunto y permitió dar otros insights sobre la misma.

#### **2.4. Herramientas informáticas utilizadas en la tesis**

Diferentes herramientas informáticas fueron utilizadas en esta tesis. Para Cuéllar et al. (2022), Cuéllar et al. (2023a) y Cuéllar et al. (2023b) en esta tesis se generaron flujos y nodos en Knime (2020) para la analítica necesaria en los estudios. La visualización de la información se hizo en Tableau (2022), Flourish (Canva, 2023) y Vosviewer (van Eck & Waltman, 2010) en Cuéllar et al. (2022), Cuéllar et al. (2023a) y Cuéllar et al. (2023b) y Gephi (Amat, 2014) en Cuéllar et al. (2023b). La recuperación de textos completos se hizo utilizando el software R (Fox & Leanage, 2016) así como los análisis de change Point (Killick et al., 2012) en Cuéllar et al. (2022). Python fue utilizado en los análisis inéditos específicamente las librerías Bert (Reimers & Gurevych, 2019) y Spacy (Yanti et al., 2021).

### **Capítulo 3. Revisión de la literatura**

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En este capítulo se presenta la literatura más cercana a la medición de la capacidad de absorción y la apropiación del conocimiento. Este análisis se hizo desde diferentes perspectivas.

#### **3.1. Medición de capacidad de absorción por sus dimensiones**

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La capacidad de absorción es considerada por muchos autores como un proceso multidimensional. El proceso de absorción normalmente lo dividen en cuatro fases que son adquisición, asimilación, transformación y explotación basándose en el modelo seminal propuesto por Cohen y Levinthal (1990).

##### **3.1.1. Medición de adquisición**

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La fase de adquisición está relacionada con la habilidad de las organizaciones de adquirir y reconocer nuevo conocimiento externo (Cohen & Levinthal, 1989). La medición de la fase de adquisición se ha centrado en obtener indicadores que permitan medir una amplia gama de información y conocimiento que proviene de fuentes externas de conocimiento.

Estos indicadores incluyen el adquirir conocimiento de fuentes externas a través de diversos medios, como interactuar con otras empresas e individuos (M. Zhang et al., 2018), la obtención de información de diversas fuentes como proveedores, clientes, competidores y universidades<sup>1</sup> (Popadiuk & Nunes, 2018), el escanear el entorno y buscar fuentes externas de información (Heeley, 1997) establecer relaciones con fuentes externas a través de la interacción, el respeto, la confianza y la reciprocidad (Jiménez-Barrionuevo et al., 2011).

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<sup>1</sup> Los autores utilizan indicadores para medir la capacidad de absorción y citan que los dos últimos, relacionados con la explotación y transformación, pueden considerarse como aspectos de la capacidad de asimilar el conocimiento.

Así mismo, estos métodos incluyen el visitar otras empresas y utilizar métodos informales adquisición de conocimiento<sup>2</sup> (Alves & Galina, 2020). Otros métodos han medido la habilidad de los empleados para utilizar sus habilidades para analizar el entorno externo<sup>3</sup> (Yang & Tsai, 2019) e identificar nuevos mercados (Jiménez-Castillo & Sánchez-Pérez, 2013), y la capacidad de las organizaciones para buscar información de diversas fuentes como proveedores, clientes, competidores, consultoras, universidades, centros tecnológicos, conferencias, redes digitales y ferias (Alves & Galina, 2020). Lau y Lo (2015) recopilaron varios de estos indicadores analizando la frecuencia de las interacciones de la empresa con su sede central para adquirir nuevo conocimiento, la regularidad con la que los empleados visitan otras sucursales, y la periodicidad de las reuniones organizadas con clientes o terceros para adquirir conocimientos nuevos. Además, examinaron la frecuencia con la que los empleados se acercan a terceros, como consultores, para obtener nuevo conocimiento.

### **3.1.2. Medición de la asimilación**

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La fase de asimilación se refiere al proceso mediante el cual una organización integra nuevo conocimiento externo con su conocimiento interno preexistente (Ven & Bruyn, 2011).

Con relación a la fase de asimilación la literatura presenta diversos enfoques para su medición. Yang y Tsai (2019) evaluaron la capacidad de las empresas para asimilar conocimiento externo basándose en la competencia técnica y la competencia gerencial. En cuanto a la competencia técnica, determinaron la habilidad de la empresa para integrar conocimientos técnicos. Adicionalmente, evaluaron cómo la empresa incorpora este conocimiento externo en su gestión y toma de decisiones.

Lau y Lo (2015) evaluaron la agilidad de las empresas para comprender rápidamente nuevas oportunidades de servir a sus clientes y la capacidad de la empresa para asimilar activamente las dinámicas del mercado y adaptarse a ellas.

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<sup>2</sup> Los autores centran su estudio en la capacidad de absorción potencial y realizada pero los indicadores utilizados están muy relacionados con la fase de adquisición, por lo que se incluyeron en este segmento

<sup>3</sup> En este documento los autores utilizan dentro de su cuestionario las siguiente pregunta: "Our company is able to acquire state-of-the-art external knowledge"

Zhang et al. (2018), usaron la reactivación del conocimiento, es decir, la habilidad de aplicar y utilizar el conocimiento adquirido de manera efectiva. Estos autores también analizaron los cambios en la demanda y la búsqueda oportunidades nuevas para los clientes para hacer esta medición. Jiménez-Barrionuevo et al. (2011) utilizaron como indicadores la similitud y compatibilidad del lenguaje común, la complementariedad, la similitud y compatibilidad en cultura organizacional, y los estilos operativos y de gestión entre organizaciones.

Pérez et al. (2019) analizaron los recursos humanos, específicamente la alta capacidad de aprendizaje. Finalmente, Jiménez-Castillo y Sánchez-Pérez (2013) utilizaron como indicador la capacidad reconocer los cambios en el mercado, la identificación de nuevas oportunidades para ayudar a los clientes y los cambios en la demanda.

### **3.1.3. Medición de transformación**

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La fase de transformación desarrolla el proceso de convertir el conocimiento externo a algo que pueda ser usado dentro de las organizaciones. Esta fase está compuesta por la reconfiguración de las estructuras de conocimiento existentes y la creación de nuevas estructuras de conocimiento (Shafique & Kalyar, 2018).

Diferentes indicadores han sido utilizados para medir la transformación, como la medición la reactivación del conocimiento existente para nuevas aplicaciones (Zhang et al., 2018), la capacidad de analizar a tiempo los cambios en la demanda del mercado y la identificación de nuevas oportunidades para ayudar a los clientes con conocimientos previos (Zhang et al., 2018).

Lau y Lo (2015) midieron la transformación en función de las habilidades de la empresa para comprender la demanda de los mercados cambiantes reflejada en nuevos productos, la capacidad de los empleados de almacenar información de conocimientos para futuros desarrollos y la generación de reuniones periódicas para hacer análisis de tendencias del mercado.

Así mismo, se ha utilizado para esta medición el uso de un lenguaje común, similitud y compatibilidad (Jiménez-Barrionuevo et al., 2011) la capacidad de los empleados para reconocer los cambios en el mercado, nuevas oportunidades para ayudar a los clientes y

comprender los cambios en la demanda (Jiménez-Castillo & Sánchez-Pérez, 2013), la comunicación, reuniones, archivos, transmisión, tiempo y flujos (Jiménez-Barrionuevo et al., 2011) y las habilidades de los empleados para identificar nuevos conocimientos de mercado que se distribuyen para ellos y las habilidades para fusionar el conocimiento previo del mercado y hacer la asimilación para propósitos comerciales (Jiménez-Castillo & Sánchez-Pérez, 2013).

#### **3.1.4. Medición de explotación**

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La fase de explotación hace referencia al proceso de aplicar conocimiento externo para crear valor adentro o afuera de las organizaciones. En esta fase ese conocimiento es utilizado para desarrollar nuevos productos, procesos o servicios o para mejorar los existentes

Para medir la fase de explotación se han desarrollado diferentes indicadores.

Por ejemplo, se ha medido a partir del desarrollo de nuevos productos (Zhang et al., 2018). También se ha medido la capacidad de los empleados para explotar el conocimiento del mercado y reaccionar con el desarrollo de nuevos productos (Jiménez-Castillo y Sánchez-Pérez, 2013). Finalmente, la "fase de explotación" puede evaluarse en función de si la empresa está activamente buscando explotar nuevos conocimientos y si los empleados tienen un lenguaje común relacionado con los nuevos productos (Lau y Lo, 2015).

#### **3.1.5. Medición basada en la capacidad de absorción potencial y realizada**

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La capacidad de absorción potencial se ha medido identificando las habilidades de los empleados para comprender nuevas oportunidades para los clientes, analizar e interpretar los cambios en la demanda y utilizar nueva información basada en el conocimiento previo (Flor et al., 2018). Otros indicadores incluyen la búsqueda de fuentes externas de productos y tecnologías, el escaneo de tendencias tecnológicas, la utilización de nuevas oportunidades de mercado, el análisis de los cambios en el mercado las tendencias tecnológicas y el almacenamiento del conocimiento tecnológico para el futuro (Aliasghar et al., 2019; Kuek et al., 2013).

Por otro lado, la capacidad de absorción realizada se refiere al grado en que una empresa ha logrado absorber y utilizar de manera efectiva el conocimiento externo. Se puede medir a través de indicadores como el desarrollo de nuevos productos (Liu et al., 2021). Vicente-Oliva et al. (2015) midió la capacidad de absorción realizada según el grado en que los empleados están al tanto de las innovaciones, su habilidad para estructurar y recopilar conocimiento, la utilización de dicho conocimiento en su trabajo y la adopción de nuevas tecnologías.

Otros autores han empleado mediciones de la capacidad de absorción, tanto potencial como realizada, fundamentándose en la habilidad de consultar fuentes externas como consultores, clientes, conferencias y prensa, entre otros y el análisis de la calidad y variedad de productos, la capacidad de producción y flexibilidad de la empresa y la reducción de costos en producción, mano de obra y materias primas (Alves & Galina, 2020).

### **3.2. Medición de capacidad de absorción en general (unidimensional)**

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Hay varios métodos que han sido utilizados para medir la capacidad de absorción de manera unidimensional.

Basse Mama (2018) midió la capacidad de absorción utilizando la relación de citas hacia dadas a la literatura académica con el número de citas dadas de patentes y citas dadas de la literatura académica. Behera (2015) , Cruz-González et al. (2015), Mowery y Oxley (1995) y Tsai (2001) midieron la capacidad de absorción basándose en la intensidad de I+D.

Boynton et al. (1994) se enfocaron en el uso de sistemas de gestión del conocimiento, mientras que Cherbib et al. (2021) midieron la transferencia de conocimientos técnicos a través de alianzas estratégicas. Gilsing et al. (2008) midieron la capacidad de absorción en términos de colaboraciones de I+D en alianzas estratégicas, utilizando indicadores de análisis de redes sociales como la centralidad del grado y la densidad. George et al. (2001) utilizaron el inversión en I+D basada en patentes como medida de la capacidad de absorción, mientras que Gkypali et al. (2018) utilizaron el capital en I+D y la relación de empleados con títulos técnicos y de posgrado en marketing, pronóstico o innovación. Heeley (1997) consideró la comunicación con el entorno externo, la diversidad y el ajuste entre estructuras y la posición

estratégica de la empresa. Huang et al. (2015) utilizaron el número de empleados de I+D como medida de la capacidad de absorción. Luo (1997) consideró la relación entre los recursos humanos técnicos y todos los empleados. Mangematin y Nesta (1999) evaluaron la capacidad de absorción utilizando la inversión en I+D, el número de investigadores, las actividades de I+D, los laboratorios de I+D, la colaboración con instituciones de investigación, el número de artículos y trabajos, y el número de empleados de I+D que captan conocimientos científicos y tecnológicos. Mowery et al. (1996) analizaron la posición técnica antes de la creación de una alianza. Rey et al. (2021) utilizaron la relación entre empleados de I+D y todos los empleados como medida de la capacidad de absorción realizada. Venturini et al. (2019) midieron la capacidad de absorción en términos de los recursos humanos técnicos que captan el conocimiento científico y tecnológico. Finalmente, Vu (2018) evaluó la eficiencia técnica en función de los empleados.

### **3.3. Otras metodologías para medir la capacidad de absorción**

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En otros casos, se han utilizado diferentes métodos para medir la capacidad de absorción. Figueiredo y Cohen (2019) analizaron la capacidad de absorción externa medida a través de la adquisición de conocimiento y las alianzas estratégicas y la capacidad de absorción interna analizada a partir de los procesos de aprendizaje organizacional, codificación e integración.

Otros indicadores que han sido utilizados para medir la capacidad de absorción incluyen los títulos académicos de los empleados, la intensidad de I+D analizada a través de una comparación entre la inversión en I+D y los ingresos, y las metodologías para la gestión de relaciones y prácticas de transferencia de conocimiento en la organización (Kafouros et al., 2020).

También se han utilizado indicadores como la visión organizacional, las responsabilidades de análisis del entorno, las habilidades técnicas para la asimilación del conocimiento, las habilidades de gestión para la gestión del conocimiento y los recursos humanos que pueden resolver problemas relacionados con el conocimiento externo (Yang & Tsai, 2019). Finalmente, otros enfoques han utilizado para medir la capacidad de absorción el escaneo y monitoreo de información que aborda las actividades de inteligencia competitiva, el

conocimiento del mercado -competidores, comportamiento de los clientes y conocimiento de fortalezas y debilidades de los competidores- (Ratine et al., 2016).

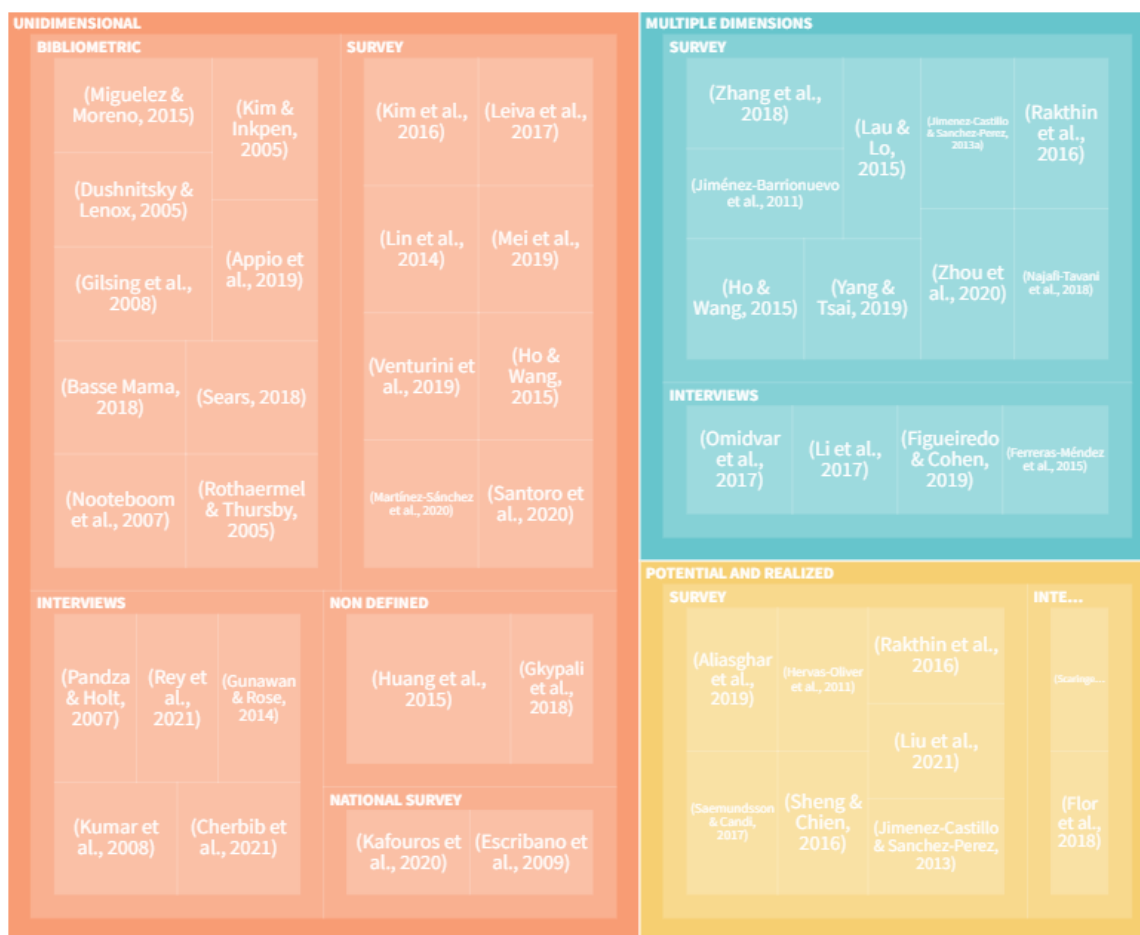


Ilustración 6 Medición de la capacidad de absorción según el tipo de medición con múltiples dimensiones, unidimensional y el método de recolección de la información (encuesta, entrevista, bibliometría)

Fuente: (Cuéllar et al., 2023b)

### 3.4. Medición de la capacidad de absorción usando métodos bibliométricos

La medición de la capacidad de absorción utilizando métodos bibliométricos ha sido utilizada por varios autores. Miguelé y Moreno (2015) analizaron la capacidad de absorción regional utilizando variables de movilidad y red. Los autores tomaron información de patentes y analizaron la movilidad y las redes de inventores en función de los solicitantes de países.

Gilsing et al. (2008) utilizaron indicadores de redes sociales como la centralidad de grado, la densidad más la distancia tecnológica (clases de patentes) para analizar el potencial de innovación de las empresas, en base a la creación y la absorción de novedad. Otros autores también han utilizado indicadores de análisis de redes para medir la capacidad de absorción (Enkel & Heil, 2014).

Algunos autores han analizado la capacidad de absorción con base a las citas, tomando las citas no propias (Appio et al., 2019; Rothaermel & Thursby, 2005a) y la citación cruzada de patentes (Kim & Inkpen, 2005).

Para medir la capacidad de absorción científica, Basse Mama (2018) estudió la relación entre las citas dadas propias y las citas dadas de patentes y literatura de no patentes.

Las citas dadas también se han utilizado para identificar la capacidad de absorción entre unidades de negocio en la misma empresa (Shin & Jalajas, 2010).

Otros autores han utilizado diferentes indicadores basados en datos de patentes para medir la capacidad de absorción. Por ejemplo, el stock de patentes de las empresas (Dushnitsky & Lenox, 2005; Wagner, 2011), las patentes por habitante en 101 países (Malik et al., 2021), las patentes acumuladas (Nooteboom et al., 2007), la participación de patentes entre todos los actores de una industria y las tecnologías pionera identificada por patentes que no tienen antecedentes de patentes relevantes (Srivastava et al., 2015). Así mismo, se han utilizado como proxy de capacidad de absorción el número de clases de patentes (Ruth et al., 2013), la comparación entre clases de patentes entre dos organizaciones que están llevando a cabo un proceso de transferencia de tecnológica (Wang & Li-Ying, 2014), el número de áreas de clasificación basadas en la clasificación internacional de patentes (vom Stein et al., 2015) y la co-ocurrencia de clasificaciones de patentes, en el stock de patentes de una empresa (Ramani et al., 2008).

La siguiente figura resume diferentes métodos para medir la capacidad de absorción basado en el análisis de dimensiones (adquisición, asimilación, transformación y explotación) de Cohen y Levinthal (1989), del análisis de capacidad de absorción potencial y realizada de Zahra y George (2002), la medición de forma unidimensional y los diferentes metodologías, indicadores o fuentes utilizadas con este propósito.



Ilustración 7 Medición de la capacidad de absorción según el tipo de dimensión y el tipo de análisis bibliometrico o información de patentes

Fuente: (Cuellar et al., 2023b)

### **3.5. La medición de la apropiación del conocimiento**

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Sobre la apropiación de conocimiento Rubira-García et al. (2018) midieron la apropiación por parte de los agricultores de café utilizando un enfoque etnográfico. Milesi et al. (2013) midió en Argentina la apropiación del conocimiento basándose en la patente, las marcas, el secreto, la estrategia de primer jugador y la participación y control de las redes de distribución. Colombelli et al. (2020) utilizó un enfoque similar y agregó otros indicadores como el tiempo de liderazgo y activos complementarios como producción y comercialización. Otros autores han utilizado enfoques similares basados en la propiedad intelectual para medir la apropiación del conocimiento (Arbussa & Coenders, 2007; Barros, 2021). Benedicto et al. (2014) y Rubira-García et al. (2018) utilizaron mecanismos de apropiación directa (propiedad intelectual) e indirecta como redes, alianzas, incubadoras de empresas, spin-offs y colaboraciones universidad-industria para medir la apropiación. Torres de Oliveira et al. (2021) midieron la apropiación utilizando los mecanismos de propiedad intelectual y otros nuevos indicadores como la complejidad del diseño del proceso del producto, los contratos de los empleados, la ventaja de tiempo de liderazgo y capacidades complementarias de fabricación.

Otros enfoques han medido otros elementos que afectan la apropiación del conocimiento. Por ejemplo, la relación triple hélice utilizando alianzas globales, redes de movilidad, iniciativas colectivas entre universidades, gobierno e industria y joint ventures (Heitor, 2015).

## **PARTE II. PUBLICACIONES APORTADAS**

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#### **Capítulo 4. Similarities and differences between absorptive capacity and appropriability: A bibliometric perspective**

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Abstract

purpose – this study aimed to examine the similarities and differences between the ability to analyze the environment and exploit new knowledge (absorptive capacity) and the skills to generate value from innovation (appropriation). these fields have similar origins and are sometimes confused by practitioners and academics.

design/methodology/approach – a review was conducted based on a full-text analysis of 681 and 431 papers on appropriation and absorptive capacity, respectively, from scopus, science direct and lens, using methodologies such as text mining, backward citation analysis, modularity clustering and latent dirichlet allocation analysis.

findings – in business disciplines, the fields are considered different; however, in other disciplines, it was found that some authors defined them quite similarly. the citation analysis results showed that appropriation was more relevant to absorptive capacity, or vice versa. from the dimension perspective, it was found that although appropriation was considered a relevant element for absorptive capacity, the last models did not include it. finally, it was found that studies on both topics identified the importance of appropriation and absorptive capacity for innovation performance, knowledge management and technology transfer.

originality/value – this is one of the first studies to examine in-depth the relationship between appropriation and absorptive capacity, bridging a gap in both fields.

**KEYWORDS:** absorptive capacity, appropriation, appropriability, bibliometrics, clustering analysis, backward citation analysis

## PAPER TYPE LITERATURE REVIEW

### 4.1. Introduction

Cohen and Levinthal (1990) defined absorptive capacity (ac) as “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends.” appropriation is a concept that has some sub-definitions. appropriation has been defined as a “firm’s ability to benefit from its resources and capabilities” (Milesi et al., 2013; Teece, 1988). the appropriability regime (a sub-concept of appropriation) was defined by Teece (1986) “as the environmental factors, excluding firm and market structure, that govern an innovator’s ability to capture the profits generated by an innovation.” Value appropriation (another sub-concept) is defined as “the share of exchange rent a focal firm can capture” (Gulati and Wang, 2003). Appropriation capability (another sub-concept) is known as “firms’ ability to protect their novel intellectual property” (Leiponen and Byma, 2009; Reitzig and Puranam, 2009). Finally, Hurmelinna-Laukkanen and Yang (2022) introduced the concept appropriation potential, which they defined “as an innovator’s potential to benefit from innovation. This potential builds on the instruments of appropriability—isolating appropriability mechanisms and complementary assets—that afford the innovator control over the innovation.” They further asserted that appropriation is realized when “innovators realize benefits in the form of private and social returns in processes employing the instruments of appropriability.” This study condensed these four concepts into appropriation (KA).

AC and KA are fields that have evolved together. For instance, AC seminal models include KA as an important factor that influences the AC process. AC has been recognized as a multidimensional process (Knoppen et al., 2022), and some authors have defined KA as a dimension of AC (Thomas and Wood, 2014). In addition, some authors have used similar methods to measure each. For example, KA mechanisms as intellectual property have been used to measure AC (Appio et al., 2019; Arbuss`a and Coenders, 2007; Bahl et al., 2021;

Barros, 2021; Malik et al., 2021; Milesi et al., 2013; Rey et al., 2021; Spithoven and Teirlinck, 2015).

Some authors have studied the benefits of AC and KA when these are together. For instance, Cenamor et al. (2019) analyzed the roles that KA mechanisms and AC play in knowledge exchange and their positive impact, and Aliasghar and Haar (2021) identified the importance of KA and AC over knowledge capacity and performance. In addition, regarding KA mechanisms and AC, some authors have studied the impact of patent stock on AC (Shuwaikh and Dubocage, 2022).

Furthermore, a large body of literature has shown the significant individual benefits of AC and KA regarding relevant topics such as innovation (Lyu et al., 2022; Sarsah et al., 2020), entrepreneurship (Ejdemo and Ortqvist, 2020; Miller et al., 2021), knowledge spillovers (Alnuaimi and George, 2015; Duan et al., 2021), small and medium enterprises (Cassia et al., 2020; de Zubielqui et al., 2016) and green innovation (Marrucci et al., 2021; Vokoun and Jilkova, 2020). In addition, some authors and practitioners have defined KA quite similarly to AC or have defined KA models similar to AC (Benamar et al., 2020; Carroll et al., 2003).

To the best of our knowledge, there is a lack of studies analyzing the relationship between AC and KA as well as its importance in innovation and value generation. Some authors have identified this gap in the literature. For instance, Da Silva Florencio and De Oliveira (2022), in their review, encouraged research on KA and AC in technology transfer processes. Moreover, Chaparro et al. (2021) showed the importance of having KA in AC, specifically in start-ups.

Hurmelinna-Laukkanen et al. (2012) showed the relevance of studying the AC and KA relationship. In addition, regarding KA, Sun and Zhai (2018) showed the relevance of performing a deep study of KA and AC, indicating that “the discussion about the relationship of appropriability and absorptive capacity is the other hotspot in this field,” and defining AC as a key element of KA considering the number of papers and citations. However, few studies have performed an in-depth comparison of AC and KA to clarify their similarities and differences and to determine whether they can be considered the same or part of the other. Therefore, we conducted a systematic review in which we deeply compared AC and KA,

comparing the dimensions of each field, analyzing the literature on both areas and identifying trends in these scientific papers.

The outline of this review is as follows:

The research methodology presents the research questions, databases, queries and analysis methods. In the “findings” section, we answer specific questions formulated to understand the differences and similarities between AC and KA. Next, we present a discussion and main conclusions of the outcomes. Finally, we present the limitations and recommendations of this study.

#### 4.2. Research methodology

We conducted a systematic review based on a bibliometric analysis (Castaneda and Cuellar, 2021). We followed Testa et al. (2021) framework, making some adaptations considering the nature of our study. The steps developed in this study were as follows.

- (1) Establishing the review questions and protocol
- (2) Downloading full text regarding AC or KA
- (3) Identifying documents focused on AC and KA, employing inclusion and exclusion criteria
- (4) Identifying scientific papers relevant to each research question

##### 4.2.1. Research questions and protocol

To establish the similarities and differences between AC and KA, we defined the following research questions:

**RQ1.** What are the similarities and differences between KA and AC in terms of their definitions?

**RQ2.** Do AC and KA have the same foundations?

**RQ3.** Can KA be considered a dimension of AC?

**RQ4.** What papers have studied KA and AC and what were their subject matters?

#### 4.2.2. Downloading full text regarding AC or KA

To answer the research questions, we used two strategies. RQ1, RQ3 and RQ4 were answered based on full-text analysis, and RQ2 was answered using the citation information recovered using bibliographic information, specifically backward citation data.

We started by identifying databases that allowed us to download full-text documents. We identified Science Direct as a data source, as it permitted the download of mostly full-text papers. Furthermore, we downloaded Scopus and Patent Lens full-text papers that could be recovered from these resources.

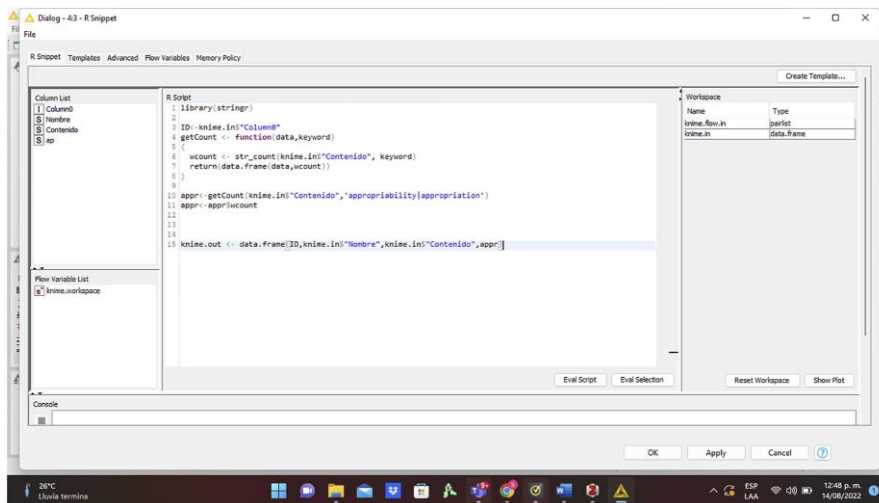
Our search query for AC literature was “absorptive capacity,” and that for KA literature was appropriability OR “knowledge appropriation” in titles, abstracts and keywords. We did not limit the search based on the year of publication to obtain all relevant literature to understand both topics. The subject categories were also filtered for management, accountancy and social sciences to recover only the scientific papers that were key to this investigation.

We used the PDF exportation option from Science Direct and Scopus to download full-text papers. However, Patent Lens does not allow automatic download of PDF documents; hence, we built a program based on web scraping (Open web Scaper, 2021) to recover PDFs from this database. For backward citation analysis, we used bibliographical information recovered from Scopus and Lens. We started working with 681 and 431 full-text papers on KA and AC, respectively. We used R to convert PDFs into text, especially the Tabulizer library (Leeper, 2018). This tool processes PDFs without changing the document structure. Finally, we filtered duplicated records using the string matching tool and the duplicate row filter from Knime.

#### 4.2.3. Inclusion and exclusion criteria

We started by identifying scientific papers that focused on AC or KA. The strategy for this was to identify papers that had more than five key terms in the text. To identify these documents, we used the Knime R tool “R Snippet.” Furthermore, the GetCount function from the stringR package was applied to obtain relevant scientific papers for their term frequency (Datacamp, 2019). Consequently, the data set decreased to 368 and 410 for KA and AC, respectively. An example of the code used is shown in Figure 1.

Figure 1. R code used in Knime for filtering scientific papers focused on AC and KA



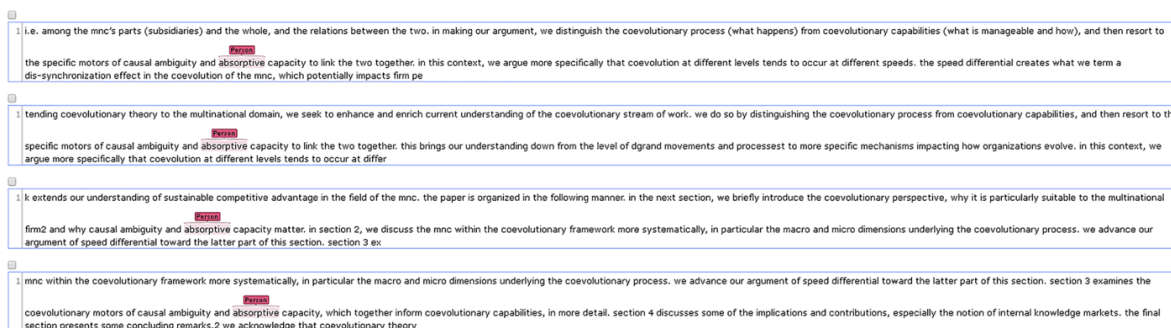
Identifying scientific papers relevant to each research question To answer RQ2, we performed a bibliometric analysis of backward citations (Castaneda and Cuellar, 2019). This analysis was performed using bibliographic information of the data set obtained in the last step of the methodology. RQ1, RQ3 and RQ4 were answered using fulltext analysis. To identify the scientific papers that could help us answer these questions, we used the GetCount function of R in Knime. We split the documents using the sentence extractor node (Tursi and Silipo, 2019) and selected phrases related to our research questions. Table 1 shows the keywords used to identify relevant documents for each research question.

Table 1. Query strategies to recover information regarding each research question

Research question	Keywords
RQ1	Define OR definition
RQ3	Dimension OR mechanism (only for KA) OR step
RQ3	(Acquisition OR assimilation OR transformation OR exploitation OR potential OR realized)
RQ3	NEAR/4 (“absorptive capacity” OR AC OR ACAP)
RQ3	“Intellectual property” OR patent OR “formal mechanism” OR “informal mechanism” OR
RQ4	“legal instruments” OR brand OR secrets OR trademark
RQ4	(“absorptive capacity” OR AC) NEAR/7 (appropriability OR “knowledge appropriation”)

We manually identified and selected the scientific papers that were most relevant to each research question. To review these documents, we split the documents into sentences. To read the sentences, we used the “Tagged Document Viewer” tool from Knime. An example of this visualization is shown in Figure 2.

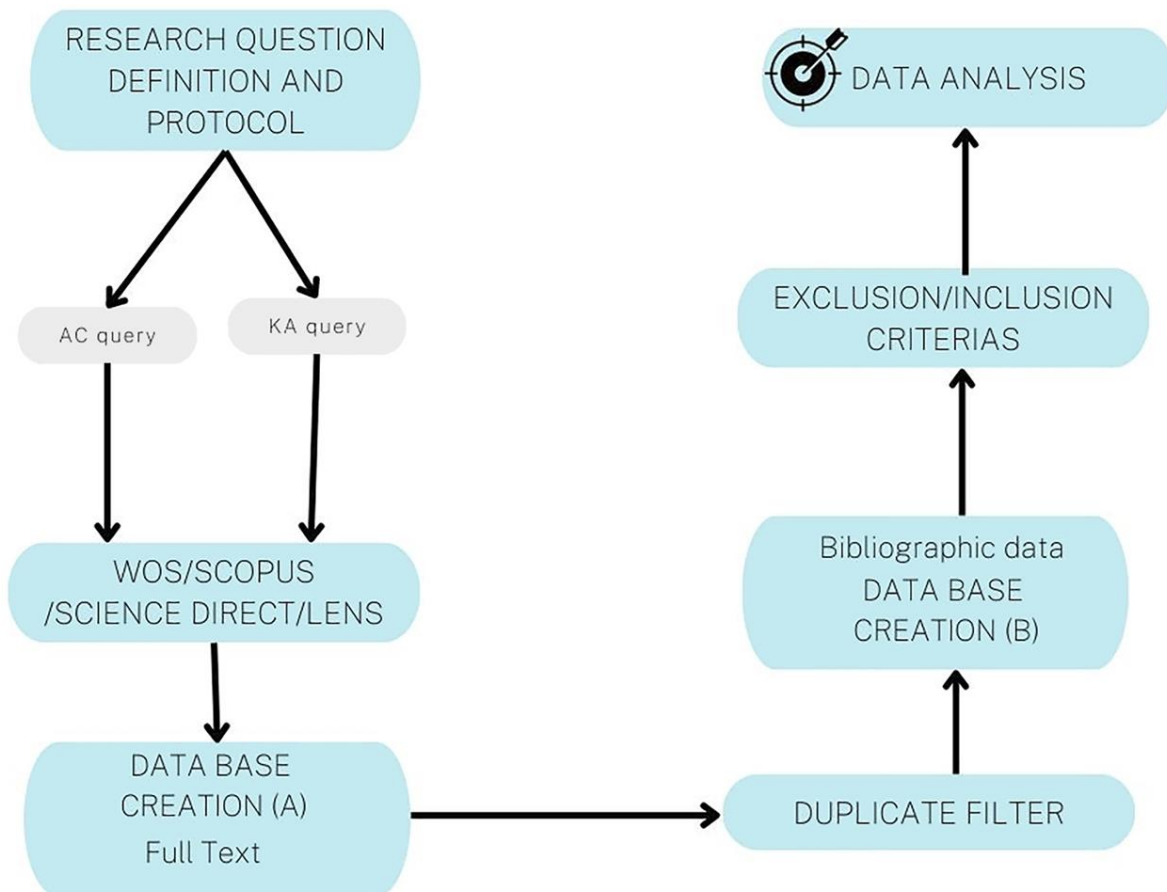
Figure 2. Text revision using Knime tool



Because of the huge volume of phrases found, bibliometric analysis – specifically cluster analysis – was the most appropriate method to analyze this volume of information and identify patterns (Castaneda and Cuellar, 2021). Semantic analysis was performed to answer RQ4. This analysis was carried out to analyze all phrases regarding both topics (AC and KA). To identify the most relevant terms, we normalized the words using different criteria. The main terms and phrases were obtained using the N-gram tool of Knime, which allowed us to obtain two-word sentences. To identify the main trends, we created a data cleansing process

that merged similar terms. Data cleansing was performed using the WinPure data cleansing tool and Tableau Desktop group creation software. Data analysis was conducted using the Knime Lda and T-sne nodes (Choo et al., 2013) and the Vosviewer modularity clustering tool (van Eck and Waltman, 2010), which facilitated the identification of patterns in the data and synthesized the data set. Figure 3 shows our analysis framework.

Figure 3. Data frame used in this Research



**Source(s):** Inspired by Testa *et al.* (2021)

### 4.3. Findings

4.3.1. RQ1: What are the similarities and differences between KA and AC in terms of their Definitions

AC is a field that emerged from management. Cohen and Levinthal (1990) introduced the concept of AC as the ability to exploit external knowledge and the capability to use it. They divided the AC process into four stages: knowledge acquisition, knowledge assimilation, knowledge transformation and knowledge exploitation. Zahra and George (2002) reconceptualized and essentially advanced the definition, dividing the process into two main steps: potential AC and realized AC. Potential AC comprises knowledge acquisition and assimilation, and realized AC comprises the transformation and exploitation stages. Potential AC is related to searching for knowledge that may be useful to a company and sharing it within the organization. Potential AC utilizes this new knowledge along with the organization's prior knowledge and exploits it via innovations, new processes or new business models. Another important contribution of the authors is that AC is a dynamic capability (Teece et al., 1997), meaning that it is a set of routines and tasks that the company learns. Arbussa and Coenders (2007), with an approach similar to that of Zahra and George (2002), divided AC into scanning the environment and the KA of the knowledge acquired. Lane et al. (2006) performed an extensive review of the literature, identifying the main contributions of relevant studies, and developed a model of AC. They based their investigation on a comprehensive bibliometric analysis and identified the main focus of the literature on AC. They identified papers that made a real contribution to state-of-the-art and the most important subtopics: AC innovation and organizational learning AC. Subsequently, they redefined AC as a "firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning." Lane and Lubatkin (1998) reconceptualized AC based on strategic alliances. They developed the concept of relative AC in their research and identified different learning mechanisms. They concluded that the acquired skills were close to their capabilities for seeking new knowledge. Jansen et al. (2005) reexamined Zahra and George's (2002) potential and realized AC and analyzed the effect of organizational antecedents on them. Other authors reconceptualized the AC concept, emphasizing the recognition of the value phase, social mechanism and power relationships (Todorova and Durisin, 2007). Tsai (2001) studied the relationship between

networks and AC. He argued that the central position in collaboration networks is better for learning and generating innovations and business performance if the units have excellent AC.

#### 4.3.1.1. KA definitions

Regarding KA, our analysis allowed us to identify different perspectives and definitions, depending on the area. In management, there are three subcategories of appropriation: appropriation, appropriability regime and value appropriation. Appropriation has been defined as “the firm’s ability to benefit from its resources and capabilities” (Milesi et al., 2013; Teece, 1988). Kamoche and Mueller (1998), focusing on the context of human resources, found that appropriation can be split in two dimensions: retention and absorptive learning. Retention is related to preserving relevant human resources, and absorption refers to the use of expertise in the processes of the firm. They also argued that appropriation is associated with preventing the erosion of knowledge stock and the ability to transfer external employees to maintain valued expertise within the firm. Kamoche and Maguire (2010) defined knowledge appropriation as “the capture and absorption of rents from the utilization of knowledge.” Workers principally maintain knowledge appropriation (Law, 2013). The most recent approach developed by Hurmelinna-Laukkanen and Yang (2022) is based on 200 key KA papers; the authors view KA as “the potential to extract value from innovation” and broadly define it as “as an innovator’s potential to benefit from an innovation. This potential builds on the instruments of appropriability—isolating appropriability mechanisms and complementary assets—that afford the innovator control over the innovation.” Regarding realized KA, they further state that “innovators realize benefits in the form of private and social returns in processes employing the instruments of appropriability.” Another concept related to KA is the appropriability regime, defined by Teece (1986) “as the environmental factors, excluding firm and market structure, that govern an innovator’s ability to capture the profits generated by an innovation.” Arbussa and Coenders (2007) defined it as “institutional protection of the knowledge spillovers that endanger the appropriation of rent from innovation.” They also established that the most common mechanism for a good appropriability regime is intellectual property based on patents, trademarks, industrial secrets and copyrights (Cenamor et al., 2019; Hurmelinna-Laukkanen, 2014). Capturing the most significant profits from innovation is called primary KA, and the creation of future innovation

is called generative appropriability (Vega-Jurado et al., 2008b). Colciencias (2010), Colombia's Ministry of Science and Technology, defines social KA as the interaction of social groups that generate knowledge as a process of comprehension and intervention in the relationship between research and development and society. In the social sciences, the term appropriation has been used in the sense of "making something your own" (Benamar et al., 2020). In technology, the term is related to adopting, adapting and incorporating the product, process or model of interest (Carroll et al., 2003).

From a marketing perspective, Benamar et al. (2020) defined the different stages in an appropriation process as symbolic appropriation, exploration, construction and stabilization. Carroll et al. (2003), in studying mobile technology appropriation, developed a similar perspective, defining the different appropriation stages as adoption, deeper evaluation, adaptation and integration. From both perspectives, the user's role is not only to absorb the technology but also to transform it and generate value. Our analysis shows that some KA definitions are analogous to those of AC. For instance, Carroll et al. (2003) presented an approach with similar stages to an AC process, where the different levels could be analogous to AC dimensions in this order: adoption with acquisition, deeper evaluation with assimilation, adaptation with transformation and integration with exploitation. Kamoche and Mueller's (1998) retention process could be analogous to acquisition and absorptive learning in the assimilation step in AC. Vega-Jurado et al.'s (2008b) generative appropriability stage is analogous to the transformation stage or "making something your own" (Benamar et al., 2020). Benamar et al. (2020) defined appropriation as "making something your own"; when this happens, it is necessary to absorb the knowledge and exploit it. The difference between KA and AC is evident in the literature, in which AC obtains and transforms knowledge from the environment. KA is a firm's ability to obtain value from innovation.

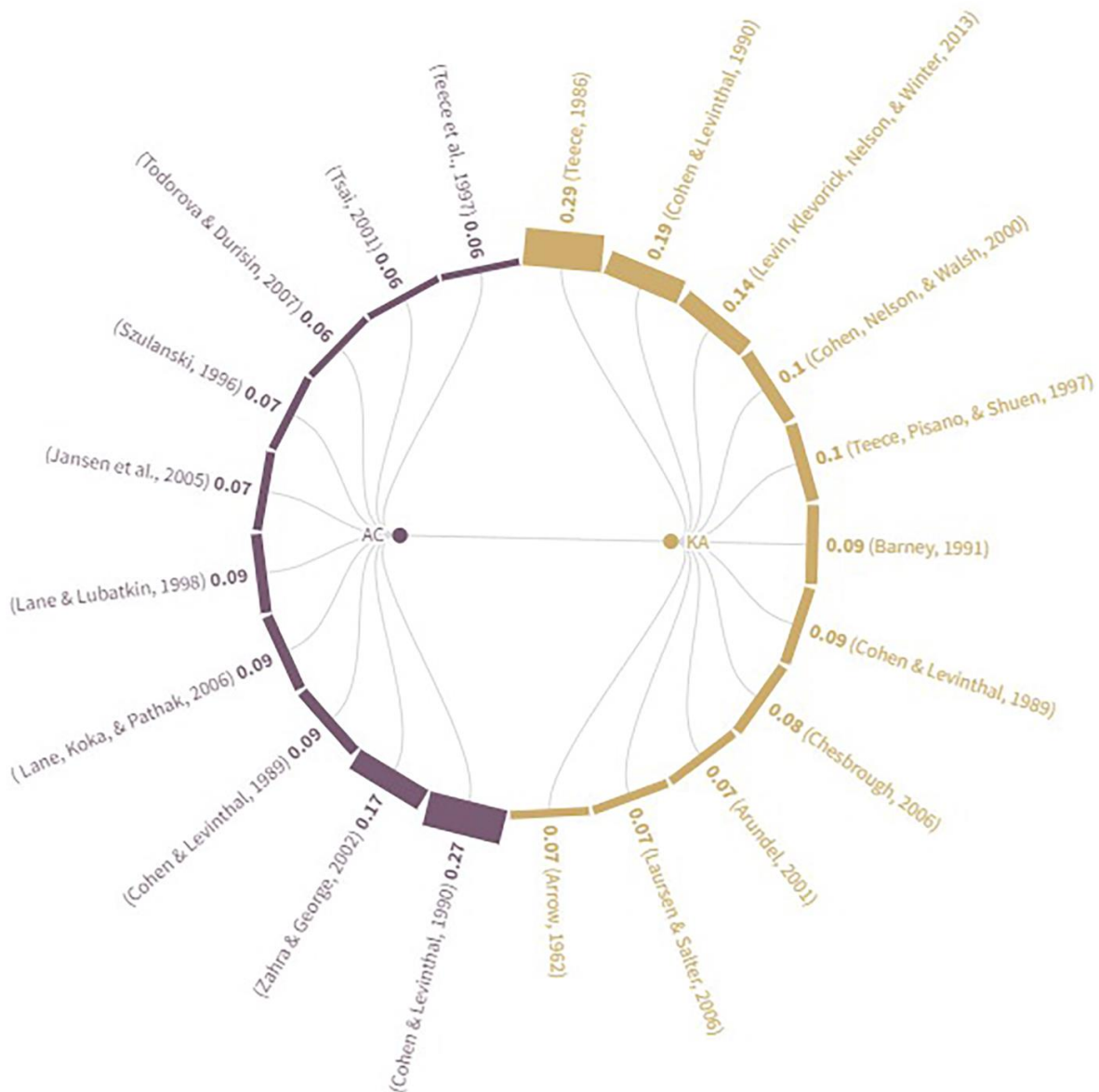
#### 4.3.2. RQ2: Backward citation analysis

RQ2 seeks to determine whether the foundations of AC and KA are the same. To answer this question, we conducted a backward citation analysis for each topic individually. A comparison was made to identify similarities and differences in their genesis. Figure 4 shows the scientific literature considered relevant to the authors of the core scientific papers. Cohen

and Levinthal's (1990) paper was the most popular reference by backward citations for AC authors, with Cohen and Levinthal (1989) being the third most cited.

In the KA context, Cohen and Levinthal's (1990) paper was the second most referenced, and their (1989) paper was the seventh. These papers establish the concept of AC as "the ability of a firm to recognize the new external information, assimilate it and apply it to commercial ends." This research demonstrates the nature of AC as a process with different stages. These investigations also propose the appropriability regime "as a moderator of the antecedent of AC" (Todorova and Durisin, 2007). Cohen and Levinthal (1990) empirically found that KA is negative for AC. When there is an industry with low KA, absorptive AC is more accessible. Zahra and George' (2002) paper was the second most crucial on AC by backward citations, and the 54th for KA (none in the backward core citations). They transform and reconstruct AC and view it as a dynamic capability or set of routines and processes. Routines are organizational activities that facilitate work via resources and organizational skills, and managerial processes are social interactions (Todorova and Durisin, 2007). Zahra and George (2002) proposed two stages: potential AC and realized AC. They established an appropriability regime as an element that regulates AC and the outcomes of sustainable competitive advantage. They defined the appropriability regime as "the institutional and industry dynamics that affect the firm's ability to protect the advantages of (and benefit from) new products or processes." They also discussed another relevant concept, knowledge spillover or loss of control over the innovations generated in the firms, which occurs when the investment in AC is low. Additionally, they found that when an appropriability regime exists, it helps to generate knowledge appropriation based on intellectual property rights. Lane et al.'s (2006) paper was the fourth most relevant backward citation for AC core literature, but it was irrelevant to KA literature.

Figure 4. Main backward citations in the absorptive capacity and knowledge appropriation fields



**Note(s):** The numbers show the relevance of each against the sum of the total number of backward citations of the ten most relevant citations

They conducted an extensive review of the literature, defined the papers' main contributions and developed a model of AC. They based their research on comprehensive bibliometric analysis. They identified literature that focuses on AC. They found papers that made a real contribution to the state-of-the-art and most important subtopics, such as organizational learning, AC, innovation and AC. Subsequently, they redefined AC as a "firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory

learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning.” This research only mentions knowledge appropriation relating to the conclusions of Cohen and Levinthal (1989). Lane and Lubatkin’s (1998) paper was the fifth most relevant paper on AC, and the second for KA, while Lane et al.’s (2006) paper was the sixth. Lane and Lubatkin (1998, 2006) analyzed appropriability based on Cohen and Levinthal (1989). They reconceptualized AC based on strategic alliances and developed the concept of relative AC by identifying different learning mechanisms. They concluded that the skills required to acquire new knowledge were close to their capabilities. Todorova and Durisin’s (2007) paper is another relevant paper on AC. They reconceptualized the AC concept, emphasizing the recognition of the value phase and the acquisition, assimilation, transformation and exploitation phases. They defined three critical items as contingent factors: the social mechanism (social relationships or networks with the environment), power relationships (relationships between players in an ecosystem) and KA.

Their model defines KA as relevant before recognizing the value and after the exploitation phase (i.e. in the first and last stages of AC). Jansen et al.’s (2005) paper is relevant in the AC literature, but KA was not among the first twenty most popular backward citations. They considered Zahra and George’s (2002) potential and absorptive capacities and analyzed the effect of organizational antecedents on

AC. However, this study did not introduce KA. Tsai (2001) provided another relevant backward citation. He defined AC as the capacity to respond to new knowledge. He examined the relationship between networks and AC and argued that the central position in collaboration networks is better for learning and generating innovation and business performance. In this study, knowledge appropriation and similarities were not examined. Figure 4 shows the backward citations in the AC and KA fields. On the other hand, we identified KA relevant backward citations. As discussed earlier, some scientific investigations have been conducted on AC and KA. The seminal authors Cohen and Levinthal (1989, 1990) were among the backward citations more relevant to appropriability authors. Other backward citations are not relevant to AC but have been KA’s building blocks or essential references. Teece’s (1986) paper is one of the seminal papers on KA in

management. He analyzed some business cases that show that an innovator company does not always exploit and generate profits from innovation. In some cases, these profits come from followers. He subsequently recognized three critical elements for capturing the market: the appropriability regime, dominant design and complementary assets. Following up, he defined the appropriability regime as “the environmental factors, excluding firm and market structure, that govern an innovator’s ability to capture the profits generated by an innovation.” The technological field and legal mechanisms of protection influence the appropriability regime. The relevance of technology related knowledge (tacit or explicit) and the role of intellectual property were also examined in this investigation. He defined two critical dimensions of appropriability: legal instruments related to intellectual property and the nature of the technology associated with the type of development (product or process) and the type of knowledge. Subsequently, he defined three types of KA. Tigh KA occurs when an innovation can be protected against intellectual property. Even when the technology is not ready for the market and the IP is not strong, the innovator can generate complementary assets for marketing. Related to weak KA, the author refers to industries that require a long period of development. Teece (1986) defined three types of players: innovators, imitators and owners of cospecialized assets. Regarded as players, he showed why large firms have more opportunities of launching innovation than small firms, emphasizing the co-specialized assets that facilitate appropriability. The relevance of industry structure in appropriability was also demonstrated in this study. In addition, he recognized that the maturity level of an industry is also relevant; this is not the same for generating profits in an emergent industry where everybody is looking to develop a dominant design for a mature industry where scale economies are essential. Winter and Nelson (1982) began with a relevant dichotomy. Patents give the owner a monopoly but are also pertinent to diffuse innovations to benefit customers. They defined the following KA methods: patents, secrecy, lead time and learning curve advantages. Learning methods were also analyzed to identify the most relevant license agreements, reverse engineering and independent R&D. Finally, they explored the cost and time required for imitation and the costs of duplicating innovations (typical and significant). One of the main conclusions of this study is that a patent system improves the appropriability of innovation returns. Lead time is also a key factor. Other mechanisms such as secrecy, the learning curve and sales and services can provide additional protection. They also

demonstrated that patents are not the best strategy for appropriation. The industry's KA levels are also an essential factor in this analysis, showing a strong correlation among them. This study did not discuss AC because the concept did not yet exist. From a similar perspective, Cohen et al. (2000), based on 1478 R&D labs, analyzed the relevance of different KA mechanisms and found that lead time and secrecy are the primary mechanisms used by manufacturing industries. To protect product innovation, they found that firms have increased confidentiality; therefore, patents are not only used for KA but also for commercialization, marketing and preventing rivals from patenting similar inventions. Teece et al.'s (1997) seminal paper on dynamic capabilities was the fifth most crucial backward citation in the KA field and the tenth most crucial backward citation in the AC field. This study focuses on one of the most critical building blocks in management. Regarding KA, the authors discuss its relationship with imitation and indicate that a robust KA regime avoids replication, and vice versa. Barney (1991) is another research paper that has been significantly cited in the KA literature. Barney analyzed the relationship between firm resources and sustainable competitive advantage. Another relevant document related to backward citation analysis was published by Chesbrough (2006). His book provides examples of open innovation. Using the case of the IBM open innovation model, he analyzes a business case, the critical aspects of open innovation and the role that patents play in business models. Some IBM open innovation strategies make their patent information available to improve knowledge flows and access to their patents, and to create new databases such as Delphion. They also use mechanisms such as cross-licensing to share and exchange technology. Arundel (2001) is another relevant KA article. He explored the relevance of patents versus secrecy for appropriation and found that companies prefer to use secrecy as an appropriation tool. Laursen and Salter (2006) were the authors of another relevant backward citation paper. They analyzed companies' strategies by searching for new ideas and technologies in innovation. New sources and actors appear as options to find innovative ideas. Arrow (1962) is another relevant KA study that focuses on invention, which is defined as a knowledge product. Arrow established the factors that influence investment in inventions. He viewed information as a commodity, and an invention as a data product. Thus, information is an appropriate commodity for inventors. Some problems related to the appropriation of inventions are the complexity of the system and lack of incentives. In

addition, he recognized that a relevant issue of investment in inventions is that appropriation is time-limited. This study also discusses the relevance of information as innovation input. Regarding RQ2, our backward analysis shows that KA is a concept that has an older foundation; it has been included as a relevant factor in seminal publications on AC. Although it is not considered a dimension of AC, the influence of KA as a negative factor or positive element of AC has been discussed by the principal authors. However, seminal researchers originally focused on KA's role in innovation and the primary mechanism for generating KA. We can conclude that AC has partially influenced the foundations of appropriability.

#### 4.3.3. RQ3: AC dimensions

To answer RQ3, regarding whether KA can be considered a dimension of AC, we identified scientific papers focusing on the AC and KA dimensions. AC researchers have clearly defined the different phases of this process. These phases include the acquisition, assimilation, transformation and exploitation phases. The acquisition phase seeks to localize, identify and acquire external knowledge (Jimenez-Barrionuevo et al., 2011). The assimilation phase aims to analyze, classify, process, interpret and internalize relevant knowledge (Cohen and Levinthal, 1990; Jimenez-Barrionuevo et al., 2011). Zahra and George (2002) call these two phases potential AC. In the transformation phase, organizations transfer and combine previous expertise with new knowledge. In this phase, knowledge is added, eliminated, interpreted or blended in new or different ways (Jansen et al., 2005; Jimenez-Barrionuevo et al., 2011). Finally, in the exploitation phase, new knowledge is incorporated and transformed into a firm's operations. This capability allows the company to enhance the creation and improvement of products, processes, services, new organizational forms and derivatives (Jansen et al., 2005; Jimenez-Barrionuevo et al., 2011).

These two phases are labeled by Zahra and George (2002) as realized AC.

Another group of authors divided AC into no codified knowledge or tacit and codified knowledge as explicit (Scaringella et al., 2017). Another classification is based on the internal and external routines of knowledge absorption (Lewin et al., 2011) or external and internal knowledge capacity (Figueiredo and Cohen, 2019). Figure 5 summarizes the different terms

that authors have used to define the various dimensions of AC and whether they study appropriability in their research.

#### 4.3.3.1. KA dimensions

Teece (1986) defined different dimensions of the appropriability regime. He established two types of crucial dimensions: (1) legal instruments that refer to intellectual property mechanisms used to protect knowledge, such as patents, trademarks and trade secrets, and (2) KA based on the nature of technology, that is, as a product, process, tacit or codified. The literature does not show significant changes in these dimensions. For example, in Argentina, Milesi et al. (2013) measured KA based on patents, brands, secrecy and two new dimensions not mentioned in Teece (1986). These are first-mover strategies and the participation and control of distribution networks. Moreover, Colombelli et al. (2020) used a similar approach and aggregated other indicators such as lead time and complementary assets, including commercial and production. Other authors have used similar methods based on intellectual property to measure KA (Arbussa and Coenders, 2007; Barros, 2021).

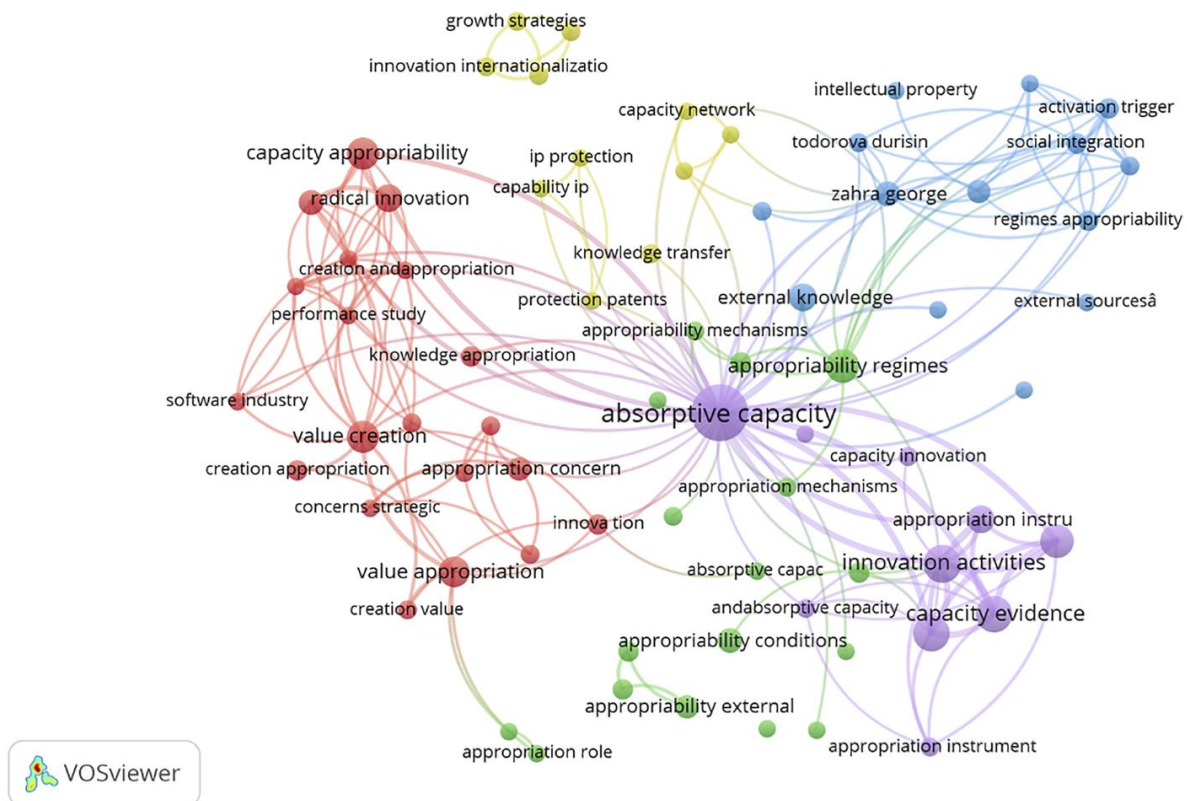
Benedicto et al. (2014) and Rubira-García et al. (2018) classified the dimensions in the direct (intellectual property) and indirect appropriation mechanisms as networks, partnerships, business incubators, spin-offs and university-industry collaborations. Torres de Oliveira et al. (2021) used the traditional IP mechanism and other new indicators such as product complexity, process design, employee contracts, lead time advantage, complementary manufacturing, marketing and service capabilities as knowledge appropriation dimensions.

Figure 5. Absorptive capacity Dimensions



To better understand the link between KA and AC, we analyzed scientific papers that have examined both KA and AC. Two methodologies were used for the analysis. The first was the Vosviewer modular-based clustering methodology. This methodology defines groups based on the strength of the relationship between nodes, in this case keywords (Apriliyanti and Alon, 2017; Tibaná-Herrera et al., 2018). The second methodology was the latent Dirichlet allocation (LDA) probabilistic methodology. This methodology defines the probability that a paper can be part of a topic or cluster, and also, for each cluster, this methodology recognizes the most representative terms (Choo et al., 2013; Kherwa and Bansal, 2018). We used the T-sne dimension reduction methodology to simplify the interpretation of LDA analysis (Choo et al., 2013). In Vosviewer, we identified five main thematic clusters, represented by different colors (Figure 6).

Figure 6. Main trends in literature analyzing Both AC and KA

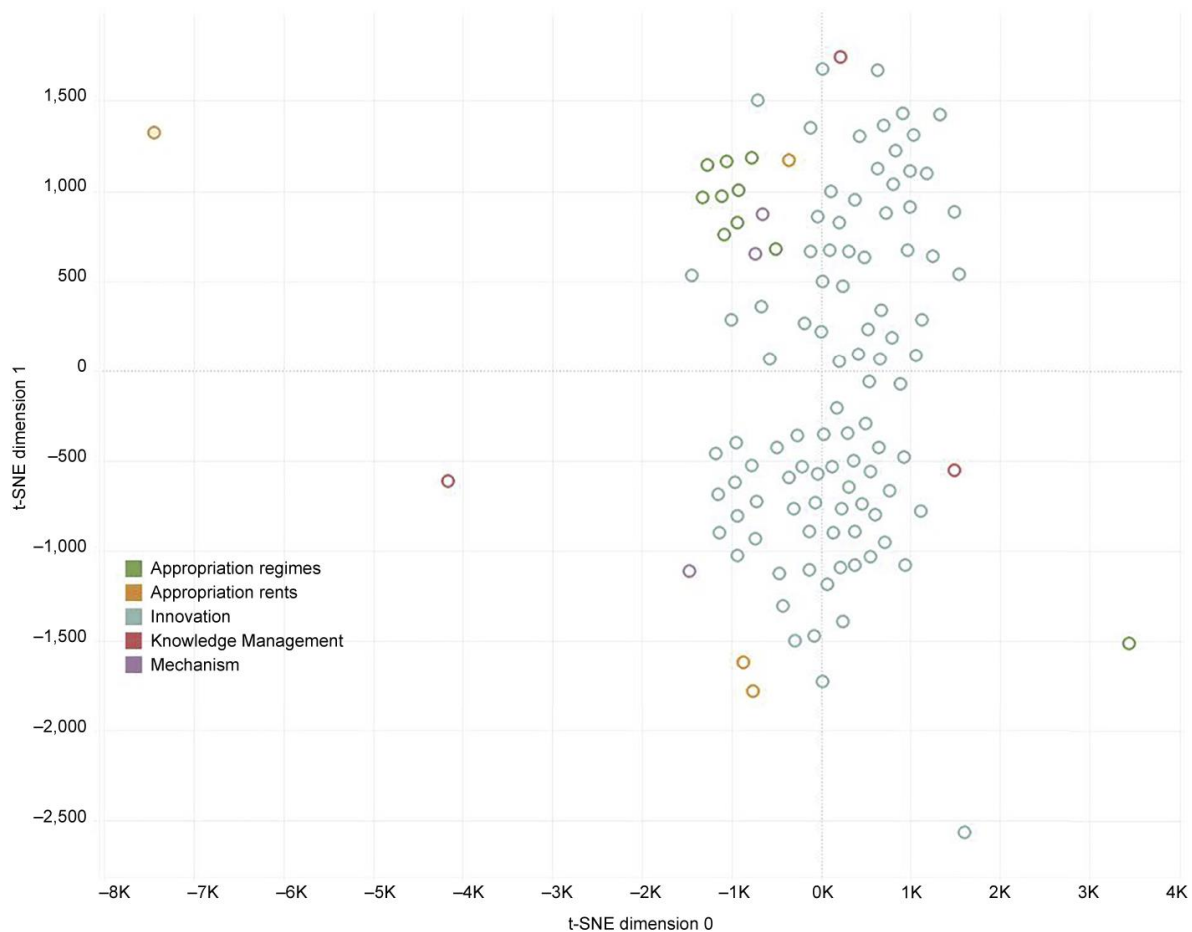


The blue cluster represents the appropriability regime and its strong links with social activation, intellectual property and external knowledge. Some relevant links in this group were social integration and intellectual property.

The purple cluster represents the link between KA instruments and innovation activities. The red cluster represents value and knowledge appropriation, and its link to innovation, particularly radical innovation and value creation. The yellow cluster represents intellectual property and its relationship with knowledge transfer, networks, internationalization and growth strategies. Finally, the green cluster analyzes the appropriability regimes, appropriability conditions and mechanisms. We used the LDA model to identify the distance between the records. We defined five topics using this model based on the Vosviewer clusters we identified beforehand. We established the importance of each topic in all the documents analyzed. Our analysis shows that the topic of innovation (blue) was identified in 82.61% of the documents (see Figure 7). The other topics (colors) had fewer occurrences than blue. For instance, appropriation regimes (green) were identified in 8.70% of the documents, appropriation rents (orange) in 3.48% of the documents and appropriation mechanisms (purple) and knowledge management (red) in only 2.61% of the documents.

To interpret each topic more deeply, we analyzed papers that had more weight in each topic and were relevant in terms of the number of times that the terms KA and AC appeared in the full text. For the appropriability regime, we analyzed the following documents. Thomas and Wood (2015) defined KA as the last dimension of AC from a tourism perspective. They recognized the relevance of this dimension in the innovation process and the difficulty of using these mechanisms correctly. Cuervo-Cazurra and Ruiz (2017) recognized KA as an external barrier to AC owing to weak KA and weak agreements, resulting in poor technology transfer and inadequate protection of intellectual property rights.

Figure 7. LDA key topics in the KA and AC literature



Bahl et al. (2021) analyzed the link between KA capability, internationalization and innovation, and found that KA weakens the link between these two topics. Synergistic effects between AC and KA were identified in this study, demonstrating the relevance of the exploration and exploitation of knowledge. Additionally, AC and KA are strongly related to innovation processes as positive or

negative triggers. The topic “Innovation” aims to deepen knowledge in this area. Giant magnetoresistance is an important innovation that has revolutionized the world. This is the basic technology for hard drives. Dedrick and Kraemer (2015) examined the history of this technology and showed that AC has contributed significantly to exploiting this technology

in the United States and Japan. They also found that the limited returns on investment to the first innovators are due to a bad appropriability regime over the technologies.

Value appropriation is a key topic identified in our Vosviewer analysis and is placed in the innovation cluster. Cepeda-Carrion et al. (2016) analyzed the link between AC and value in the banking industry. They also examined the role of knowledge application. They found that banks had mainly focused on realized AC to obtain value appropriation in the industry. They referred to value appropriation as “the development of a set of capabilities to extract benefits that stem from value creation” or the retention of value in organizations, which they argued is more important than avoiding imitation from competitors. Kokshagina et al. (2017), from an open innovation viewpoint, recognized the relevance of AC for KA and implementation processes in ecosystems and organizations. They proposed a new type of open innovation to stimulate AC. Hervas-Oliver et al. (2011) identified a correlation between technological opportunities, KA conditions and innovation performance by observing the differences between intensive R&D industries and non-intensive R&D organizations. Firms with more internal resources can develop AC correctly and obtain relevant information from the environment. Escribano et al. (2009) showed that AC is important for managing external knowledge flows to stimulate innovation outcomes. They found that AC was an important source of competitive advantage in environments with turbulent knowledge. They analyzed the degree of turbulence and level of legal appropriability and found that solid legal appropriability facilitates external knowledge flows. Vega-Jurado et al. (2008a) analyzed the external and internal factors that affect product innovation and novelty. They found that a company’s technological competency is a key factor in product innovation. They also found that environments with more appropriability conditions are better for innovation performance. Furthermore, they examined the indirect effect of increasing AC, which affects a firm’s capability to exploit external knowledge.

Another relevant topic is knowledge management. O’Dwyer and O’Flynn (2005) analyzed the importance of knowledge value in alliance governance, mainly in knowledge exchange, and the critical role of AC and organizational learning in these relationships. They studied knowledge appropriation in networks and the coordination of these communities. The mutual relationship between AC and KA was analyzed in detail in this research. They recognized

that it is harder to perform KA when knowledge is tacit. However, when knowledge is explicit, is easier to appropriate it, which can result in better governance. Hurmelinna-Laukkanen et al. (2012) examined the relevance of improving AC, KA and network stability in orchestration. They found that AC and KA were enhanced when the networks were stable. Therefore, intellectual property plays an important role in this governance because it is the channel that generates knowledge transfer and protects knowledge inside the network.

The final topic we explored was KA mechanisms. Spithoven and Teirlinck (2015) examined R&D outsourcing based on four elements: internal capabilities, AC, formal and informal KA mechanisms and network resources. One of the main conclusions of this study is that informal mechanisms, such as complexity design, are better at generating a competitive advantage than formal mechanisms, such as patents, which are harder to protect. The study found that stronger use of the KA mechanism stimulates R&D outsourcing.

Hurmelinna-Laukkanen and Olander (2014) recognized the lack of information about AC and KA. To evaluate KA, the authors used formal and informal mechanisms. They found that KA positively affects firms' innovation performance. They also argued that the appropriability regime significantly affects controlling innovations when competitors have AC.

Concerning RQ4, we found that AC and KA are strongly linked to innovation performance and each subfield of KA, such as value appropriation and the appropriability regime.

#### 4.3.5. Discussion

AC and KA are key elements of innovation performance (Hurmelinna-Laukkanen et al., 2012). The objective of this study was to analyze the similarities and differences between AC and KA and how they have been studied in the literature. The academic community has identified the necessity of studying the relationship between AC and KA in depth. Systematic reviews have identified the need to study these topics together (Chaparro et al., 2021; Da Silva Florencio and De Oliveira, 2022; Hurmelinna-Laukkanen et al., 2012; Sun and Zhai, 2018). Our research addresses this gap in the literature by comparing the origins of AC and KA based on backward citations, comparing AC and KA definitions and identifying the links between AC and KA based on the literature. Our findings show that the AC building block

literature typically includes KA as a key element (Cohen and Levinthal, 1990; Zahra and George, 2002), while regarding KA, Cohen and Levinthal's (1989, 1990) AC building blocks are also key backward citations. In addition, although the seminal authors (Cohen and Levinthal, 1990; Todorova and Durisin, 2003, 2007; Zahra and George, 2002) included KA as a key element in their models, the last models do not include KA as a dimension of AC (Harris and Yan, 2019; Marrucci et al., 2021), with some exceptions such as Thomas and Wood (2014). These analyses suggest that KA cannot be considered an AC dimension and vice versa, but both should be considered key elements (Da Silva Florencio and De Oliveira, 2022). Notwithstanding, although there are similarities in some specific definitions, both concepts have clear differences. Studies that have examined both topics have focused on the impact of AC and KA on value generation, mainly in innovation performance (Dedrick and Kraemer, 2015), the link of AC and KA with knowledge transfer and management (O'Dwyer and O'Flynn, 2005) and the link between AC and KA mechanisms (Spithoven and Teirlinck, 2015), but not the theoretical relationship between the two. Our results show that AC and KA are key elements with similar origins and have evolved together.

Regarding RQ1, in management, there is a clear difference between AC as a process for acquiring, assimilating, transforming and exploiting knowledge, and KA as the generation of value and rents from innovation. However, the KA concept has not been developed solely in the field of management, and some authors have proposed definitions that are similar to AC (Benamar et al., 2020; Carroll et al., 2003; Kamoche and Mueller, 1998).

RQ2 concerns whether AC and KA have similar foundations. In the literature, we did not find any other studies that compared the backward citations of AC and KA. Nevertheless, some bibliometric studies have identified the seminal papers of KA using methods such as cocitations and have recognized the majority of building blocks that we recognized in our study (Arrow, 1962; Teece, 1986; Winter and Nelson, 1982), which validates our results. Our investigation showed that KA always plays a key role in the main building block of AC (Cohen and Levinthal, 1990; Todorova and Durisin, 2007; Zahra and George, 2002). However, our findings show that the key literature on AC (Cohen and Levinthal, 1989, 1990) has also been among the most cited references in the KA literature. Our findings corroborate those of Sun and Zhai (2018), who recognized AC as a "citation bust node" of KA. Our

findings further show that the foundations of both topics are strongly related, and for a large set of authors, they have the same foundations.

Regarding RQ3, many authors have used the KA mechanism for measuring AC dimensions and AC when it has been considered a nondimensional process (Cuéllar et al., 2022). For instance, KA mechanisms, specifically patents, have been used to measure AC (Appio et al., 2019; Bishop et al., 2011; Deeds, 2001; Dushnitsky and Lenox, 2005; Kim and Inkpen, 2005; Malik et al., 2020, 2021; Ramani et al., 2008; Rothaermel and Thursby, 2005; Ruth et al., 2013; Shin and Jalajas, 2010; Srivastava et al., 2015; vom Stein et al., 2015; Wagner, 2011).

The state-of-the-art subtopics show the importance of KA as a proxy for AC dimensions. Our analysis shows that KA is considered a key element of AC in the seminal models of AC, but not as an AC dimension (Cohen and Levinthal, 1990; Todorova and Durisin, 2007; Zahra and George, 2002). The last AC model typically does not have KA as an AC dimension. These outcomes suggest that this trend is not included as a dimension (Ferrerias-Mendez et al., 2015; Harris and Yan, 2019). Although some authors have included KA as a dimension (Thomas and Wood, 2014), this is not common in the literature. Regarding RQ4, clearly, the investigation of AC and KA has been a hot topic in the literature, as Sun and Zhai (2018) recognized in their study. Our analysis addresses a gap in the literature on AC and KA, showing that studies have focused on the effects of AC and KA and their mechanisms on innovation and technology transfer. Our analysis corroborates the lack of studies on the relationship between AC and KA as indicated in the literature (Chaparro et al., 2021; Da Silva Florencio and De Oliveira, 2022; Hurmelinna-Laukkanen et al., 2012; Sun and Zhai, 2018).

#### 4.3.6. Conclusions

This study clearly and concisely shows the differences and similarities between AC and KA. Both fields have similar foundations based on a deep and extensive analysis of their origins. There are similarities in some definitions of KA and AC, but both concepts are different in the management sciences. KA is not considered an AC dimension; however, KA is a key element of AC, and vice versa. Both fields are crucial to innovation, knowledge management and technology transfer. This study addresses a gap in the literature by deeply analyzing both

fields and conducting a rigorous comparison of these fields and the importance of both in strategic topics in innovation and knowledge management.

This study employs a new approach for conducting systematic reviews based on web scraping, robot process automation, machine learning methodologies and bibliometrics. This methodology has not been common in other systematic reviews. One of the advantages of this approach is that we can more easily identify relevant papers based on full-text analysis.

Furthermore, we found more papers relevant to our analysis using this approach than using the title, abstract and keywords approach, showing the robustness of our method. Some limitations of our research include the lack of availability of full text in the databases we used. This type of analysis is challenging, and access to full-text documents depends on the agreement between libraries. Another limitation concerns the database used in this study. Other databases, such as Proquest or Web of Science, could be useful for future studies. Our analysis has created an opportunity for future research. Therefore, more studies are needed to analyze the influence of AC on KA, and vice versa. Specifically, more research needs to be conducted to analyze the macro and micro levels. For instance, researchers could study the influence of AC and KA on innovation in a country, or they could compare two similar countries with different innovation performances, such as Chile and Colombia. Scientific papers such as those by Dedrick and Kraemer (2015) are needed to understand why the production of innovations is limited in some countries. However, to understand the link between these two fields from other perspectives, a convergence and divergence analysis could provide another perspective on the benefits of these topics in different management areas (Hacklin et al., 2021). We suggest that policymakers should generate policies that improve AC and KA to improve innovation performance and technology transfer in emerging economies with weak innovation ecosystems.

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**Capítulo 5. *Convergence between absorptive capacity and knowledge appropriation: A new methodology Mapping the hidden links***

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Abstract

This study investigates the relationship between Absorptive Capacity (AC) and Knowledge Appropriation (KA), two significant domains in technology transfer, knowledge management, and innovation. While there is an inherent connection between these fields, there remains a gap in understanding their comprehensive convergence. To address this, we reviewed 3412 AC and 368 KA articles, employing techniques such as life-cycle, changepoint, and advanced keyword analyses. We also introduced innovative methods like the H-index, CAGR, and a unique approach comparing keyword frequency over time between AC and KA, spotlighting key convergence areas: innovation, entrepreneurship, and knowledge spillover. Our analysis revealed a parallel evolution of AC and KA, as demonstrated by their shared timelines, thematic overlaps, and mutual influences in the realm of innovation. The life-cycle analysis showed a faster evolutionary pace for AC than for KA but highlighted their shared roots in management during the late 80s. Furthermore, we identified foundational building blocks, including patents, R&D, and knowledge management, that underpin their convergence. Interestingly, some divergent areas were also pinpointed, such as the emphasis on organizational learning in AC but its absence in KA. In summary, this study provides a clear picture of the intertwined relationship between AC and KA, presenting a refined methodology to explore convergence between academic fields, setting the stage for further research in this domain.

## 5.1. Introduction

Absorptive capacity (AC) is defined as the ability to acquire, assimilate, transform, and exploit knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002 ) based on environmental scanning (Lane et al., 2006 ) and mediated by social mechanisms and strategic alliances (Todorova and Durisin, 2007 ). Knowledge appropriation (KA) is defined as the "firm's ability to benefit from its resources and capabilities" (Milesi et al., 2013; Teece, 1988), generating profit from the innovation (Teece, 1986 ), and the protection strength depends on the depth of the appropriability (Chen and Chang, 2019 ). AC and KA are strongly associated with their origins, and the main AC models have named KA as a trigger or an adverse effect for AC (Cohen and Levinthal, 1990; Zahra and George, 2002 ). In addition, AC and KA are essential elements that improve innovation performance (Dedrick et al., 2010; Hervás-Oliver et al., 2011; Kokshagina et al., 2017 ), knowledge management-KM- (Hurmelinna-Laukkanen, 2012a; ODwyer and OFlynn, 2005 ), and entrepreneurship and value generation (Cepeda-Carrion et al., 2017 ).

The specialized literature on each topic has identified the relevance of studying AC and KA in depth (Chaparro et al., 2021 ; Hurmelinna-Laukkanen, 2012; Sun and Zhai, 2018 ), recognizing, AC as a hotspot of KA (Sun and Zhai, 2018 ) and identifying the need to study both topics in depth. Some studies have analyzed the link between AC and KA, comparing their origin and the effects on innovation and KM (Cuellar et al., 2022 ). These approaches have identified explicit connections between AC and KA but not the underlying links.

Hidden links between two or more topics can be identified using convergence analysis. It was defined as "the increasing overlap between different scientific fields and is manifested through intensified cross- disciplinary scientific research" (Hacklin et al., 2021 ). Through this type of analysis, we can better understand the relationship between fields that may seem disconnected (Rosenberg, 1963). Convergence has mainly been applied to understand the convergence between techno - logical fields or industries (Klarin et al., 2021 ), mostly based on patent data (Heo and Lee, 2019 ), and it is mainly used to understand the influence of further scientific development and technologies in various industries. In the management

field, convergence analysis is an emerging topic. Recognizing this gap, our purpose was to leverage convergence analysis to elucidate the nuanced relationship between AC and KA. We posited the research question: "What are the hidden links between AC and KA, and how do they converge in the context of management studies?" This study seeks to provide clarity on this intricate interplay. To identify the hidden links between KA and AC, we conducted a convergence analysis by comparing the evolution of both topics to identify the patterns over time. We identified the main trends in each field to distinguish the convergence of the impact in different areas. In addition, we analyzed the convergence in time to determine whether this convergence has grown. In addition, we examined the positive and negative impacts of AC and the influence of KA on the main management convergence fields to uncover convergences based on their impact. Finally, we identified other management topics that have been important to generate this convergence as essential complements building blocks. To conduct this analysis, we performed a review based on bibliometric analysis. This paper is divided into the following sections.

Fig. 1. Convergence between AC and KA in AC models.

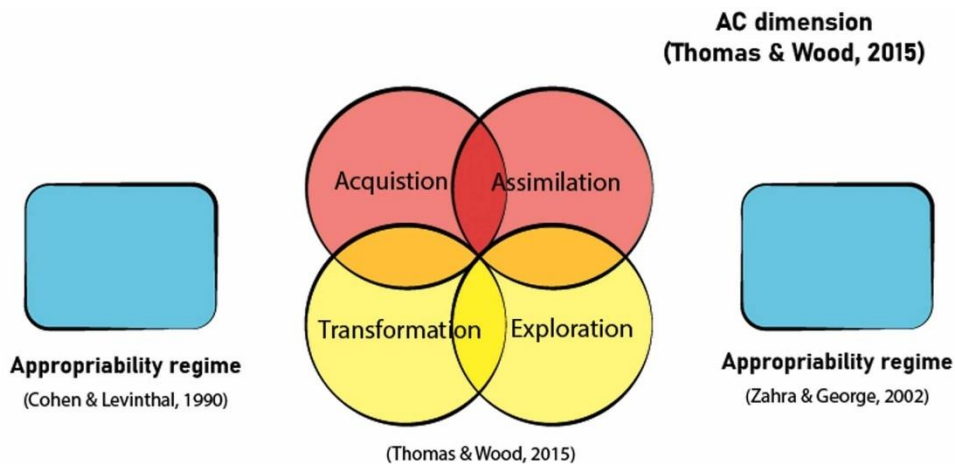
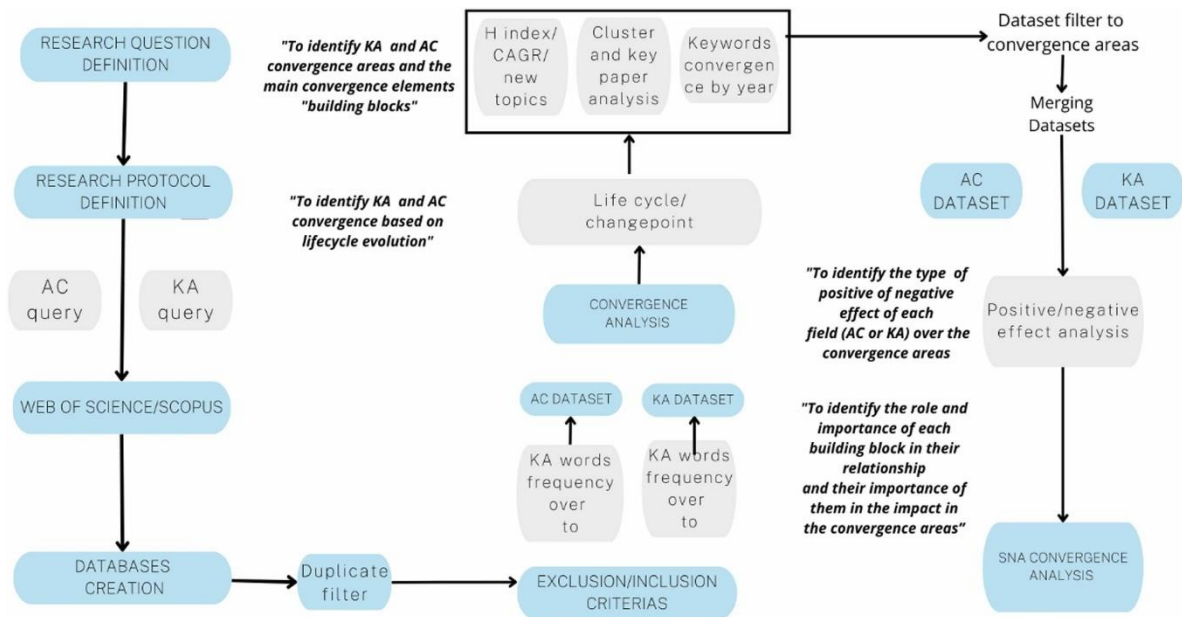


Fig. 2. Framework of analysis of our research.



First, we examine the literature on convergence and instances of convergence between AC and KA. Second, we present our bibliometric methodology for convergence analysis. Third, the results section illustrates the primary convergence between absorptive capacity (AC) and knowledge appropriation (KA). We demonstrate how AC and KA have evolved over time, pinpointing the main thematic intersections, the profound impacts on key domains, and the intricate relationships and coevolution among central topics and areas of convergence. Finally, we discuss our findings, outline the main conclusions, and provide recommendations for future research.

Fig. 3. Search strategies for recovering AC and KA literature.

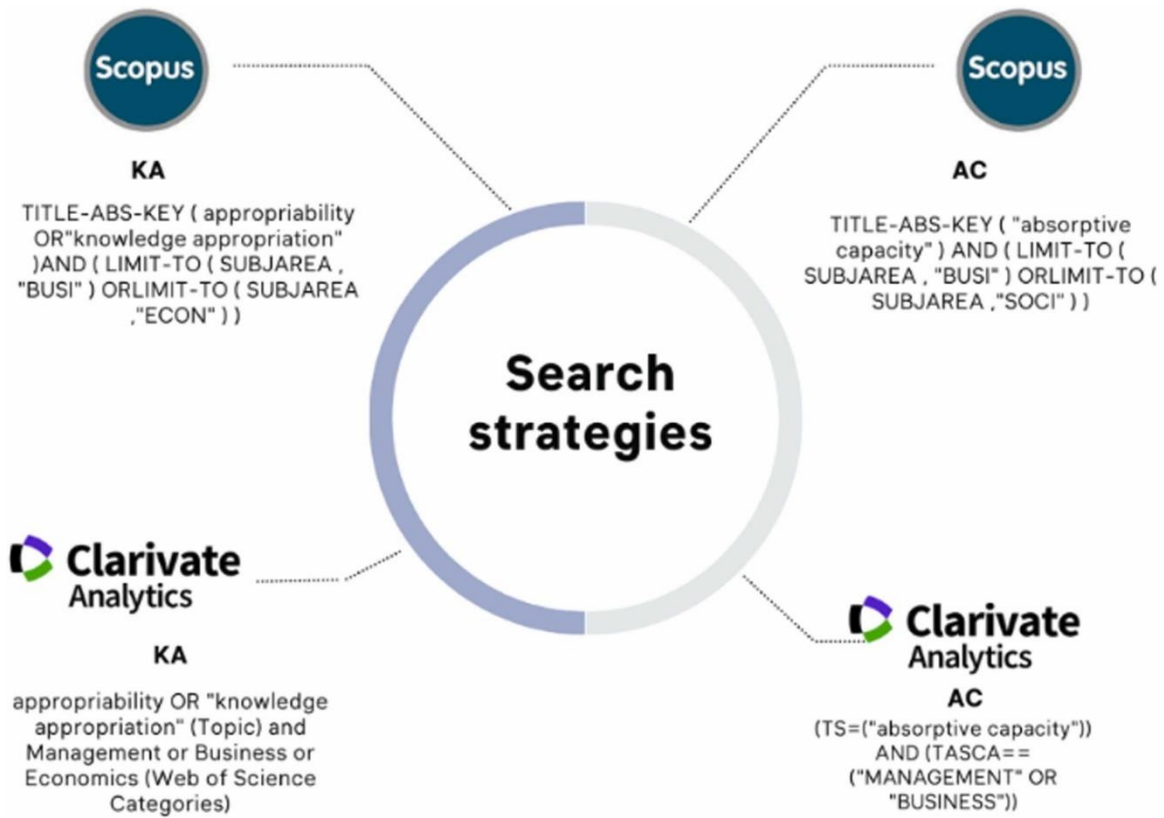


Fig. 4. Life-cycle method used in this study.

Number of researchers per year	Maturity (low investment in science)	Growth
	Emergent	Maturity (High investment in science)
	Number of Scientific papers per year	

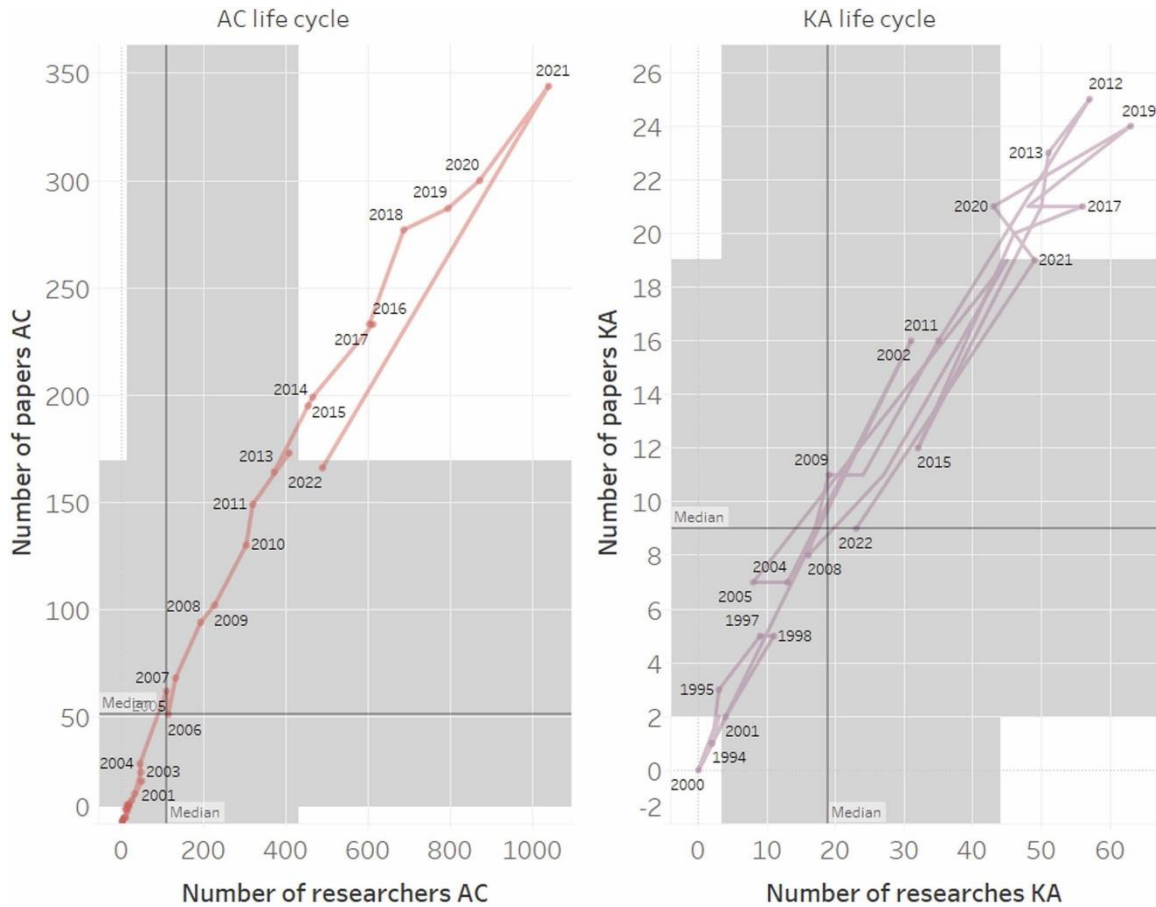
Table 1 Year convergence analysis between AC and KA.

AC Topics	KA Topics	Convergence	Divergence
Intellectual capital, patent	Patent, knowledge sharing	Intellectual capital	Knowledge sharing

Fig. 5.Part of speech analysis.



Fig. 6.Life-cycle convergence between AC and KA.



Legend: In the provided diagrams, the left illustrates the AC life cycle and the right shows the KA life cycle. Both use a red line for the left trajectory and a purple line for the right. Quadrants are categorized into Emergent (bottom left) and Growth (top right) phases, with a division line marking the median number of papers and researchers.

## 5.2. Convergence literature

Convergence has been analyzed by the academic community to recognize the affinity between fields and technologies and the occurrence of overlapping. Rosenberg (1963) introduced this concept to explore the Computer Numerical Control (CNC) industry. This notion has been mainly studied in technological fields (Jeong et al., 2015; Shmulewitz et al., 2006; Sick et al., 2019). Another form of convergence is industrial convergence. It arises from the interconnections among industrial clusters (Chen et al., 2022) and is characterized by the application of technology from one domain to another (Curran et al., 2010), often

termed as industry fusion (Bierly III and Chakrabarti, 2001 ). In new product development, convergence unfolds through four stages: scientific, technological, application, and industry (Chen et al., 2022 ). According to Sick and Broring (2022), convergence is an emerging topic. Convergence has been studied in various areas, including pharmaceuticals, nutraceuticals, functional foods (Bornkessel et al., 2015; Curran et al., 2010; Curran and Leker, 2011 ), information and communication technologies (Hacklin et al., 2021 ), energy storage (Sick et al., 2019 ), urban metabolism (Cao et al., 2020 ), digital technologies for banking (Thomas, 2019 ), lightweight materials (Kim and Lee, 2021 ), fintech (Pietronudo et al., 2021 ), and quantum mechanics (Luan et al., 2021 ).

Table 2 Change point years in KA and AC. Change point KA Year AC Year Media 2011 2013  
Media Variance 2001 2004

Fig. 7. Main topics in AC based on H-index, CAGR, and new topics.



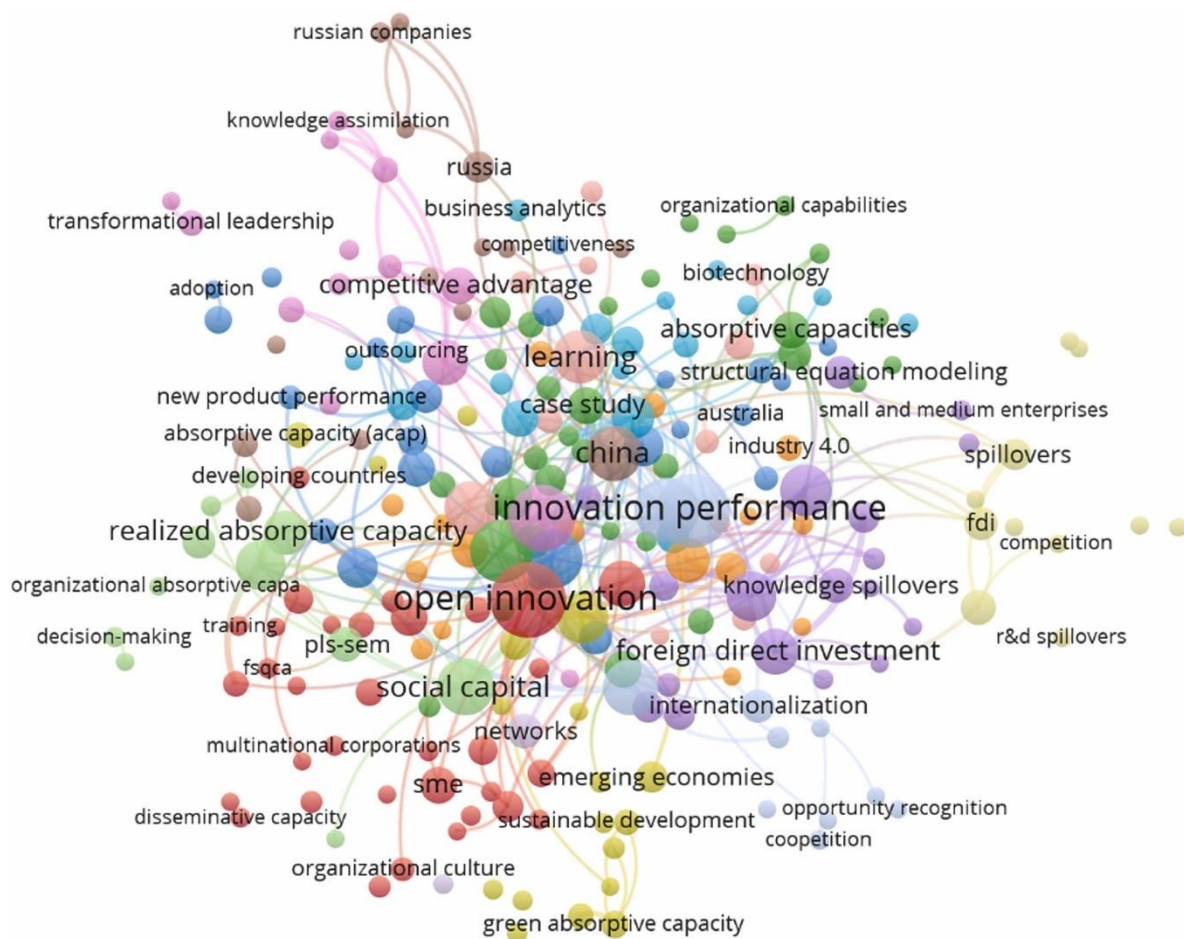


Fig. 9. AC keyword co-occurrence analysis. Legend: In the network visualization, colors distinguish thematic clusters; node size represents theme frequency, and edge thickness highlights link strength.



(Hacklin et al., 2021 ), Jaccard index analysis and scientific community similarity (Hacklin et al., 2021 ), patent analysis (Curran and Leker, 2011 ), social network analysis (Duan and Guan, 2021 ), IPC (international patent classification), SIC (Standard Industrial Classification) code convergence (Curran and Leker, 2011 ), and life cycle (Bornkessel et al., 2015 ).

Fig. 9.AC keyword co-occurrence analysis. Legend: In the network visualization, colors distinguish thematic clusters; node size represents theme frequency, and edge thickness highlights link strength.



### Scientific convergence between absorptive capacity and knowledge appropriation

To our knowledge, no studies have specifically addressed AC and KA convergence, though certain indicators suggest a connection between these fields. Hacklin et al. (2021) described citation analysis convergence as an appropriate method for identifying convergence. Cuellar

et al. (2022) show that seminal works on AC (Cohen and Levinthal, 1989, 1990; Todorova and Durisin, 2007; Zahra and George, 2002) have garnered significant citations within the KA literature, illustrating convergence and underscoring their foundational role in both domains. In contrast, Thomas and Wood (2015) show a more implicit relationship between AC and KA, defining KA as a dimension of AC and showing the convergence of both fields. (Fig. 1). Topic similarity is another indicator used to identify convergence (Ciomaga, 2015). Cuellar et al. (2022) identified several KA definitions analogous to some AC dimensions (Carroll et al., 2003; Kamoche & Mueller, 1998; Vega-Jurado et al., 2008). The application of both fields to find an outcome is another convergence indicator. Cuellar et al. (2022) , doing an analysis of papers that studied both topics, identified that AC and KA are strongly associated with innovation (Bahl et al., 2021; Escribano et al., 2009; Hervás-Oliver et al., 2011; Hurmelinna-Laukkanen, 2014; Vega-Jurado et al., 2008 ). The measurement methods show other convergences between AC and KA. Patents have been used to measure AC (Deeds, 2001; Dushnitsky and Lenox, 2005; Srivastava et al., 2015 ) and KA (Arbussa and Coenders, 2007; Bahl et al., 2021; Barros, 2021; Colombelli et al., 2020; Milesi et al., 2013 ).

### 5.3. Methods

To understand the convergence between AC and KA, we followed the protocol shown in Fig. 2. We started with 7213 AC and 833 KA papers. To identify the most relevant documents, we identified papers that contained the words appropriab\* for AC most frequently and the phrase "absorption capacity" for AC literature to obtain a dataset of 3412 AC and 368 KA papers. The queries used are illustrated in Fig. 3. Various methods were employed to analyze the convergence between AC and KA. First, we examined the time evolution of both AC and KA literatures to compare the growth of these fields. For this temporal convergence, we utilized life-cycle and changepoint methodologies. In our "life cycle" analysis, we delineated different stages of development based on the methodology by Chanchetti et al. (2016) , using two metrics: the number of authors and the number of scientific papers. Fig. 4 illustrates these various stages in the life-cycle analysis.



Additionally, to identify convergence, we employed a temporal convergence analysis methodology inspired by Malik (2019) splitting the analysis by different periods, allowing us to track the evolution of main topics annually. This thorough approach focused on discerning whether topics were present in both KA and AC literature (signifying convergence) or exclusive to one field (indicating divergence). For this analysis, topics were recognized using keywords with frequencies of 5 or more. The following table illustrates an example of this meticulous scrutiny. (Table 1). To better understand how AC and KA influence the top convergence areas, we crafted a fresh approach. We looked at phrases that mentioned either AC or KA alongside these main areas. Using the part-of-speech analysis method from Toutanova and Manning (2002) and running in Knime software, we spotted key words: adjectives like "lower", verbs like "enhancing", and nouns like "effectiveness". This gave us a clearer picture of how AC and KA either positively or negatively affect these areas, revealing another layer of convergence. For a visual, check out Fig. 5 which showcases our part-of-speech analysis. Finally, we filtered the corpus to focus on the main convergence areas where AC and KA had a convergence. Then, we blended AC and KA literature to investigate the influence of key elements in both fields. Next, we performed a co-occurrence analysis to investigate the relationship between the main building blocks and their impact on the convergence area (Cuellar et al., 2023 ). We also used social network analysis (SNA) to identify the importance of these building blocks in the network (Luan et al., 2021 ) and their relationship with impacts and the convergence area.

#### 5.4. Convergence analysis between absorptive capacity and knowledge appropriation

##### Life-cycle convergence

We identified the AC and KA evolution that can be seen in Fig. 6. The emergent stage had a low number of publications and researchers. For AC, this stage began in 1989 and ended in 2006. For KA, it began in 1988 and ended in 2009. The growth phase had exponential development, as reported by most authors. It started in 2007 for AC and 2010 for KA and is still ongoing in both fields. The AC analysis had more publications than KA, with 290 articles in the emergent phase and 3122 in the growth stage. KA had 93 articles in the emergent phase

and 275 articles in the growth stage. In contrast to life-cycle analysis, changepoint analysis identified single and multiple changepoints in data using various common and unique changepoint techniques (Killick et al., 2012 ). We applied the same variables from the life cycle analysis —the annual number of authors and scientific papers to compare changes in KA and AC

Table 3 Some representative AC papers.

Reference	Topic	Description
Armstrong and Lengnick-Hall (2013)	Potential and Realized AC	Influence of social integration mechanisms in organizations.
(Popaitoon et al., 2021) Sarsah et al. (2020)	Potential and Realized AC	New product development in bipolar SMEs. Relationship between potential and realized AC, entrepreneurial orientation, and radical innovation performance.
(Seo, 2020)	Innovation performance	Mechanisms linking environmental dynamism with IP and the mediating role of AC and social innovation.
(Duan et al., 2020) (Lyu et al., 2022)	Open innovation	Effect of AC on organizational slack and IP. Relationship between social capital, IP, and AC's mediating role.
(Wu et al., 2021)		Relationship between Information Technologies and OI and the mediating role of potential and realized AC.
(Bianchi et al., 2016) (Mubarak and Petraitis, 2020)	Technological innovation	Role of OI in acquiring technological knowledge. Relationship between OI, digital trust, and Industry 4.0.
(Xiong et al., 2020)		Impact of R&D investment on technological innovation and the role of talent mobility in increasing AC.
(Liu et al., 2020)	KS	Influence of artificial intelligence on technological innovation, promoting knowledge creation, KS, learning, absorption, and investment in R&D.
(Du et al., 2015)		Relationship between technological diversification and technological innovation and the moderating effect of AC.
(Marcin, 2008)		Effect of KS on FDI, relevance of AC in domestic firms, relationship between FDI and horizontal and vertical spillovers, and influence of AC on the size of spillovers.
(Al-Eisawi et al., 2020)	AC Dimensions (acquisition, assimilation, transformation, and exploitation)	Influence of AC dimensions on business intelligence systems.
(Miroshnychenko et al., 2021)	AC Dimensions	Nexus between AC dimensions, strategic flexibility, and business model innovation.

Our analysis showed that KA had a faster changepoint than AC regarding the two indicators, as measured by the average and variance analysis. Table 2 illustrates the results.

Table 2. Changepoint years in KA and AC

Changepoint	KA Year	AC Year
Media	2011	2013
Media Variance	2001	2004

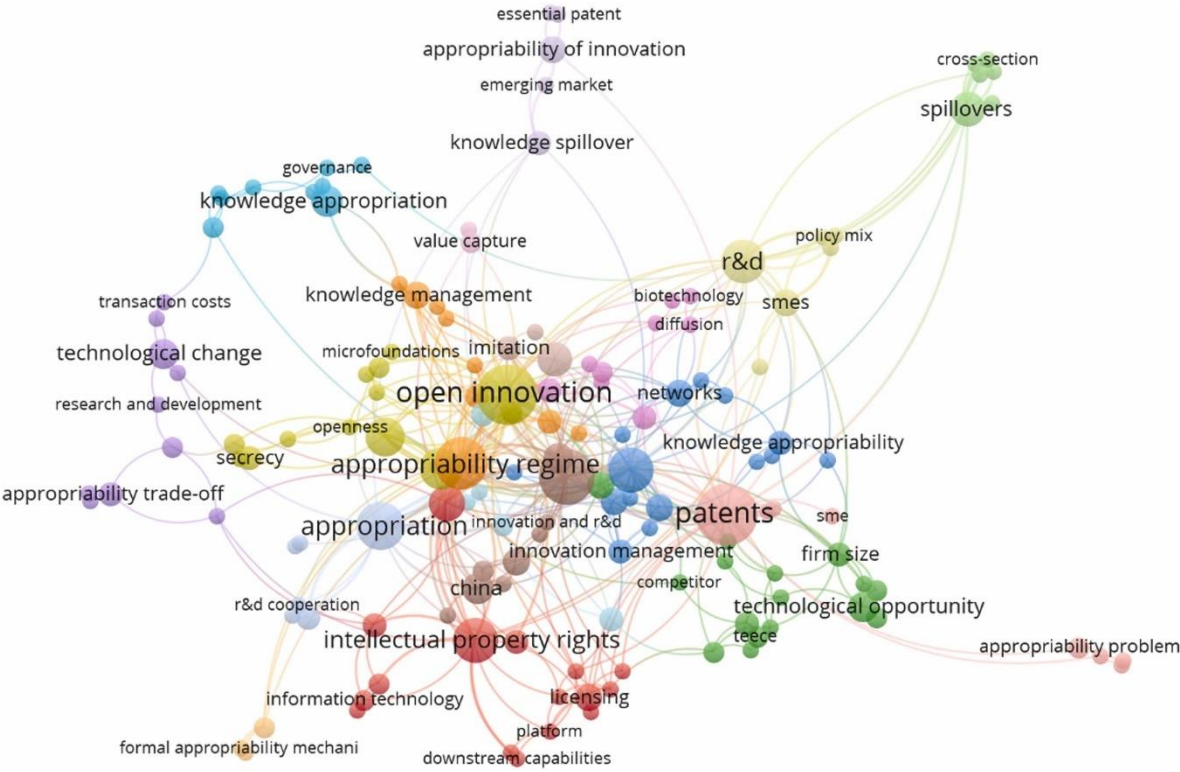
Our analysis revealed several points of convergence between the two fields. For instance, AC and KA began at similar starting points and are currently in the growth stage. In addition, our changepoint analysis showed that the two fields experienced similar stage changes, with only a 2-year difference between AC and KA. These findings suggest a strong convergence of both domains based on the life cycle and changepoint analysis.

#### 5.4.1 Convergence based on topic analysis

We compared the literature (AC and KA) to identify the convergence. First, we used the H-index to investigate the areas and building blocks relevant to AC and KA. The H-index measures the impact of terms based on the number of records and forward citations (Castaneda and Cuellar, 2021 ). CAGR was used to investigate the topics with the highest growth between the emergent and growth stages (Castaneda and Cuellar, 2021 ). Finally, new topics were recognized in the growth stage that had relevant productivity. For AC, Fig. 7 shows that the most important topics in the H-index were AC, innovation, KM, organizational learning, and knowledge transfer. Based on a CAGR analysis, the most important topics were organizational learning, small and medium enterprises (SMEs), human capital, technology transfer, and KM. According to our new topic analysis, open innovation, innovation performance, dynamic capabilities, entrepreneurial orientation, and firm performance were the most prominent trends in the field. In KA, Fig. 8 shows that the most important terms based on the H- index were appropriability, innovation, patents, intellectual property rights, appropriability regime, open innovation, and AC. Furthermore, CAGR analysis revealed that the most important topics were open innovation, intellectual property, patents, appropriation, and AC. Regarding new topics, the most significant trends were appropriability regime, intellectual property, appropriability mechanism, and entrepreneurship. Our analysis indicates that AC has a greater impact on KA. We identified the main trends in AC literature based on cluster analysis (Fig. 9). The cluster colors indicate different trends. The cluster in red shows that open innovation was the primary type of innovation model related to AC, the relationship between open innovation and SMEs, and the link between entrepreneurship and organizational learning. Blue shows AC and its link with technological innovation, ambidexterity, and knowledge creation. The blue-white color

shows the other side of AC as a relevant element for IP and its relationship with dynamic capabilities. Purple and brown demonstrate the impact of AC on knowledge spillovers (KS) and its relationship with foreign direct investment (FDI). assimilation, transformation, and exploitation).

Fig. 11.KA keyword co-occurrence analysis. Legend: In the network visualization, colors distinguish thematic clusters; node size represents theme frequency, and edge thickness highlights link strength.

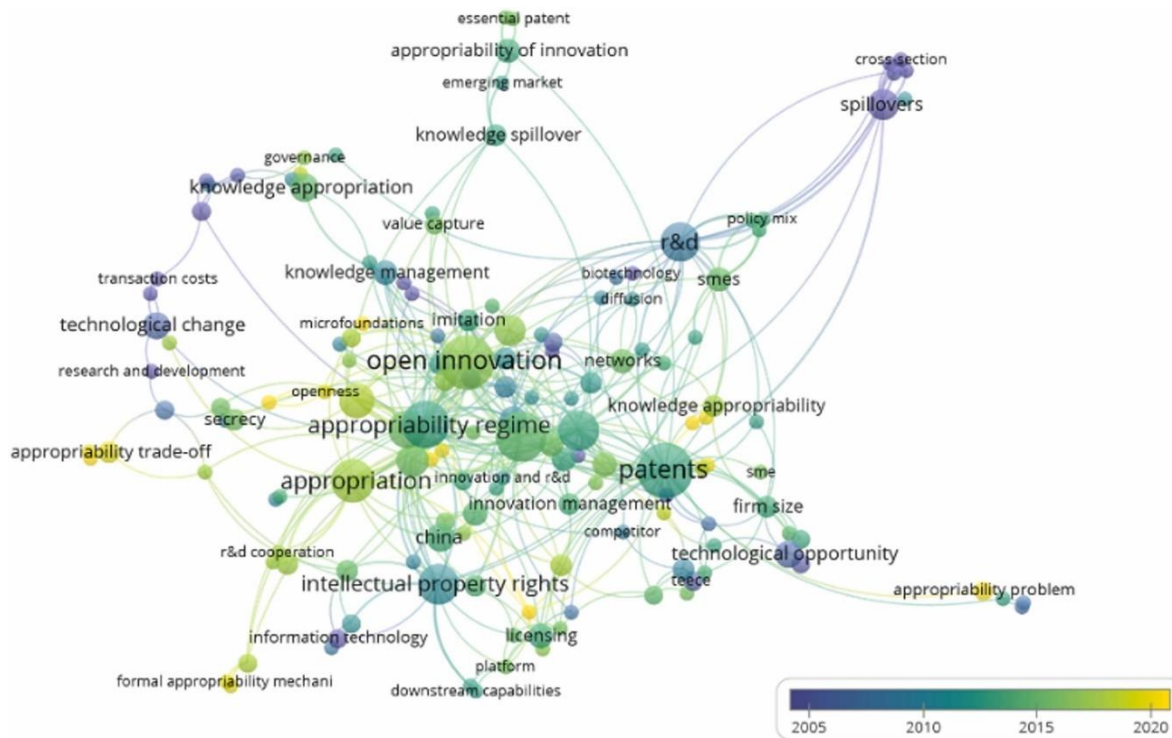


In addition, the light green matched the model created by Zahra and George (2002) on synthesizing the acquisition and assimilation stages in potential AC and transformation and exploitation in realized AC. Furthermore, we identified topics that have the greatest impact recently (Fig. 10). A notable new concept is green AC in relation to ecoinnovation. Another important new topic is the relationship between AC and emerging technologies, such as Industry 4.0, digital transformation, and ambidexterity. Some topics, such as technology diffusion, organizational learning, organizational change, and value creation, have become less relevant. Moreover, we identified the most important academic papers on the most important trends by examining the frequency of each topic in each paper's key bibliographic field (title, abstract, and keywords). The next table shows some representative scientific papers. Table 3. With respect to KA, the number of key clusters (Fig. 11) was lower than AC cluster. The brown cluster focused on intellectual property and the main mechanisms of appropriation. Yellow analyzed appropriability mechanisms and their relationship with open innovation. Orange studied the appropriability regime and its link with KM. In addition, this cluster analyzed KA's link with the type of knowledge (tacit or explicit) and the first-mover advantage as a type of appropriation mechanism. Green and pink represent patents (another key KA mechanism), technological appropriation, and technological innovation, respectively. Violet studied KS, technological change, and appropriability tradeoffs and red analyzed technology transfer and some essential elements of this process as licensing and Trade-Related Aspects of Intellectual Property Rights (TRIPS). Fig. 12 shows the cluster time evolution in KA. We identified new trends in appropriability, tradeoffs, technological congruence, process innovation, open innovation, entrepreneurship, R&D cooperation, and technological complexity. Moreover, other topics, such as KS and technological changes, have lost their relevance. The most relevant articles based on the main trends in KA were also identified using the frequency of the topic in key topic fields (title abstract and keywords). (Table 4). Cluster analysis showed a strong convergence in innovation, especially in innovation performance and open innovation. Other relevant convergence areas were KS and entrepreneurship. The AC and KA fields have been associated positively with these topics as having a mediating role or positive effects on each field over these topics. The main divergences were found in specific areas of each field, such as AC dimensions and KA mechanisms.

## 5.5. Convergence between KA and AC over time

We measured convergence using the approach shown in Table 1. We performed an S-curve analysis based on Ernst (1997) to understand KA and AC convergence (Fig. 13). We split the growth stage into two stages to visualize convergence. S1 was defined as an emergent stage with low convergence.

Fig. 12. KA keyword evolution co-occurrence analysis. Legend: blue highlights older themes, yellow the recent; node size denotes frequency, and edge thickness shows connection strength



S1 has four keywords that converged. S2 was a consolidation stage with large variability and convergence like that of S1. At this stage, 33 keywords converged. S3 was defined as the first growth stage when the convergence started to exhibit exponential growth. S3 had a total number of 63 converging keywords. Finally, S4 was the last growth stage, with exponential growth and 77 keywords converging. In contrast, we identified the main areas of convergence. AC and KA converged with a relevant frequency in all stages (Fig. 14), confirming that both topics were strongly linked, as Cuellar et al. (2022) showed in their paper. Another relevant topic was patents, one of the main KA mechanisms that increased the convergence in recent periods. However, the main topic with more convergence between the fields was innovation, represented by keywords such as open innovation, innovation performance, product innovation, innovation management, and new product development. Entrepreneurship started to be relevant in KA and AC convergence in the last period, as well as internationalization. R&D was a key topic in S2 and S3, but it was not recognized as key in S4. Our semantic analysis shows that open innovation, innovation performance, entrepreneurship, and KS are the main converging areas of AC and KA. We identified the effect generated by KA on these topics and AC on these topics to compare both fields. We followed the process illustrated in Fig. 3. Regarding innovation, we found that the main effect of KA on this topic was a moderator element, generating a positive influence. In addition, KA was found to be an element that enhances, increases, and improves innovation performance and open innovation. Only two studies have examined the negative effect of KA on innovation. We identified an inverse relationship between KA and KS; the main outcome was that KA reduces KS. However, other studies have found a positive effect of KA on KS, increasing and mediating KS. Finally, some authors have recognized the positive effect of KA on entrepreneurship. (Fig. 15). Regarding AC effects on open innovation and innovation performance, our analysis shows a positive effect, mediating innovation performance and open innovation, moderating, enhancing, improving, increasing, promoting, achieving, benefiting, and facilitating innovation performance and open innovation. However, some authors identified a negative effect of AC over innovation performance and open innovation, although the number of academic papers that showed a negative effect was considerably lower than that showing a positive effect. Regarding AC and KS, some authors have identified the positive impact of AC on KS: increasing, improving, contributing,

moderating, enhancing, promoting, mediating, facilitating, and stimulating KS. In contrast, other authors have identified a negative effect of AC over KS, reducing and decreasing KS. AC also plays a relevant role in mediating, moderating, enhancing, promoting, improving, benefiting, and increasing entrepreneurship. The convergence of the positive effect of AC and KA on innovation, entrepreneurship, and KS can be seen in some terms as a positive effect or the moderating effect, influence, promotion, enhancement, and contribution. (Fig. 16). We also explored other elements influencing the generation of innovation, entrepreneurship, and KS. After examining the literature on both topics, we identified the key elements - or building blocks - crucial for their convergence. Fig. 17 illustrates these building blocks and their significance in the network, as determined by SNA indicators. Our analysis indicates that R&D, patents, and networks are the pivotal building blocks in the convergence of AC and KA. These topics have robust connections to other essential network elements. KM is closely connected to networks, while intellectual capital is strongly associated with both R&D and networks. Additionally, R&D maintains a potent relationship with patents. Fig. 18 presents the cluster analysis, which identifies the most closely related topics based on cluster colors. The primary clusters identified encompass patents, foreign direct investment, and R&D. Another cluster groups together networks, internationalization, and knowledge protection. A different cluster combines intellectual capital, ambidexterity, sustainability, digitalization, and stakeholders. Additional clusters include topics such as KM, dynamic capabilities, knowledge transfer, and financial capabilities. Yet another group features openness, information technology, and new product development. The final cluster comprises SMEs, firms, and knowledge conversion. Fig. 19 shows the analysis done with SNA indicators. The betweenness centrality reveals that certain building blocks serve as bridges between different clusters, while degree centrality points out topics that are more interconnected with others. From these SNA indicators, the standout topics include R&D, firm size, SMEs, patents, KM, sustainability, internationalization, FDI, and intellectual capital. As per the degree centrality from the SNA indicators, the predominant topics are networks, IT, and knowledge transfer. Notably, digitalization emerges as a significant topic in betweenness centrality but not in degree centrality. The subsequent pie chart illustrates the significance of each topic for AC (highlighted in yellow) and KA (in red), gauged by their publication frequency in each domain. Topics prominently featured in both fields encompass

R&D, patents, SMEs, firm size, KM, networks, knowledge protection, knowledge externalities, preemptive patenting, stakeholders, and knowledge conversion. The following figure illustrates the relationship between each building block and its impact on primary convergence areas.

Table 4 Some representative KA papers.

Reference	Topic	Description
(Cohen et al., 2002) (Harhoff, 1996) (Alnuaimi and George, 2015) (Martin, 2002) (Bahemia et al., 2017)	KS	Positive effect of Japan's policies in generating KS and KA compared with the U.S. Positive effects of KS when KA levels are weak. Studied knowledge retrieval type of KA associated with recovery KS.
(Holgersson et al., 2018) (Hannigan et al., 2018)	Open innovation	Effects of input KS, imperfect appropriability, and their link with innovation. Identified innovation type, appropriability regime, and product complexity in new product development. Impact of complementary and substitute KA in systemic open innovation. Studied knowledge flows, product innovation rumors in the software industry, role of KA in open innovation processes.
(Chung and Lee, 2020)  (Hurmelinna-Laukkanen, 2014; Hurmelinna-Laukkanen and Puumalainen, 2013) (Cheng et al., 2014)	Intellectual property	Positive effect of knowledge exchange activities and application of KA informal mechanisms over intellectual property. Effects of KA and AC over rival intellectual property  Role of dynamic capabilities and KA in intellectual property in supply chains.

The R&D building block is particularly notable, while Intellectual Capital and KM closely follow in significance. Moreover, Networks and patents exhibit notable positive impacts. Upon closer examination, the prevailing positive influence is termed "Enhance." This influence plays a crucial role in strengthening the connection between the building blocks and central convergence areas such as innovation performance, KS, and open innovation. This dynamic underscores the importance of these building blocks in shaping the direction of the targeted convergence areas. Conversely, some building blocks have adverse effects on convergence areas. The R&D block is especially prominent in this regard. Patents and foreign direct investment also display some negative tendencies. The most significant negative impacts are evident in KS, innovation performance and open innovation, highlighting the potential challenges posed by these building blocks in these areas. (Fig. 20).

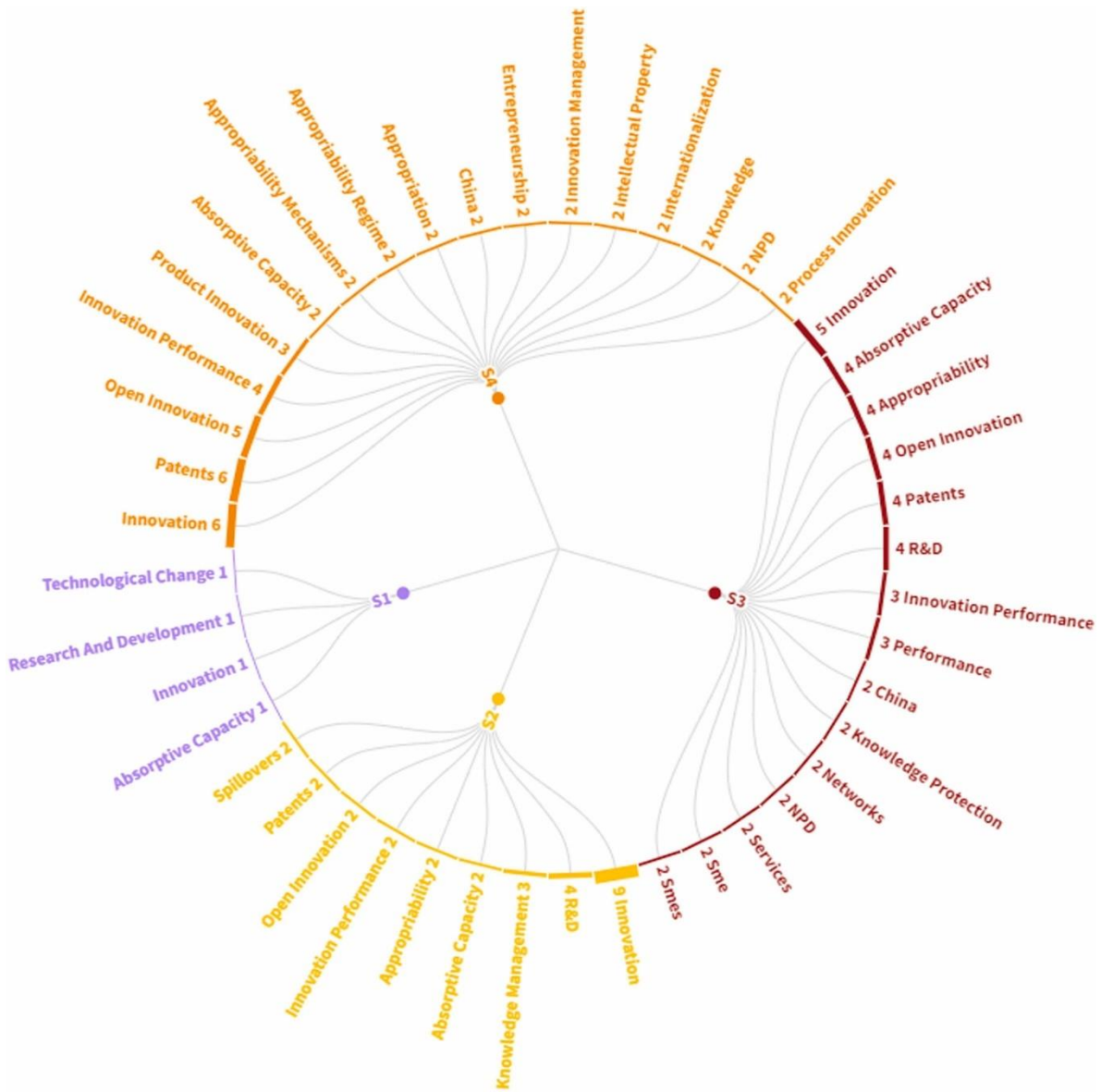
## 5.6. Discussion

AC and KA are pivotal in transferring technology and innovations to society, with both fields historically interconnected, as highlighted in primary AC models, and specialized literature (Cuellar et al., 2022; Hurmelinna-Laukkanen, 2012b; Sun and Zhai, 2018 ). While some researchers, like Cuellar et al. (2022) , have started addressing this, we identified a gap in uncovering hidden connections through our literature review. Convergence analysis has been used to identify hidden relationships between areas (Bornkessel et al., 2015; Curran et al., 2010; Curran and Leker, 2011). Few studies have explored convergence in the management field (Bosch and Grobbelaar, 2021; Ibrahim et al., 2021; Moutinho and Silva, 2021; Popkova and Sergi, 2020 ), to our knowledge, no research has specifically addressed the convergence of AC and KA. Our research question for this study was: What are the hidden links between AC and KA, and how do they converge in the context of management studies?

Fig. 13.AC and KA convergence evolution in time. Legend: The chart shows four phases: S1 (up to 2001), S2 (2001-010), S3 (2010-2015), and S4 (after 2015). The blue line marks cumulative keyword convergence, while the orange line represents annual convergence frequency.



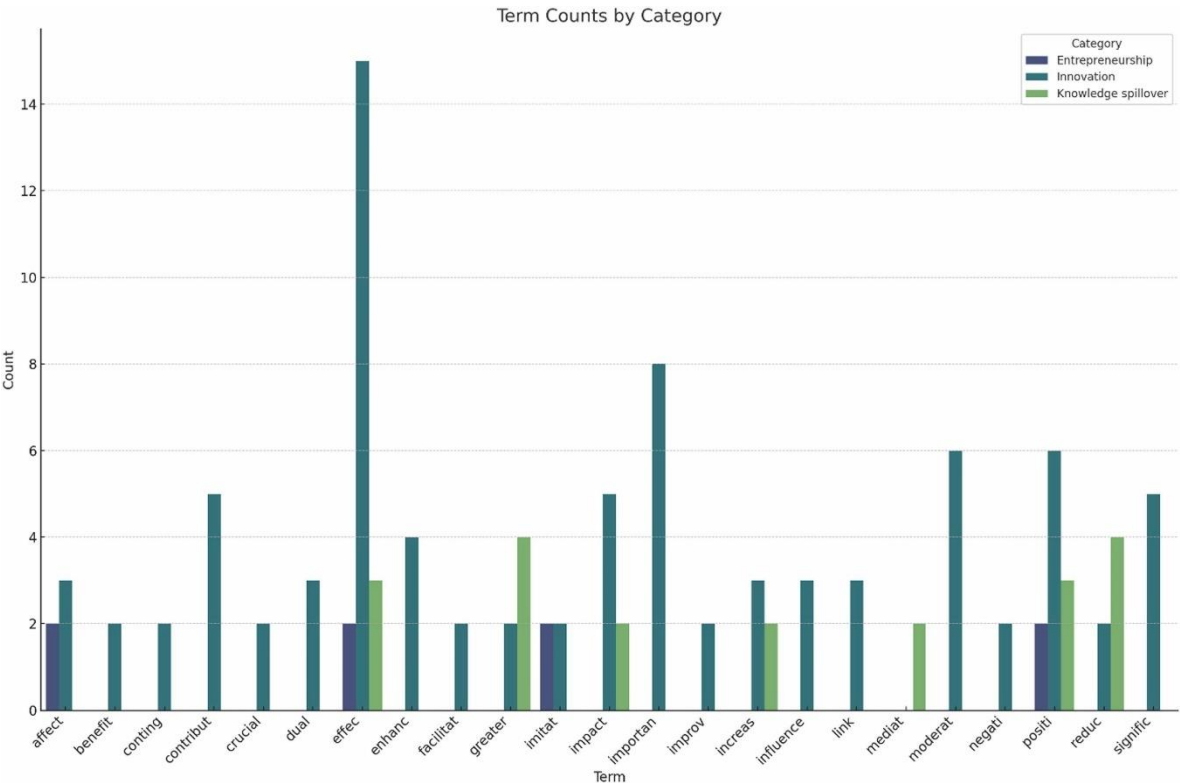
Fig. 14. Convergence topics between AC and KA in time. Legend: Four phases of keyword convergence: S1 (purple) up to 2001, S2 (yellow) 2001 – 2010, S3 (red) 2010 – 2015, S4 (orange) post-2015. Numbers indicate convergence frequency



To answer this question this study analyzed the convergence of KA and AC based on different elements, such as evolution over time and topic convergence. Convergence was analyzed based on the topic of convergence. The convergence of AC and KA was analyzed based on the impact of each on innovation, entrepreneurship, and KS (areas identified as key in our analysis). Finally, we identified the building blocks (other key elements in the growth medium) that were key to convergence. Our research revealed a pronounced convergence between AC and KA, evidenced by parallel timelines and mutual influences within specific fields. Life-cycle analysis indicated that AC evolved at a faster pace than KA. However, both AC and KA exhibited notable similarities in their evolution, notably their emergence in management disciplines during the latter part of the 1980s Cuellar et al. (2022) pinpointed that foundational papers of both domains emerged in the latter part of the 1980s. The transition from the emergent phase to the growth stage marked another convergence point for both fields. AC entered the growth phase in 2007, closely followed by KA in 2010. A changepoint analysis revealed a mere two-year gap between their respective transition points. Bornkessel et al. (2015) noted the rarity of using life cycle for convergence analysis in academic topics. Our study offers a unique contribution in this area. In our study, we explored thematic convergence. While past research measured convergence using clusters (Ciomaga, 2015 ), semantic analysis, machine learning, and bibliometrics (Kim and Sohn, 2020 ), we introduced a novel method. This approach combined the H-index, CAGR, and new topics approach with a unique keyword comparison between AC and KA to identify annual convergence. Additionally, we assessed the impact (both positive and negative) of KA and AC on primary convergence topics and key elements. This method provided a comprehensive and detailed view of convergence topics. Using the H-index, we pinpointed major topics with vast publications and citations. CAGR analysis highlighted rapidly emerging subjects, while new topic analysis unveiled previously overlooked themes. Open innovation and innovation performance stood out as primary convergence fields. Thematic cluster analysis underscored the significance of open innovation and KS. Time-based keyword assessment showed a rising convergence between AC and KA, emphasizing areas like open innovation, innovation

performance, innovation forms, patents, foreign direct investment, SMES and entrepreneurship. Notably, the significance of KM in convergence appears to be diminishing. We identified topics that covered many subtopics and were relevant to convergence. These were termed "convergence areas." The key areas were innovation, entrepreneurship, and KS.

Fig. 15.KA effects over innovation, knowledge spillover, and entrepreneurship.



These are rather present in the literature and are the main convergence points of AC and KA. We identified the effects of KA and AC on these topics and terms related to their impact on these key topics. Our results show that each field (AC or KA) is mainly associated with generating a positive effect over key areas. The major positive impacts were the "positive effect," the "moderator effect," influence, promotion, enhancement, and contribution. Concerning KA, a dichotomy in its effect on KS is evident. Hurmelinna-Laukkanen and Yang (2022) differentiate KA into distinct concepts. They describe appropriability conditions as factors influencing the use of appropriability instruments and processes. Strong appropriability conditions enable benefits from external knowledge at a macro level. Conversely, they define "realized KA" as the process where innovators achieve both private and societal

returns using appropriability instruments. When realized KA is robust, it negatively impacts spillovers by impeding knowledge exchange. Regarding our definition of the main areas of convergence, our outcomes are validated by some specialized literature, such as Sun and Zhai (2018) , who identified open innovation and entrepreneurial venture as key topics in KA literature, and Hurmelinna-Laukkanen (2012), who recognized AC and KA as key drivers of innovation performance. The importance of AC and KA over knowledge management have been validated for other authors as Cuellar et al. (2022) . In our analysis, we blended AC and KA literature to explore factors influencing innovation, entrepreneurship, and KS. Focusing on studies directly linked to these topics, we utilized Social Network Analysis (SNA) to identify key building blocks for these outcomes. Degree centrality revealed the interconnectedness of these elements, while betweenness centrality highlighted those bridging major thematic clusters (Luan et al., 2021 ). Notably, R&D, patents, SMEs, firm size, and knowledge management were central in both metrics, emphasizing their role in the convergence of AC and KA. The study outlines a complex coevolution of AC and KA, highlighting an evolving interdependence through time. Pre-2001, the emphasis was on R&D and integrating new processes. Post-2001, the focus shifted to evaluating innovation outputs and incorporating OI, with patents becoming essential for knowledge transfer. From 2010 - 2015, attention turned to the impact of key players like China and SMEs on innovation pathways, with an increased focus on NPD and patenting. After 2015, the conversation broadened to internationalization and entrepreneurship, with a variety of mechanisms for knowledge appropriation, where patents remained significant. AC and KA's coevolution is defined by fundamental components such as R&D and patents, which underscore their interlinked growth. KM is central to the diffusion and application of knowledge, with intellectual capital closely tied to R&D and networks, crucial for knowledge generation and usage. Thematic clusters reveal complex interactions across networks, internationalization, knowledge protection, digital transformation, and stakeholder engagement. Additional clusters

Fig. 16.AC effects over innovation, knowledge spillover, and entrepreneurship.

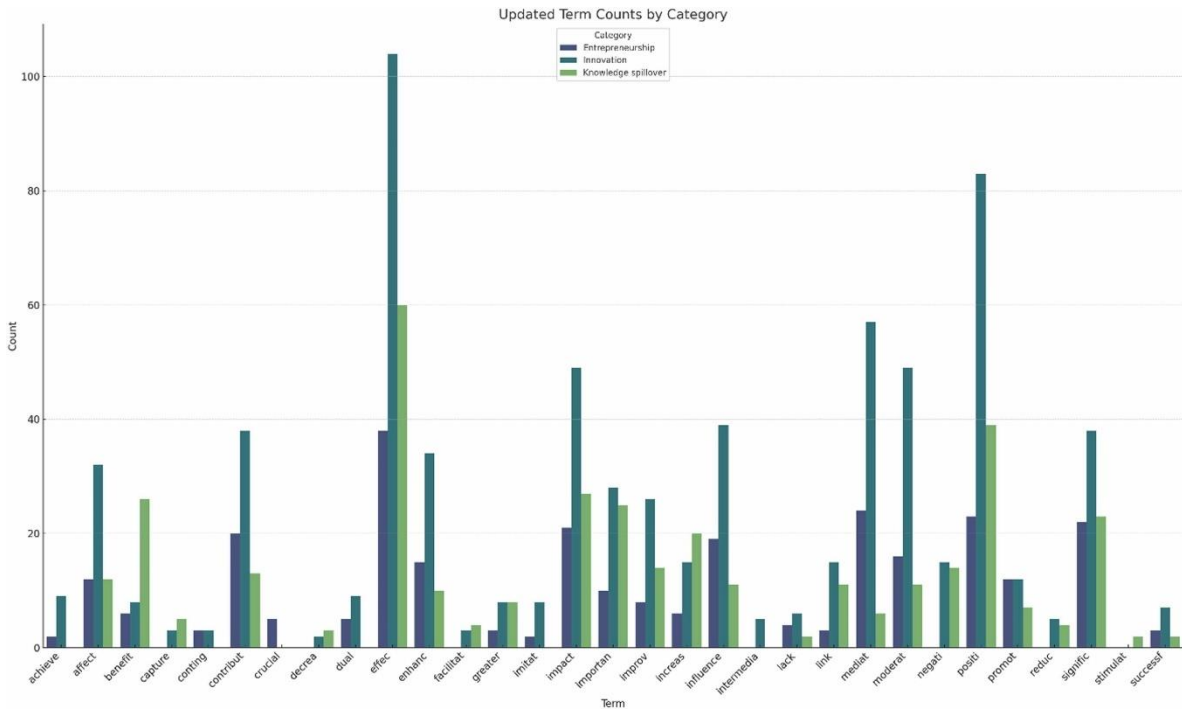
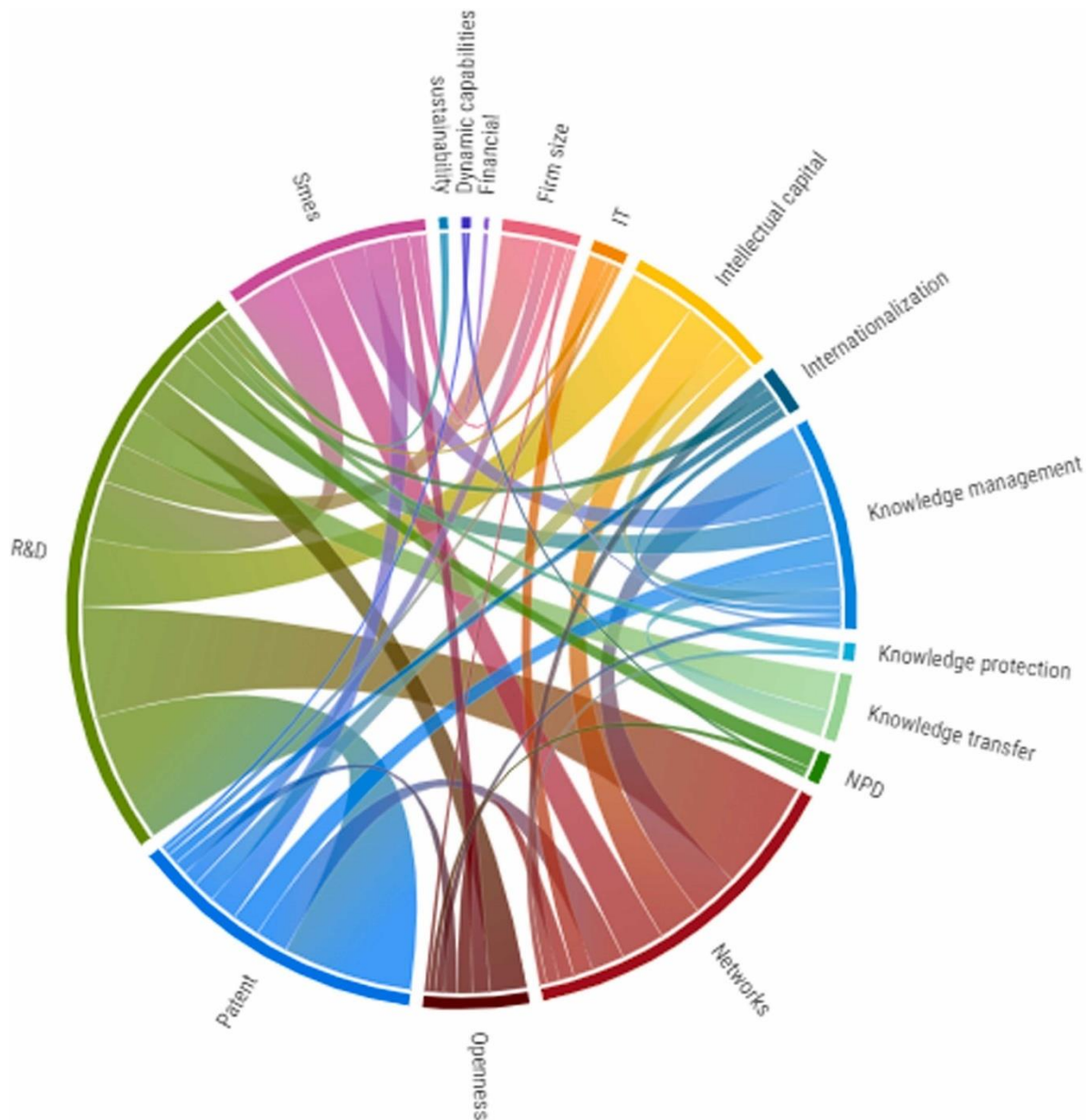


Fig. 17. Relationship of key topics based on a social network analysis. Legend: Distinct colors denote specific building blocks of innovation, entrepreneurship, and KS.



The thickness of connecting lines showcases the significance of interrelationships between these building blocks involving KM, dynamic capabilities, knowledge transfer, financial expertise, and IT are key to AC and KA. These clusters signify a deeper integration, suggesting robust interrelations that enhance coevolution understanding. The strategic synergy between R&D and patenting forms a nexus for advancing knowledge protection and commercialization. Patents hold a pivotal role in the convergence of AC and KA. Often, they serve as a primary KA appropriation mechanism, as highlighted by studies from Bahl et al. (2021) and Barros (2021) Additionally, some researchers, utilize patents as an indicator to

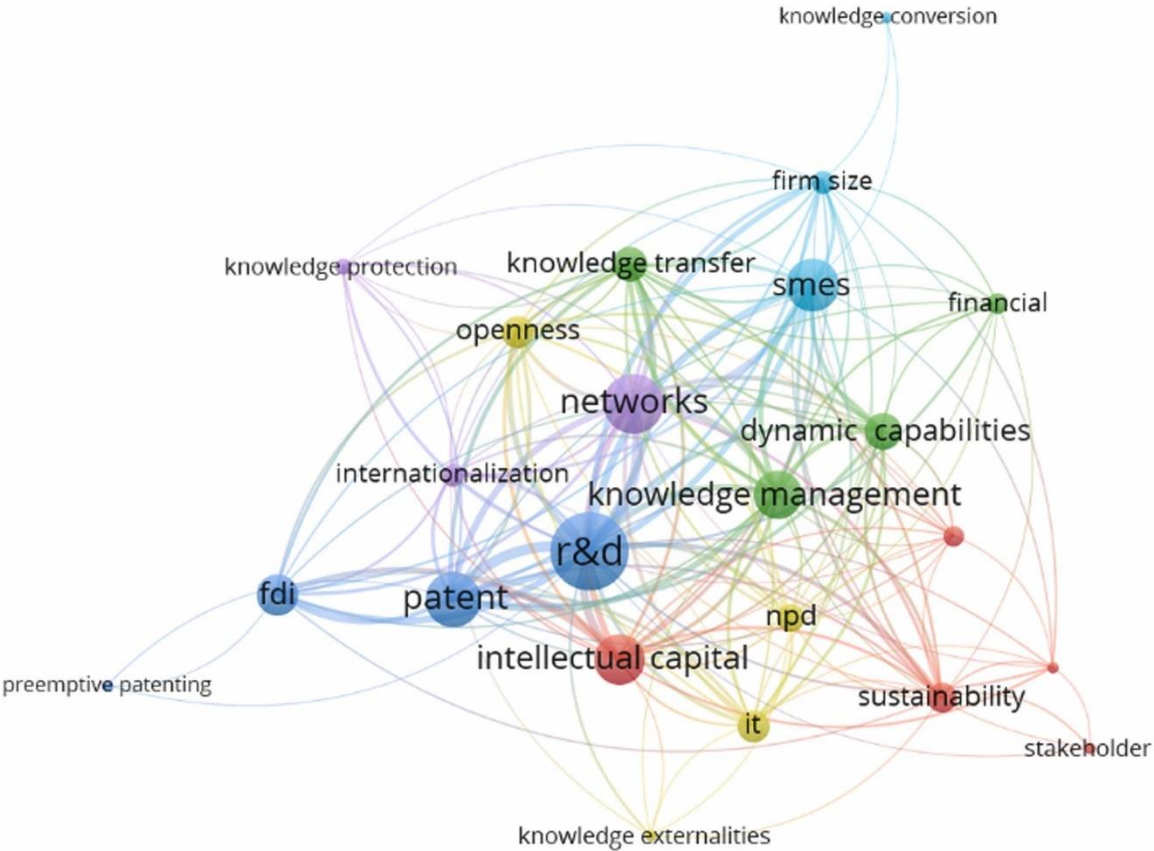
measure AC (Malik et al., 2021), further emphasizing their intertwined nature. This interconnectedness is intrinsic, suggesting that patents are integral to both AC and KA's core. Sun and Zhai (2018) identified patents as key elements in specialized studies on KA. Furthermore, several authors, including Alnuaimi and George (2015) and Dushnitsky and Lenox (2005), have underscored the significance of patents in fostering and impacting innovation, particularly when combined with AC and KA. Thus, the prevailing literature underscores our assertion about the centrality of patents in the AC and KA convergence. R&D has been highlighted by researchers as pivotal in driving innovation in conjunction with KA and AC. (Amoroso and Audretsch, 2022; Park and Lee, 2022; Roud and Vlasova, 2020). Several authors have utilized R&D as a metric for AC, including Behera (2015) and Hervas-Oliver et al. (2011). The significance of R&D, along with KA, is evident in innovation (Kim, 2022; Martinez-Noya & Garcia-Canal, 2018), entrepreneurship (Da Silva & Teixeira, 2012; de las Heras Rosas & Ballesteros, 2021; Spulber, 2012), and KS (de Almeida et al., 2021; Egbetokun & Savin, 2012; Roy & Paul, 2022). Sun and Zhai (2018) further emphasize R&D's centrality in KA literature. These studies confirm our findings that R&D is a pivotal convergence point between AC and KA. Several authors emphasize the role of KM alongside AC and KA in promoting innovation and KS. Specifically for entrepreneurship (Gimenez-Fernandez et al., 2022) and KS (Alnuaimi and George, 2015) significance is underscored in conjunction with KA. Codified knowledge stands out in KA literature (Sun and Zhai, 2018). Firm size, especially SMEs, is central in both AC and KA studies. For example, Oliveira et al. (2020) explored KA and AC within SMEs. However, while organizational learning is prominent in AC, it's less so in KA. Similarly, dynamic capabilities and AC dimensions are key in AC but not in KA. These differences offer avenues for deeper investigation.

#### 5.7. Conclusions and limitations

Our analysis reveals a pronounced convergence between Absorptive Capacity (AC) and Knowledge Appropriation (KA) in shaping innovation, entrepreneurship, and Knowledge Spillovers (KS). Employing a life-cycle approach and a unique thematic convergence methodology, we identified mutual influences and convergent areas like Open Innovation

(OI) innovation performance (IP). Key building blocks driving this convergence include R&D, patents, SMEs, and Knowledge Management (KM).

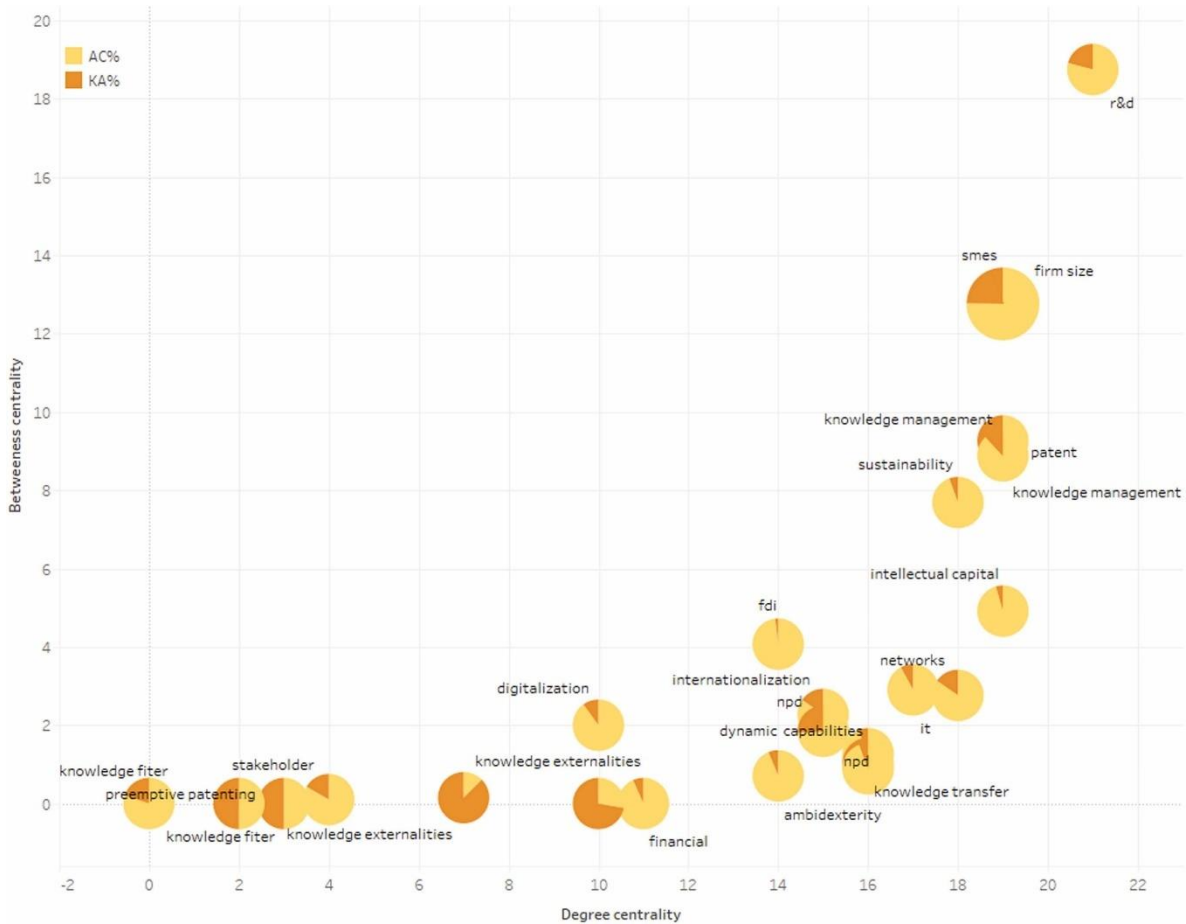
Fig. 18. Clusterization of the main building blocks in the convergence between AC and KA. Legend: Color-coded clusters represent related building blocks. Thicker lines indicate stronger relationships between terms.



While the intertwined nature of AC and KA was evident, notable divergence points also emerged, like the significance of organizational learning in AC but not in KA. This study bridges a critical gap, highlighting the symbiotic relationship between AC and KA and suggesting avenues for future interdisciplinary research. Our outcomes open many possibilities for studying KA and AC in combination with different convergence points (e.g., R&D, KM, and patents) for relevant topics such as innovation, entrepreneurship, and KS. Our study tracked possible roadmaps or indicators for studying these topics. Our methodology can be replicated across various fields of literature, particularly in management where convergence analysis is limited, as well as in patent and market research literature

where such analysis holds significant importance. Full-text analysis could enhance the depth and breadth of this methodology and the understanding of convergence. Furthermore, empirical research on KA and AC in emerging economies, and the influence of key sectors such as KS on innovation, represent additional domains where our findings could be utilized. Importantly, the building blocks identified through our research offer a foundation for developing new methodologies and indicators that can more accurately measure and assess the intricacies of AC and KA. Our study had some limitations. The research used bibliographic information specifically for topic analysis with titles, abstracts, and keywords. A full-text analysis is more precise for convergence analysis. Additionally, we used the Scopus and Web of Sciences Databases. Other resources such as ScienceDirect, Google Scholar, and Lens would improve the scope of this type of study. Our analysis confirmed the hypothesis that AC and KA have strong direct links, as Cuellar et al. (2022) showed, but based on identifying hidden links between AC and KA. The convergence is strong between these fields, and this should motivate further studies that combine both, for example, to study emergent innovation topics, such as frugal innovation, and other trend topics, such as Industry 4.0, and the influence of AC and KA, or to study the relevance of AC and KA in emerging economies characterized by weak innovation ecosystems

Fig. 19. Relevance for KA and AC of the main building blocks and importance by degree centrality and betweenness centrality. Legend: The X-axis displays topics with extensive interconnections. The Y-axis emphasizes bridge topics between clusters. The area of the pie chart indicates the importance of the topic in each field (KA or AC)



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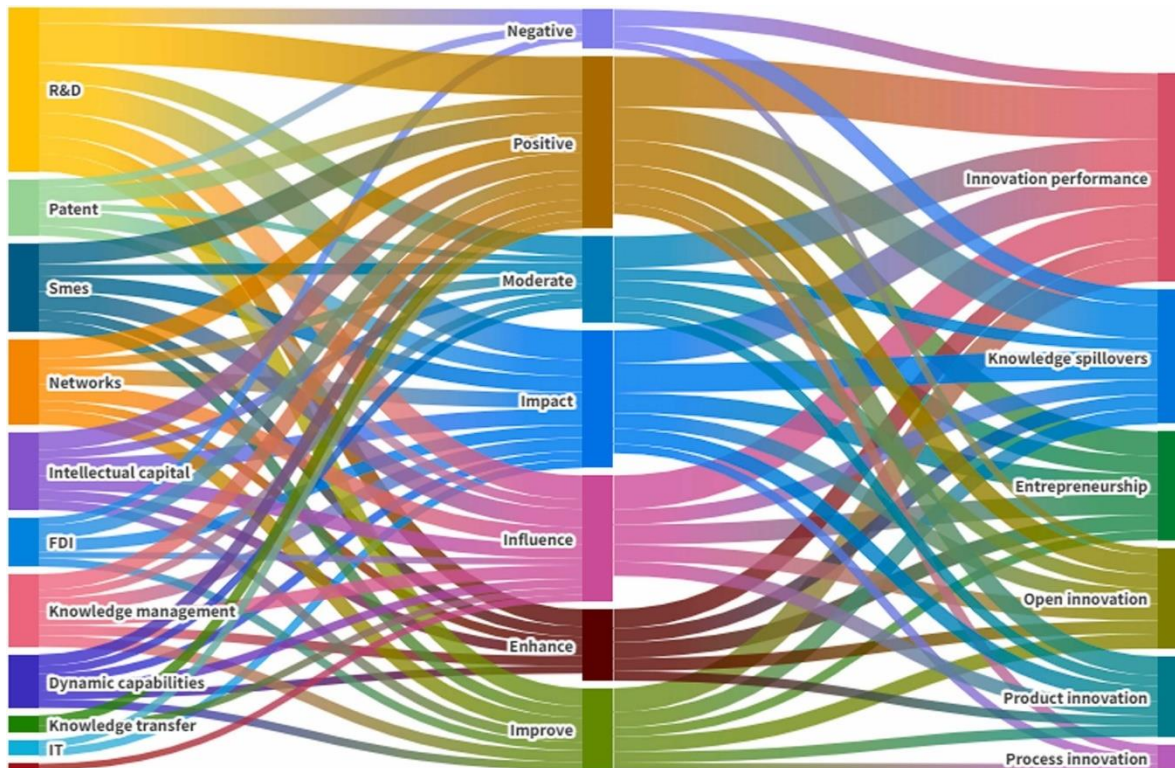
Conceptualization, Writing review & editing, Supervision, Project administration. Maria Teresa Fernandez Bajon: Supervision, Project administration.

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Fig 20. Relationships between main building blocks



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**Capítulo 6. *A New Approach to Measure Absorptive Capacity and Appropriability:  
A Case of Study in Emerging Markets.***

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**ABSTRACT**

Absorptive capacity (AC) and appropriability (KA) are crucial elements in generating competitive advantages and improving innovation performance in different countries and organizations. Moreover, the relationship between AC and KA has not been sufficiently studied, and there is still not a clear understanding of the impact they have on in the generation of rents and value. This research proposes a methodology to analyze AC and KA at a country level using the scientific capabilities of a country as base. We identified the Colombian scientific literature SKL (1680 record) from the Patents Lens database, which have been cited at least once or more per patent (3066 records), and we identified the papers that were cited by this SKL (50697) in order identify the flows between forward citations (FC) and backward citations (BC) at a country level. We associated BC to the AC acquisition stage, SKL to assimilation, and FC to transformation and exploitation AC phases. The patents were also associated with KA. In addition, we focused on the KA process, analyzing the organizations involved in the SKL and KA process by studying when KA was done by local organizations, by international organizations in the SKL development or when knowledge was leaked (KS). Finally, we identified when the SKL organization was the corresponding author to analyze whether KA changes in these situations.

Our main conclusion was that KA and the last stages of AC of native scientific development rarely happens in Colombia. The primary outcome of this absorption is a KS.

**KEYWORDS:** Absorptive capacity; appropriability; knowledge appropriation; bibliometrics; patent analysis; text-mining; analytics; emerging economies

## 6.1. Introduction

Scientific knowledge appropriation (KA) or the ability to generate rents or value from scientific knowledge is a big challenge for countries when trying to recover investment in research and development (R&D). It is not only a problem for emerging economies (Dedrick & Kraemer, 2015) robust R&D systems. Nevertheless, knowledge leakages or spillovers are common because national innovation systems do not have the strength to retain this knowledge. AC has been demonstrated as a critical element of appropriation and vice-versa (Cuéllar et al., 2022; Cuéllar et al., 2023). AC has been defined as the ability to acquire external knowledge, transform, and exploit it (Cohen & Levinthal, 1990). AC seminal authors have shown the relevance of AC in the KA process and the importance of both AC and KA in generating competitive advantages and innovation performance (Cuéllar et al., 2022; Cuéllar et al., 2023). Nevertheless, to the best of our knowledge, the relationship between AC and KA at a country level has not been studied or even partially analyzed. For instance, some studies have investigated AC and KA in subsidiaries (Volvo Group), and they were able to identify the relevance of AC and KA to emerging economies (Cenamor et al., 2019). Researchers were also able to demonstrate the relevance of AC over KA but only for specific technologies (Dedrick & Kraemer, 2015). In addition, as Fig. 1 shows, the number of studies conducted either on AC or KA individually in emerging economies and especially in Latin America has been few. This study seeks to increase knowledge of AC and KA at a country level using scientific papers and patents, designed to provide a more complete perspective of players, networks, and knowledge flows. In our business case study, we analyzed the Colombian innovation ecosystem. We used text mining, bibliometrics, and patent analysis methods to recognize local KA and KS.

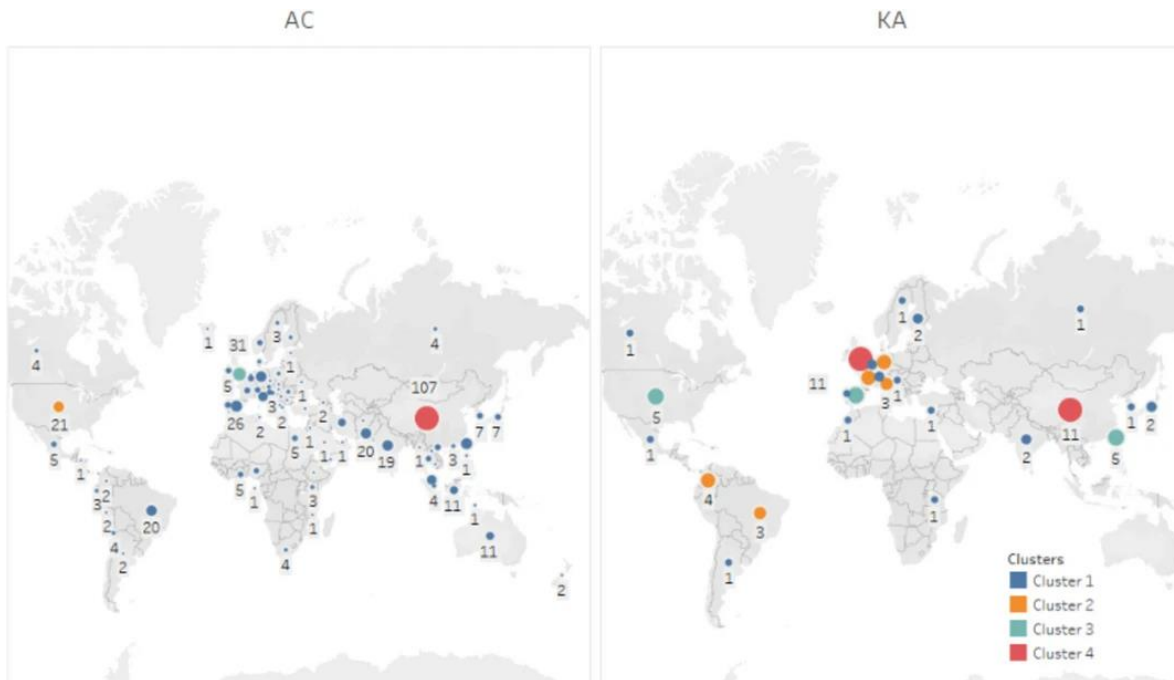
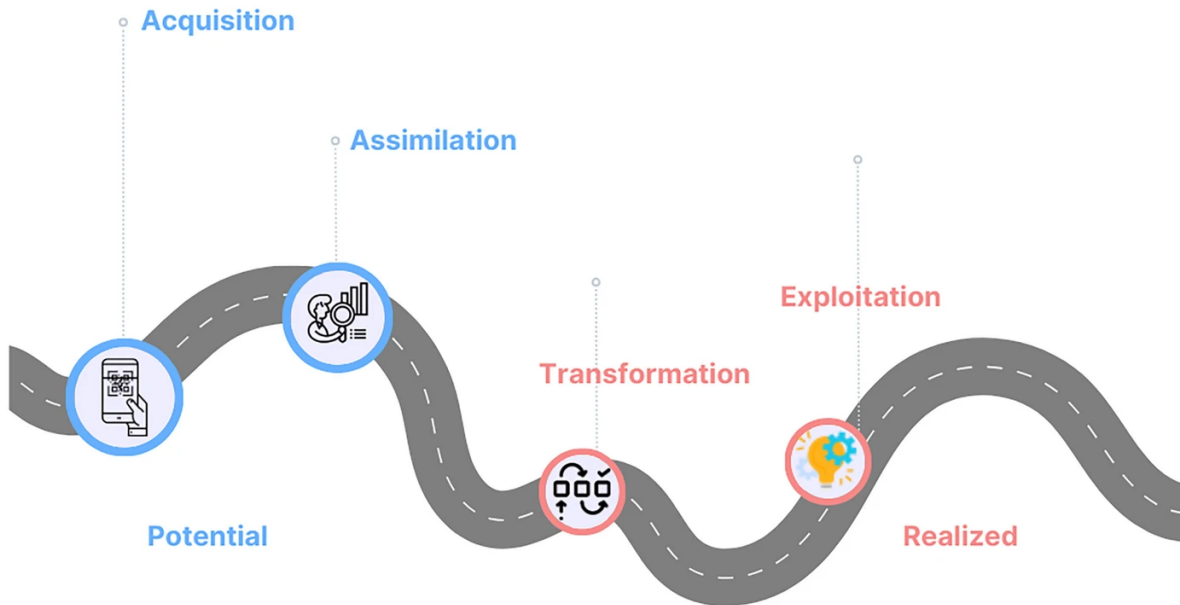


Fig. 1 Studies of AC or KA in a country level. Legend: Red color is the country with the most studies, followed by light blue, orange, and dark blue

Our research is divided into the following sections: Firstly, we analyze the state of knowledge of AC and KA measurement methods to identify the different strategies used in the academic community showing the main approaches and identifying the best options to analyze AC and KA at a country level. Secondly, we propose our new methodology, which blends text mining and bibliometric indicators to analyze AC and KA at a country level. Finally, we show our case of study of Colombia (Fig. 2). The following research questions were proposed in our study: RQ1 seeks to understand which indicators are best for measuring the AC and KA at a country level. RQ2–RQ4 were created to show our tool for AC and KA measurement. The specific questions were: RQ2 How has the KA of Colombian scientific knowledge evolved, and who has conducted KA, Colombian organizations or foreign organizations? RQ3 What is the cycle of KA and AC at country level, and what have been the knowledge flows? RQ4 Who is appropriating Colombian scientific knowledge, native or foreign organizations, and which type of organization are done this KA?

Fig. 2 AC dimensions based on Cohen and Levinthal (1990) and Zahra and George (2002)

# Absorptive capacity dimensions



## 6.2. Background in the Art

### 6.2.1. Absorptive Capacity Measuring Based on AC Dimensions

We reviewed AC and KA measurement literature to answer RQ1, asking which indicators are best at measuring AC and KA at a country level. We started analyzing AC. As Cuéllar et al. (2022) and Cuéllar et al (2023) showed, AC was built as a multidimensional concept, and many authors have created methods to measure AC based on its dimensions. The acquisition stage has been measured by scanning the microeconomic and macroeconomic environment to obtain market knowledge from suppliers, customers, competitors, consultancies, universities, technological centers, conferences, digital networks, and fairs (Alves & Galina, 2020; Heeley, 1997; Jiménez-Castillo & Sánchez-Pérez, 2013; Popadiuk & Nunes, 2018; Yang & Tsai, 2019; Zhang et al., 2018). The assimilation stage has been measured using different indicators, such as knowledge reactivation, demand analysis, and new opportunities identified by customers (Zhang et al., 2018); the human resources with high learning capabilities and employees capacity for recognizing market changes, new

opportunities to help customers, and skills to understand demand change (Jiménez Castillo & Sánchez-Pérez, 2013; Pérez et al., 2019). Lau and Lo (2015) measured transformation based on the employees skill to store knowledge information for future development and to conduct periodic meetings to identify market trends, the company's skills to understand the demand of changing markets. The last indicator was used also by Jiménez-Castillo and Sánchez-Pérez (2013). Other approaches measured human resources with relevant learning capabilities (Pérez et al., 2019), Finally, exploitation phase was measured by identifying the knowledge used on new products (Jiménez-Castillo & Sánchez-Pérez, 2013; Zhang, et al., 2018). Other investigators have used the quality and variety of products, the production and flexibility capability, cost reduction, labor cost reduction, and raw material cost reduction to measure the exploitation phase (Alves & Galina, 2020). Finally, Lau and Lo (2015) analyzed exploitation by identifying whether companies seek to exploit the new knowledge, and whether employees have a common language related to new products.

#### 6.2.2. Measuring Based on Potential AC and Realized AC

Other researchers have measured AC based on Zahra and George (2002) who put together acquisition and assimilation in a new phase named Potential AC and transformation and exploitation in Realized AC. Potential AC is measured by scanning skills of the organization and employees to understand new opportunities for customers (Flor et al., 2018) to search for information inside and outside the organization (Vicente-Oliva et al., 2015), and it is used for 1 3 Journal of the Knowledge Economy industrial structure analysis and technological trend analysis (Aliasghar et al., 2019) and knowledge storage (Aliasghar et al., 2019; Flor et al., 2018; Kuek et al., 2013). Realized AC was analyzed based on new product or service development (Liu et al., 2021), capabilities to use external knowledge, grab opportunities of external knowledge, periodical meetings to conduct market analysis, development of new products, employee's consciousness regarding innovations, evaluation of the best form for exploiting knowledge, and to share a common language to talk about products and services (Flor et al., 2018). In addition, other authors have used employees of R&D area and R&D investment, the employees academic background (Hervas-Oliver et al., 2011), and employees capacity to structure and exploit new knowledge (Vicente-Oliva et al., 2015).

#### 6.2.3. AC Measurement Using a Non-Dimensional Approach

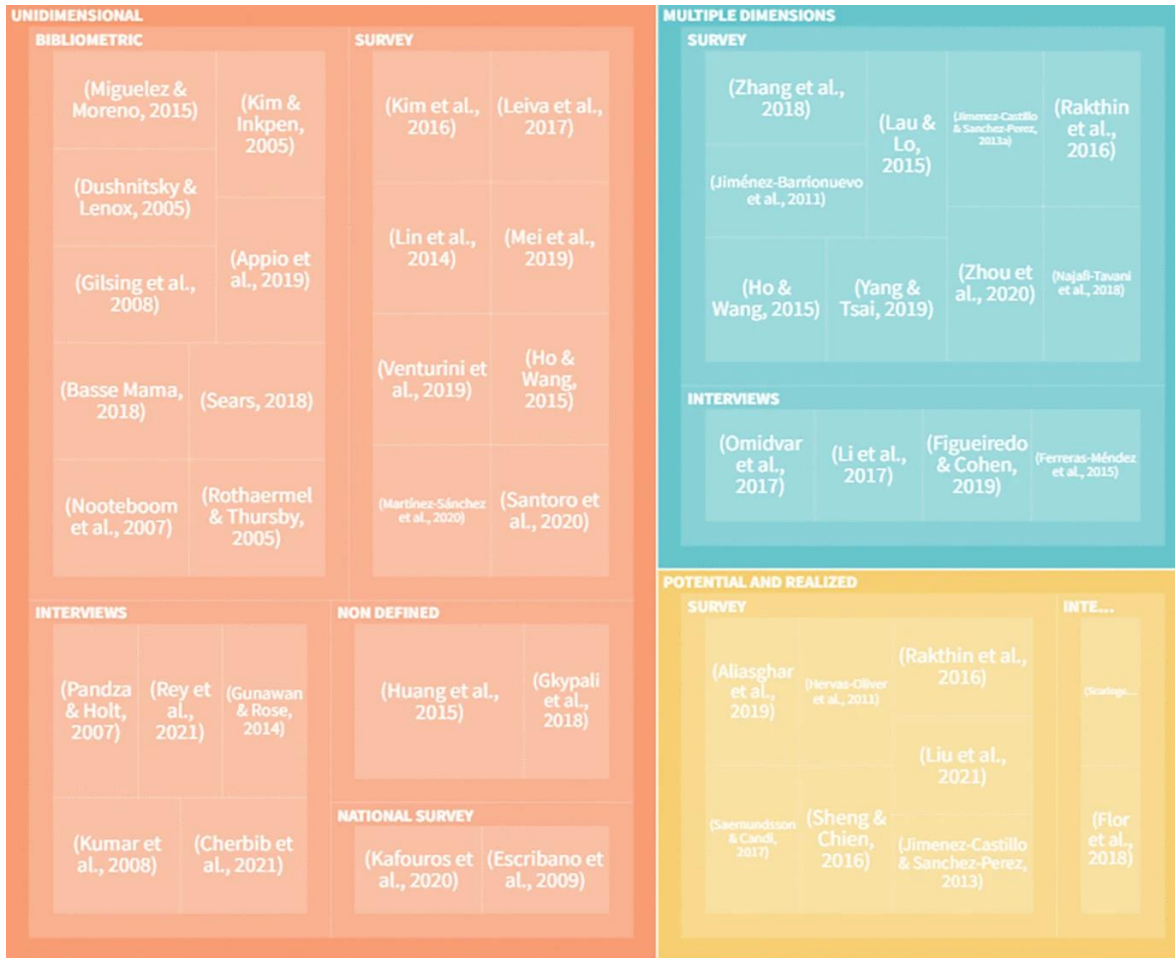
R&D has been one of the main proxies used to measure AC through a non-dimensional approach based on human resources (Luo, 1997; Veugelers, 1997; Wang et al., 2018), R&D intensity (Behera, 2015; Cruz-González et al., 2015; Jiménez-Castillo & Sánchez Pérez, 2013; Mowery & Oxley, 1995; Tsai, 2001), R&D investment based on the scientific literature (Mangematin & Nesta, 1999), patents (George et al., 2001), and strategic alliances (Cherbib et al., 2021; Gilsing et al., 2008; Mangematin & Nesta, 1999; Mowery et al., 1996).

#### 6.2.4. Patent Analysis and Bibliometrics Methods for Measuring AC and KA

Some authors have analyzed AC based on backward citations (BC) (Sears, 2018), for instance, non-self-BC to measure AC (Appio et al., 2019; Rothaermel & Thursby, 2005), self BC (Shin & Jalajas, 2010), and the ratio between own BC compared to BC of patents and non-patent literature (Basse Mama, 2018). Another approach has used cross patent citations (Kim & Inkpen, 2005). Miguélez and Moreno (2015) analyzed regional AC using mobility and network variables. They took patent information and analyzed inventors' mobility and networks based on the countries of the inventors (Gilsing et al., 2008). Other authors have applied social network analysis indicators to measure AC (Enkel & Heil, 2014; Gilsing et al., 2008; Zhang et al., 2007). Other authors have used other indicators based on patent data to measure AC. These approaches include firm stock patents (Dushnitsky & Lenox, 2005), patents per capita in 101 countries (Malik et al., 2021) prior cumulative patents (Nooteboom et al., 2007), the share of patents among all the players in an industry and pioneer technology identified by patents that do not have patent prior art (Srivastava et al., 2015; Srivastava & Shainesh, 2015), and by analyzing the interaction between universities and industry measure by patents (Bishop et al., 2011). Figure 3 shows the different approaches that were studied in this research paper. The different methods applied are shown by the measuring done (non-dimensional, multiple dimensions, potential, and realized). The best approaches for country analysis to have relevant samples are national surveys and bibliometrics (where we included social network analysis patent analysis). The figure also shows that nondimensional methods and potential and realized analysis have been more commonly applied than multiple dimensional analysis. Patent classification has been used by numerous authors to compare organizations based on their patent classification (Ruth et al., 2013; vom Stein et al., 2015),

for instance, the Ompi international patent classification IPC (Ruth et al., 2013). The Fig. 4 summarizes AC measurement methods. The size in the pie indicates the number of scientific papers identified in our analysis used to measure AC. R&D analysis, R&D employees, social network analysis, and citation analysis have been the preferred methods for one dimension measurement. For the acquisition stage and Potential AC, environmental scanning has been the most popular. For the assimilation stage, the most popular methods have been customer analysis and human resource analysis. For transformation measurement, demand and market changes have been the most popular form of measurement. For exploitation, development of new product and services is the most studied. For realized AC, human resources and new products and services have been the most common measurement methods.

Fig. 3 Absorptive capacity measurement approaches explored in this study. Legend: The square size indicates the size of the analyzed sample. Legend: The square size indicates the size of the analyzed sample (<https://public.fourish.studio/visualisation/14079619/>)



### 6.2.5. Knowledge Appropriation Measurement

We analyzed different KA measurement methods. Milesi et al. (2013) measured KA in Argentina based on patent, brands, secrecy, first-mover company strategy, participation, and control of supply distribution networks. Colombelli et al. (2020) used a similar approach but aggregated the lead time of products or services. Other authors have used similar approaches based on IP (Arbussà & Coenders, 2007; Bahl et al., 2021; Barros, 2021; Spithoven & Teirlinck, 2015). These authors either mixed IP with informal mechanisms (Leiponen & Byma, 2009), collaboration between organizations (Benedicto et al., 2014; Rubira-García et al., 2018), or examined the complexity of product design, employees contracts, lead time advantage, complementary manufacturing, marketing, and service capabilities (Torres de Oliveira et al., 2021). Other approaches have measured the impact that research studies have

had in the news (Uribe-Tirado et al., 2020), patent citations (Wang & Chen, 2010), or the triple helix interaction in small-scale fisheries (Fig. 5).

Fig. 4 Main indicators use to AC measurement. Legend: [https:// public. flourish. studio/visua lisat ion/ 73137 87/](https://public.flourish.studio/visua-lisation/7313787/)



### 6.3. A methodology to measure ac and ka in a macro and meso level

The last chapter showed that surveys and bibliometric methods are the best methodologies for analyzing AC and KA at a country level. In order to explore the AC and KA of Colombian

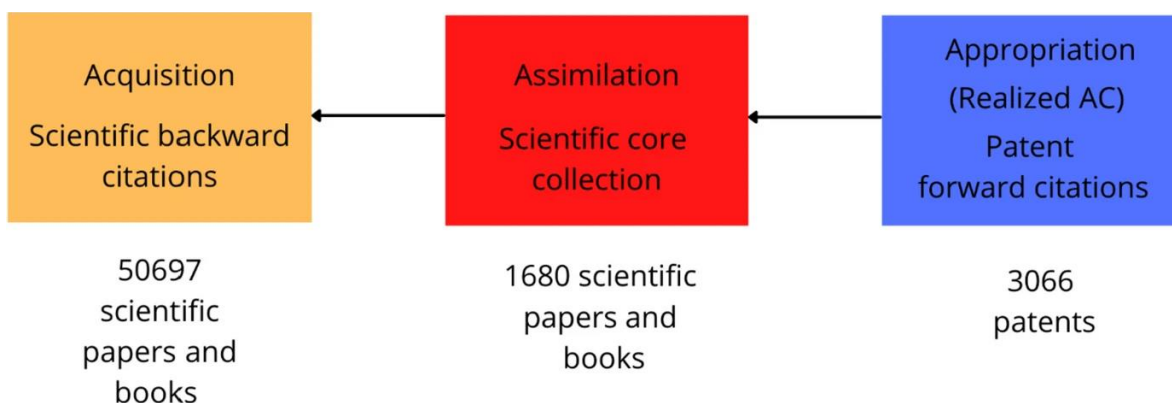
scientific knowledge we used bibliometrics and patent analysis to analyze the entire landscape.

#### 6.3.1. Data recovery

We analyzed the scientific papers published by Colombians that generated KA, which was measured by patent FC. We decided to use the Patent Lens database and Scopus to link scientific and technological (patent) literature using scientific and technological citations. Our main objective was to show the KA of scientific knowledge appropriation at a macro and meso level and the relevance of AC in this process. Therefore, we analyzed the origin of the publications and patents by country. We focused on Colombia as a business case study because, in innovation rankings, this country is not known as a generator of innovation. However, Colombia has historically produced more scientific literature than other emerging countries in the region (Incites, 2022).

We searched the patent lens database by using the following query: `author.affiliation.grid.address.country_code:"CO"`. This search strategy produced 227,922 results. Due to not every scientific publication has been cited by patent literature, we filtered our search to only look for scientific literature that is cited by patents. Through this method, the number of results decreased considerably to 1,680 results. These final results were named scientific key literature (SKL) due to its importance to generate technological developments. Afterward, we analyzed the knowledge exchange process to understand the AC process of the scientific papers and the generation of patents, which we associated with KA and AC transformation and exploitation stages. Therefore, we did a BC analysis of the scientific literature that the SKL cited. BC was found using the "Patent Lens database," and 50,697 BC were recovered through this process. In addition, we were able to identify the world patents that have exploited SKL. These were used as an indicator of KA and realized AC. In order to recover this data, the Patent lens database was also used. A complete dataset of 3,066 patent families was obtained.

Figure 1 Framework of analysis of AC and KA



### 6.3.2. Data cleaning

A specific Knime workflow was designed to normalize duplicate data and to link the three main blocks of information -scientific key literature, backward citations, and patents- (Tursi & Silipo, 2019). In addition, we used Tableau Desktop and WinPure clean and match community edition to normalize country information.

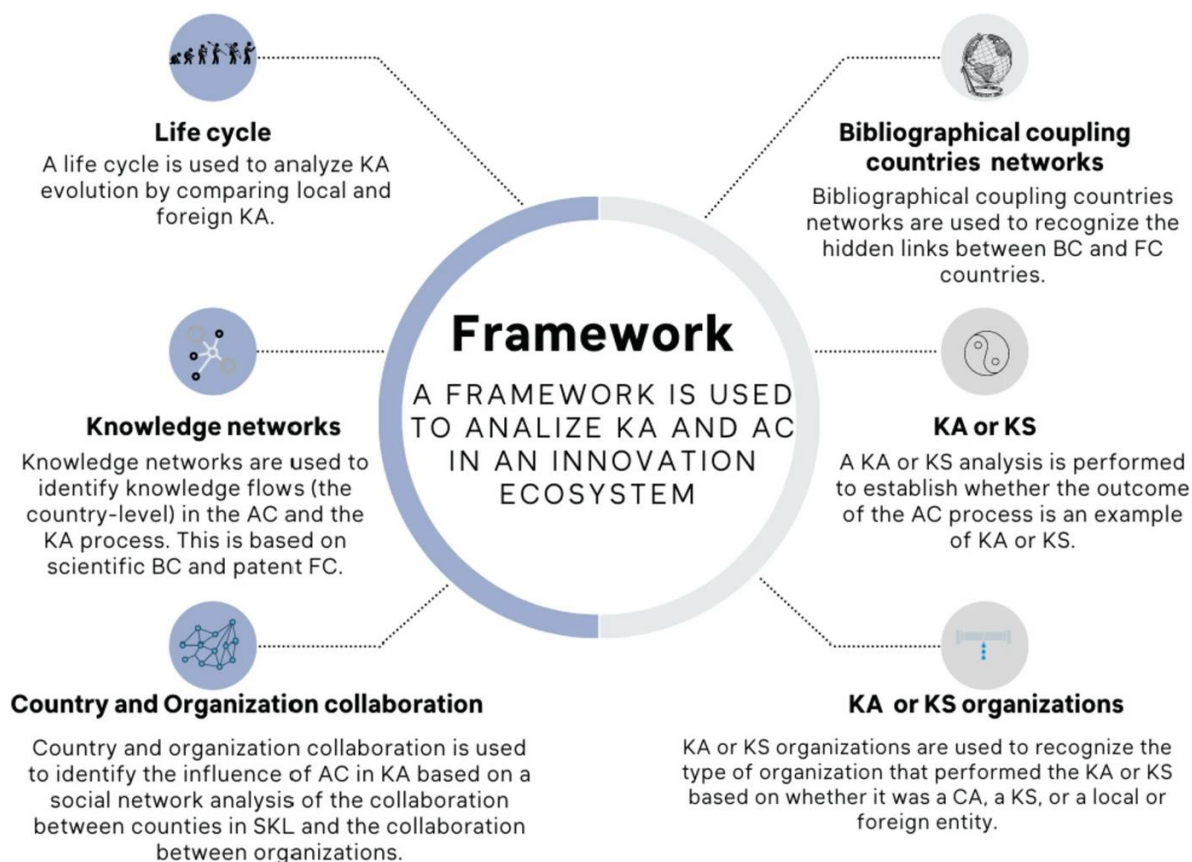
### 6.3.3. Data analysis

Our research was conducted on two levels: macro and meso. Macro analysis was done based on countries, and meso analyses used authors affiliations and correspondence author affiliation.

The knowledge flows between countries were created using BC and FC, which were analyzed by using social network analysis methodologies. We analyzed KA, the type of organizations, and the influence of AC based on network centrality to generate appropriation.

The framework summarizes the methodology and indicators that were used in our analysis.

Figure 2 Toolbox generated to measure AC and KA at the macro and meso level



#### 6.4. Case of study "knowledge appropriation of colombian scientific key knowledge and the influence of absorptive capacity over the appropriation"

Based on the framework showed in the methodology, we conducted a case study of KA by examining scientific key literature and the influence of AC.

RQ2 seeks to recognize how KA evolved at the local and foreign level. By basing KA evolution on the FC, we were able to track the evolution of KA. The life cycle showed that this appropriation began in 1975 with an emerging phase characterized by low KA. The rising number of patents began in 1998 with a new phase called the growth stage characterized by an exponential increase in appropriation. This period has not ended. This analysis shows that KA has increased over time.

Regarding local KA, we found a negative outcome of only 1.76%. This result shows that the primary phenomenon with SKL has been a KS. In other words, SKL has been appropriated, transformed, and exploited by foreigners and not by Colombians.

Figure 3 Knowledge appropriation life cycle and percentage of appropriation by national applicants and foreign applicants

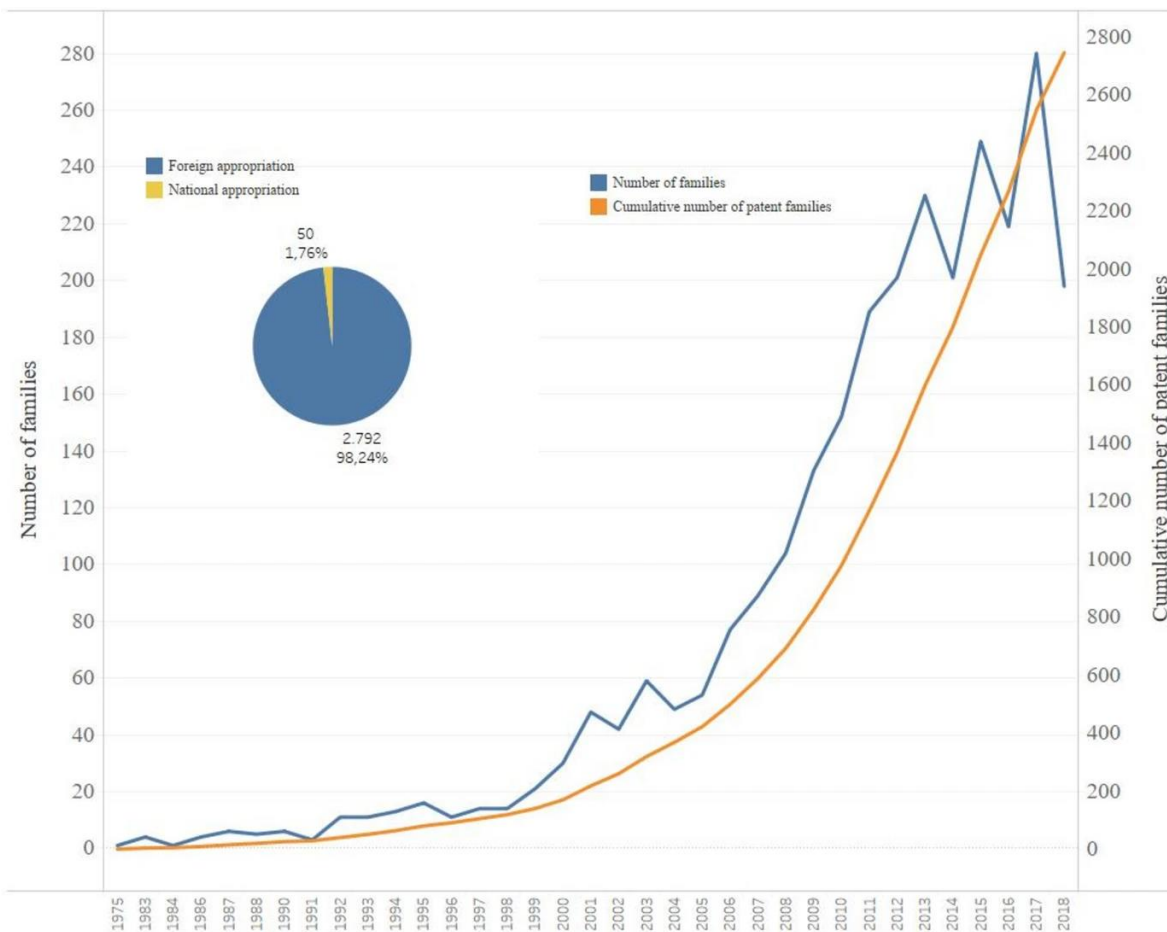
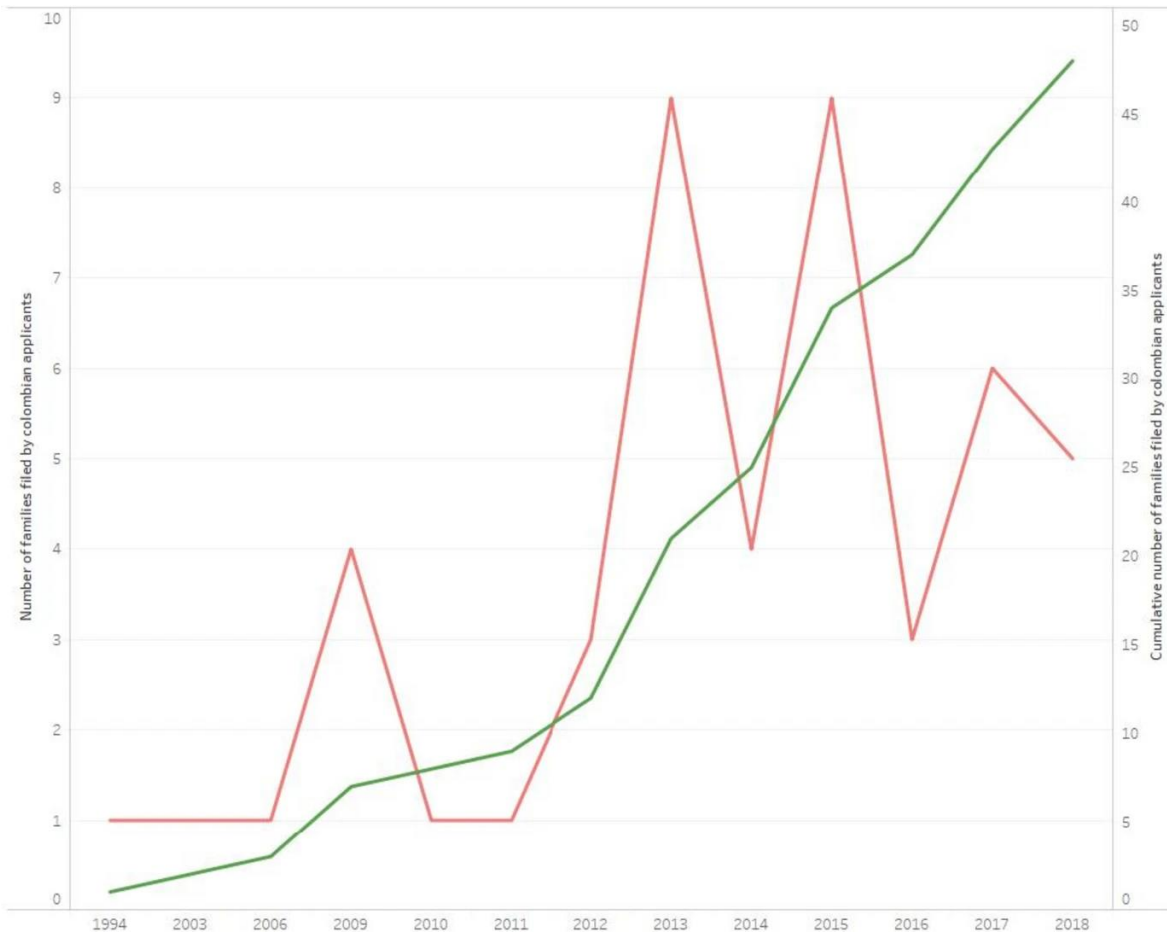


Figure 8 focuses on local KA. Although our research shows an increase in Colombian filed patents, the amount of patents filed are so low as to be considered irrelevant (In the peak year of 2013 only nine patents were filed). This analysis shows that the KA process by local patent applicants is a rare phenomenon, and the technology transformation and exploitation associated with *realized* AC is rarely undertaken by local organizations.

Figure 4 Knowledge appropriation process by Colombian applicants based on patent FC



In RQ3, we identified the critical countries in BC, SKL, FC, and the knowledge flows. Our goal in this analysis was to show the KA cycle at a country level to see the link between AC and KA. We followed the framework proposed in figure 5. To understand the knowledge flows, we recognized the countries of origin of BC. We identified the United States, the United Kingdom, Germany, and Japan as major BC countries in the emergent and growth

stage. Spain and France were two other major countries considered to be in the growth stage. In the emergent stage, only 2.10% were acquired from Colombian sources, and in the growth stage, this number double but was still such a low number as to be considered irrelevant when compared to other countries.

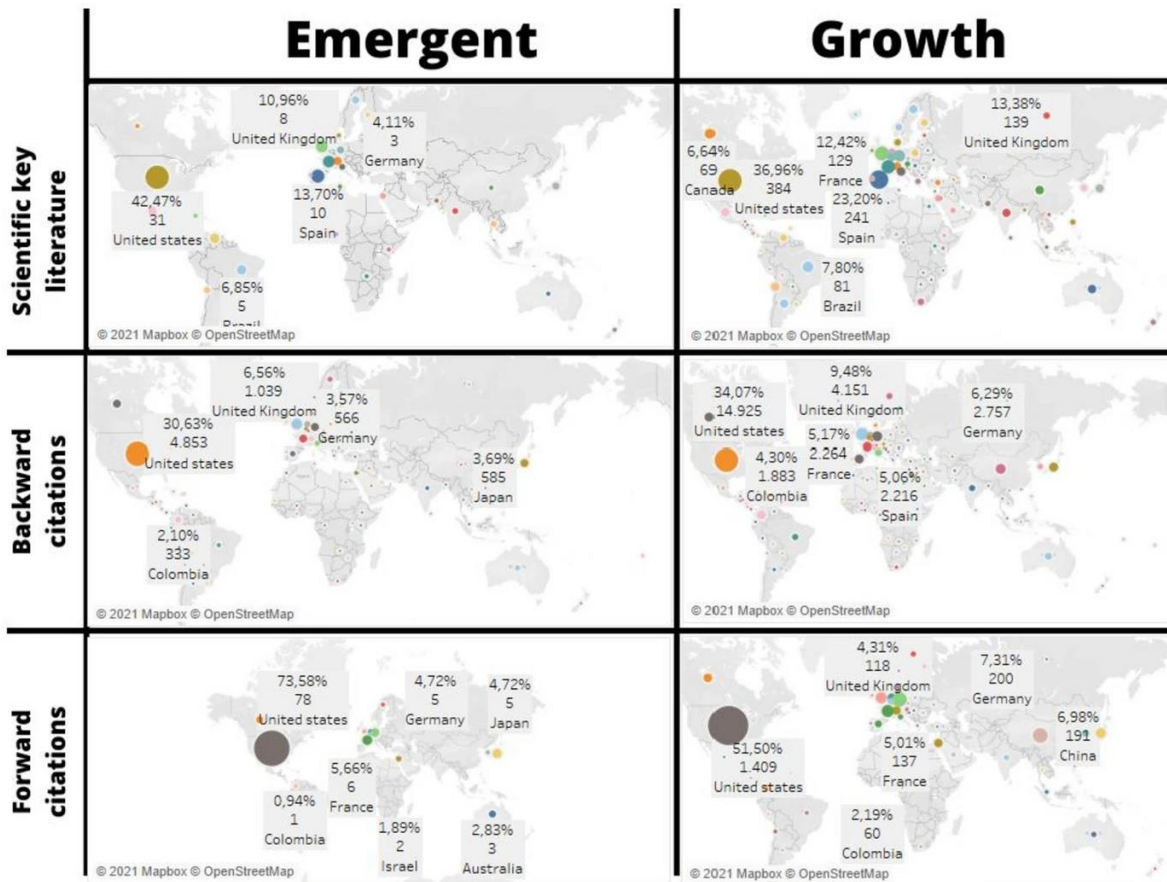
We started analyzing main countries by coauthorship with Colombian organizations regarding the assimilation stage. We found that the United States was the main collaborator, followed by the United Kingdom, Spain, Germany, and Brasil. This analysis showed that the assimilation process carried out by SKL has been developed mainly through collaboration with countries with strong R&D and not with neighboring countries such as Ecuador, Venezuela, or Peru.

Finally, we analyze transformation and exploitation of knowledge based on the countries of origin of the patent applicants (FC), which also reflects KA.

The United States has been the most active country for KA, followed by Japan in the emerging stage and Germany and China in the growth stage. The FC analysis shows that the KA process has been carried out mainly by developed countries.

This analysis also shows that latin american KA has been irrelevant and African countries have been isolated from these knowledge flows.

Figure 5 Key countries identified by developed backward citations, forward citations, and SKL

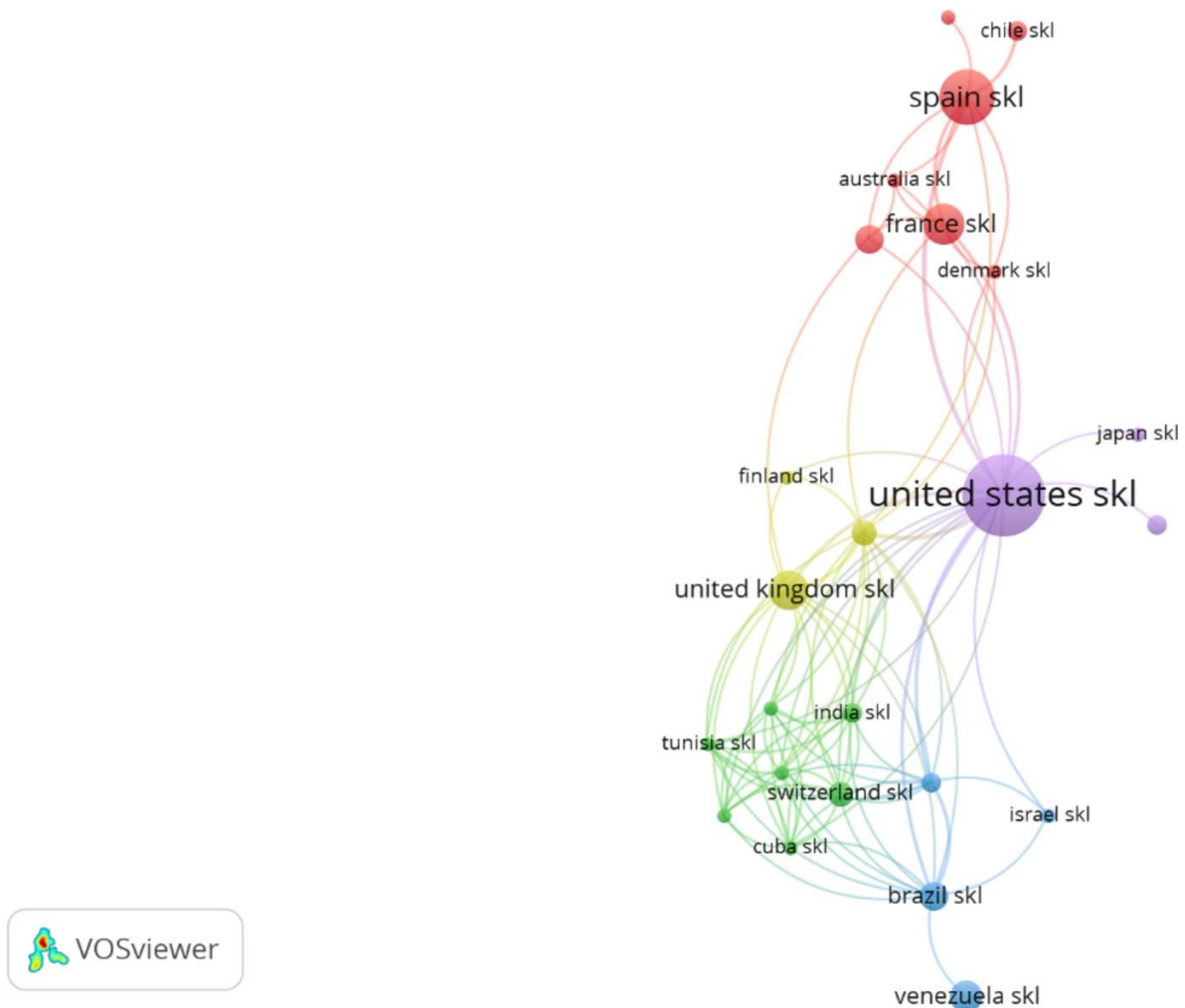


#### 6.4.1. Assimilation AC and its relevance in KA and KS and exploitation

RQ3 aimed to understand *the AC assimilation process*, based on country collaboration. Five communities were found in the emergent stage using the VOS viewer community detection tool shown in figure 7 with the different colors (van Eck & Waltman, 2010). The major countries in each subgroup were identified. The United States was the most visible in the violet color cluster, while Spain was a key country in the red cluster, the United Kingdom in the yellow, and Switzerland in the green. The major countries that were involved in social network analysis were the United States, Sweden, Brazil, and United Kingdom. Another relevant indicator that came to light through social network analysis is the betweenness centrality. This indicator identifies the countries that are bridges between the different

communities. We found that the United States, Spain, Sweden, Brasil, and the United Kingdom had the biggest betweenness centrality.

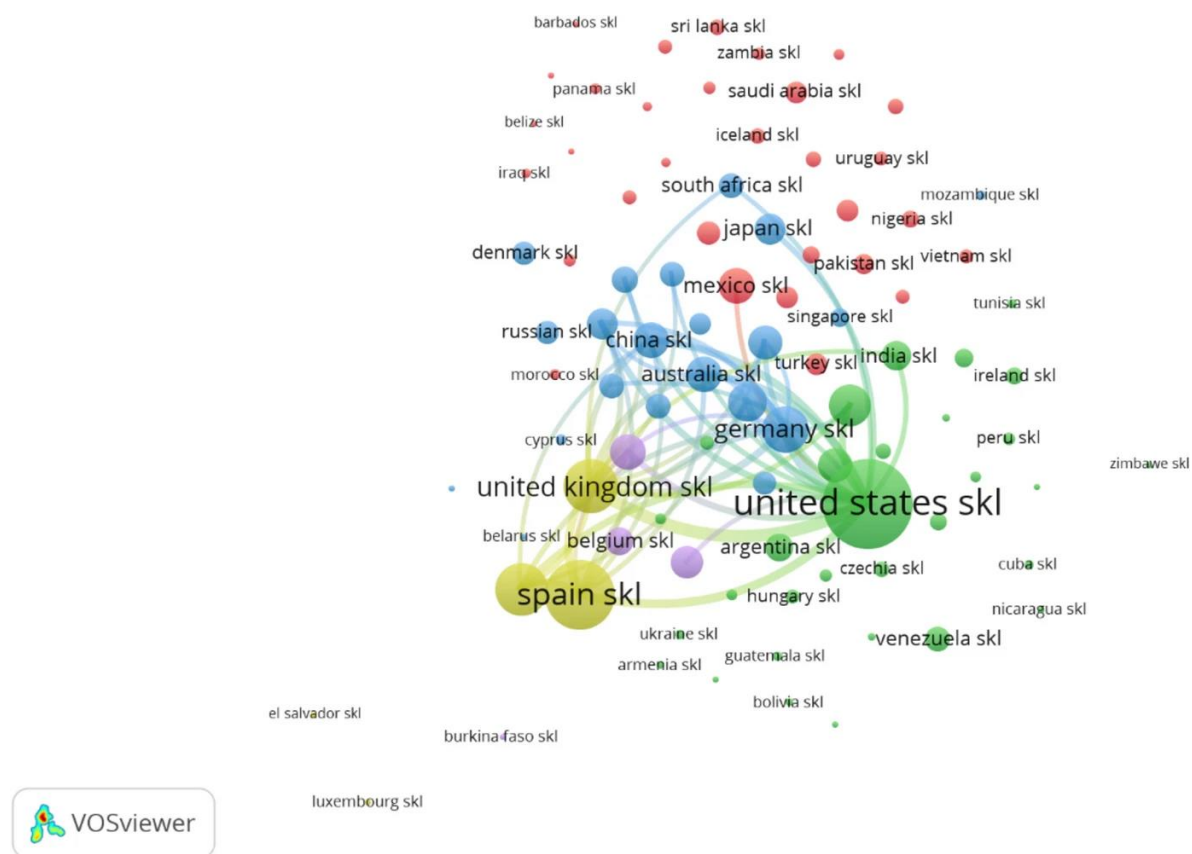
Figure 6 Country scientific coauthorship in SKL in the emergent stage



In the growth stage, we found as key country The United States. A major scientific partner of the United States was Spain and Germany, which can be seen by the number of records and the number of coauthorships by country. Subgroups between countries such as Sweden, Australia, and Norway were identified through SNA analysis. A strong cohesion between Europe, Asia, and North America was found to be evident in this stage. Using the

betweenness centrality indicator, we found that the main bridges of countries in the growth stage were between France, Spain, the United States, and Brazil.

Figure 7 Country scientific coauthorship in SKL in the growth stage



Social network analysis indicators show the evolution that has occurred in the network over time. Some critical insights can be obtained based on this analysis. For instance, half of SKL was developed by Colombians without international collaboration. In addition, the growth stage shows an increase of 32% in the collaboration between Colombians and international organizations. An increase in collaboration between 2 or 3 countries can also be seen in the emerging and growth stage. This analysis shows that increased collaboration is related to growth in KA. Network diameter shows that the network is more compact in the growth stage than in the emergent stage, and density analysis shows that the growth stage has increased the strength of collaboration between countries.

Table 1 Country coauthorships statistics

Stage	Density	Diameter	Statistics	Number of countries
Emergent	0.126	4	Min: 1; max: 13; media: 1.816	1 (48%); 2 or 3 (47%); more than 3 (5%)
Growth	0.721	3	Min: 1; max: 58; media: 2.864	1 (32%); 2 or 3 (56%); more than 3 (12%)

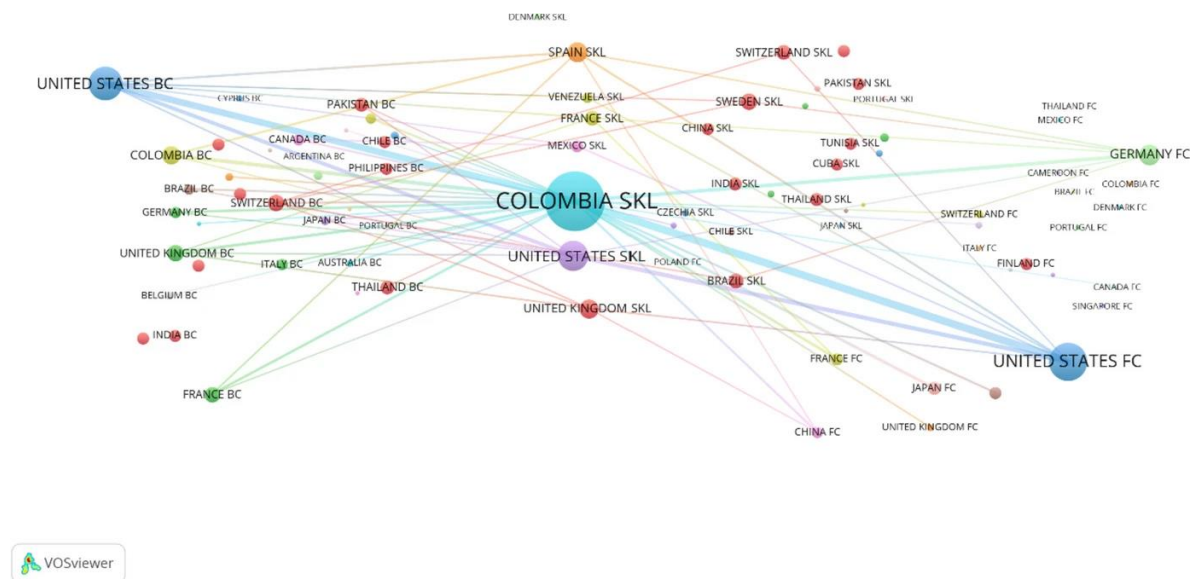
#### 6.4.2. Going deeply among knowledge acquisition, knowledge assimilation, and knowledge exploitation and appropriation

To understand knowledge flows and the dynamics of knowledge acquisition, assimilation, realized AC, and KA, we analyzed the relationship between BC countries, SKL countries, and FC countries by citations.

Our first analysis (see figure 12), as seen on the left side of the figure, shows the cited countries and where knowledge was acquired by Colombian organizations. In the center of the figure, you can see the SKL countries that assimilated knowledge from BC. On the right side of the figure, the countries that made KA and knowledge transformation and exploitation by patents are shown.

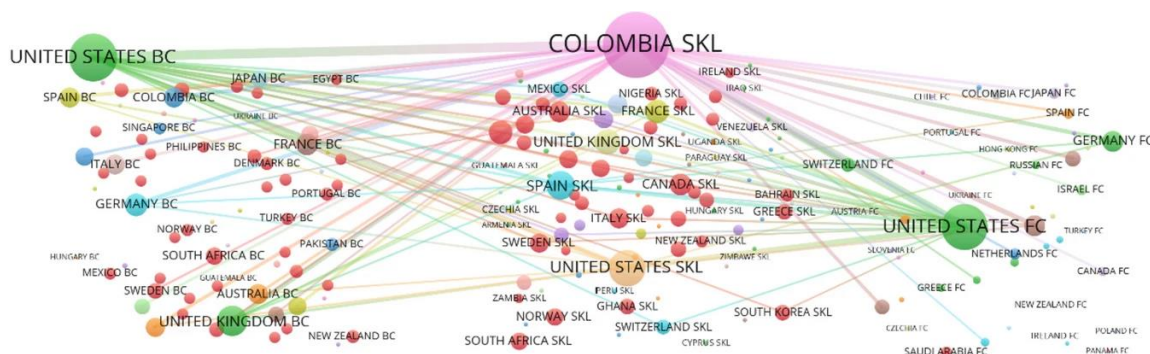
This analysis shows that the United States was the primary knowledge source in the emergent stage, and the knowledge from this country has been acquired mainly by United States organizations and appropriated by them. The assimilation process was done by Colombian organizations in collaboration with Spain, Venezuela, France, Mexico, and the United Kingdom, as shown in Figure 12. Germany, Brasil, and China were other prominent countries in the appropriation and exploitation process.

Figure 8 Country by BC, SKL and FC in the emergent stage



The growth stage shows an increase in the number of countries where knowledge was acquired and assimilated. The growth stage had almost twice the number of countries where knowledge was acquired as the emergent stage, and the number of SKL countries moved from 35 to 95 countries. FC analysis shows that the number of countries moved from 13 to 53, demonstrating a significant increase in countries that appropriated and exploited this knowledge.

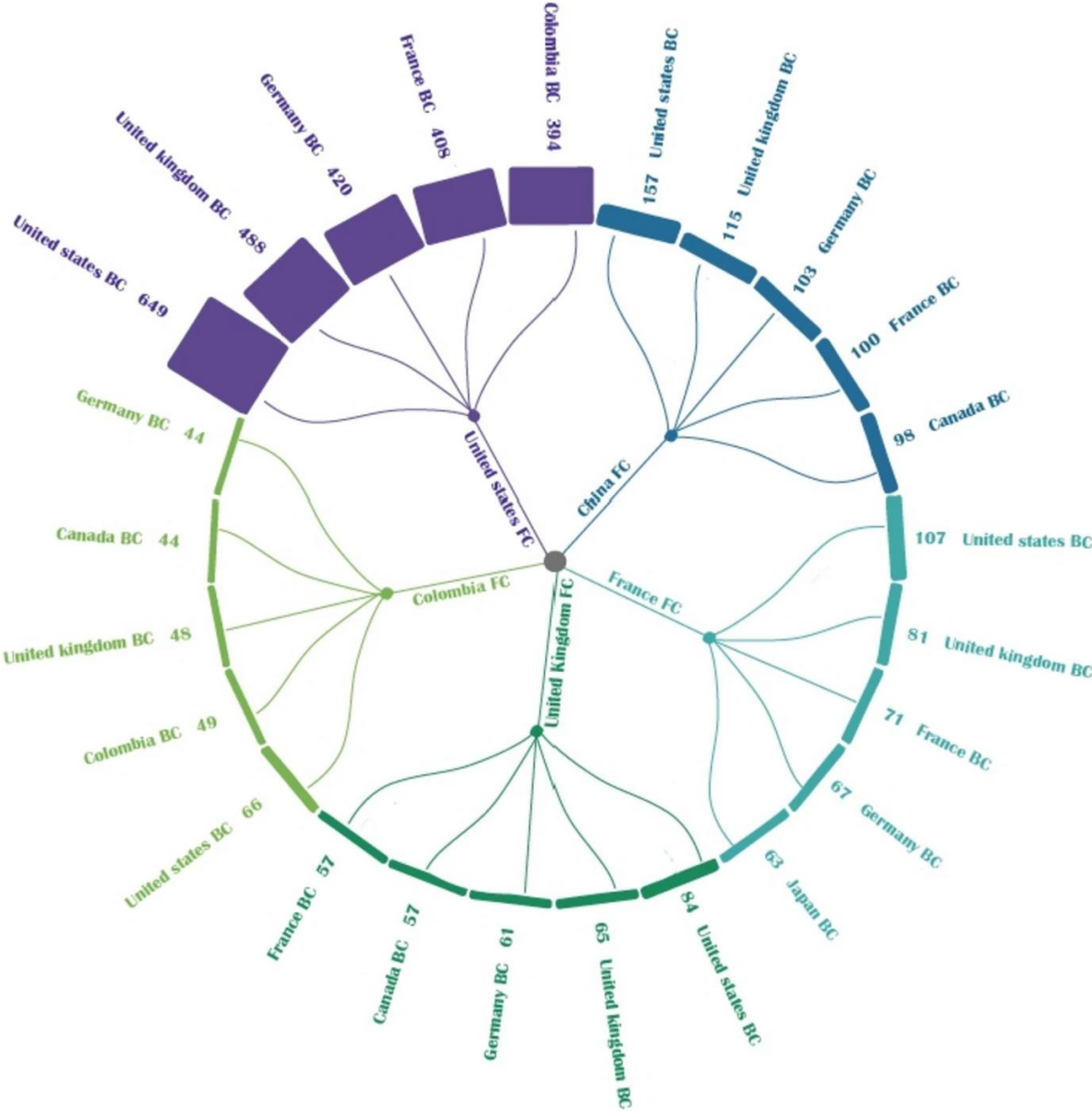
Figure 9 Country by BC, SKL and FC in growth stage



We built a bibliographical coupling analysis to further explore the link between countries where knowledge was acquired (BC) and countries that were involved in knowledge appropriation (FC). We did not filter for different stages to have a holistic perspective for this analysis.

A relevant pattern in our analysis was recognized. The major BC countries were the United States and the United Kingdom. They can be considered building blocks in the generation of scientific development that is later appropriated by other countries. Other major countries that had considerable BC were Germany, Canada, and France. When KA was performed by Colombian applicants, Colombian BC was shown to be an important building block.

Figure 10 Bibliographical coupling analysis between BC and FC countries



<https://public.flourish.studio/visualisation/7601018/>

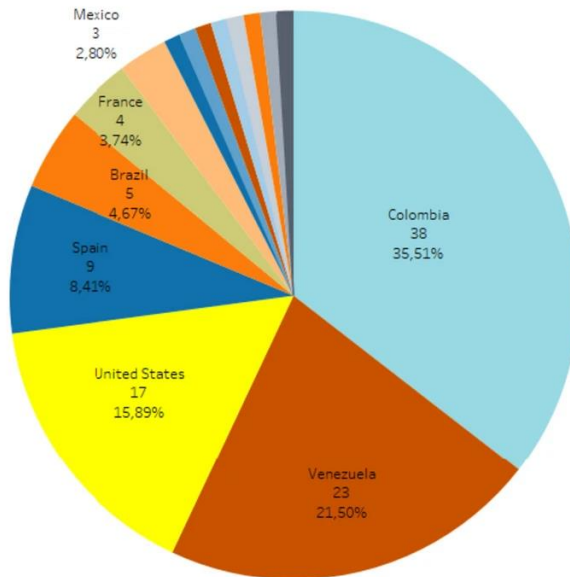
#### 6.4.3. What happens when a country is the main owner of the skl knowledge?

In this research, we wanted to understand what happened when a country was the primary developer of the SKL. To answer this question, we used the corresponding author (CA) which is defined as the author who is the leader in the development of the SKL. Among the roles of a CA are to be in agreement with the journal, to make the payments and to make any required corrections in the manuscript (Cambridge University, 2022).

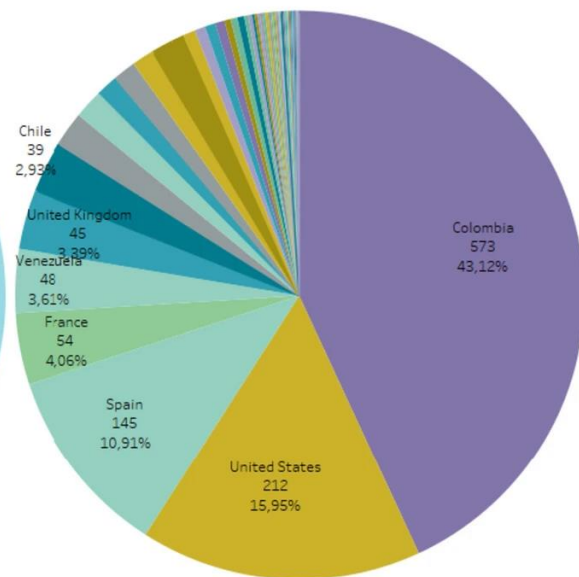
We found that Colombia made up 35% of SKL CA in the emergent stage and 43% of SKL CA in the growth stage. On the other hand, Venezuela had a 22% of CA in the emergent stage. In addition, the United States had a 15% of CA and Spain had 11% of CA in the growth stage. This analysis shows the leading role that Colombian organizations played in SKL.

Figure 11 Countries CA in emergent and growth stages

Emergent 1975-1997

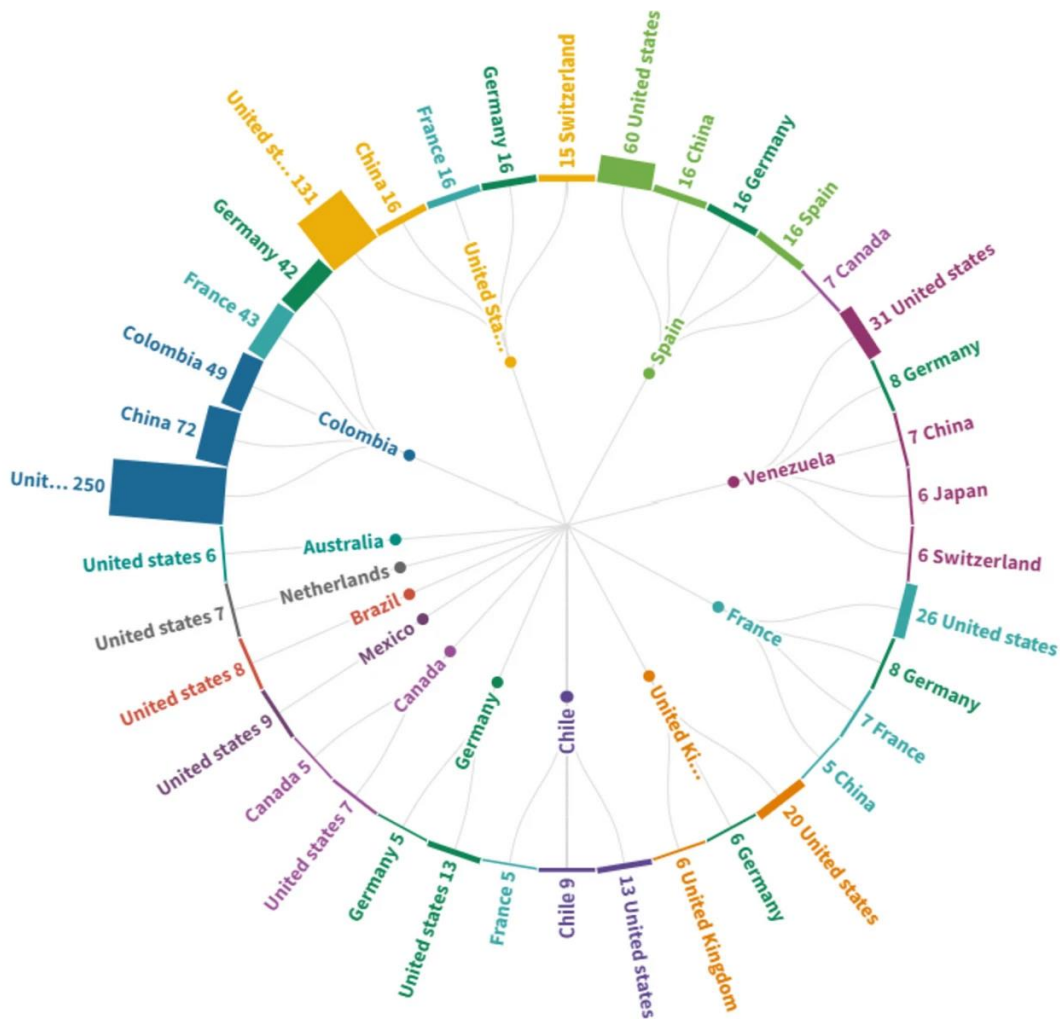


Growth 1998-2020



To understand knowledge flows when a country was a CA, we identify the networks between CA countries in SKL and FC countries. When Colombia was CA, the main outcome was a knowledge spillover where knowledge was transformed, exploited and appropriated mainly by the United States (41%), China (12%) and Colombia but by a lesser proportion than by other countries (8%). On the other hand, this outcome shows that local KA improved from 1.76% to 8% when Colombia was the CA. In addition, this analysis showed that the United States has been the only country that has been able to transform its own knowledge with 57% of its academic articles being appropriated by themselves when they were the CA. Other countries that have achieved KA when they were the CA were Germany, Chile, and Canada. These outcomes show that most developed economies have developed better mechanisms to do KA.

Figure 12 Relationship between SKL correspondence author country and KA country



<https://public.flourish.studio/visualisation/7979624/>

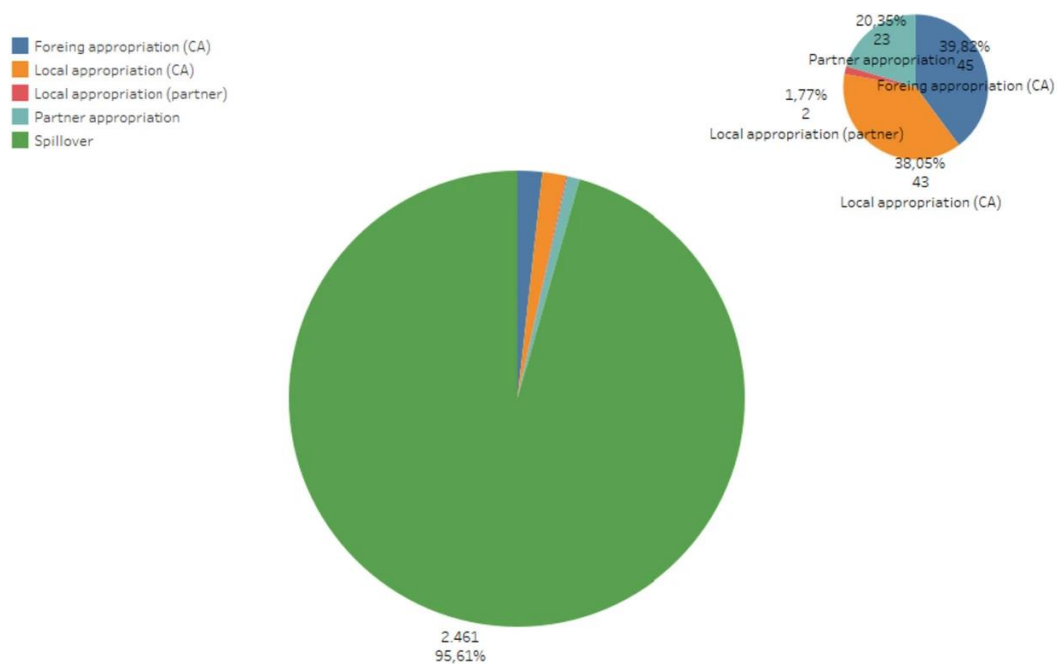
#### 6.4.4. Understanding KA at an organizational Level

RQ5 seeks to understand when appropriation happens by local applicants, by partners, or by other organizations unrelated to scientific development. In order to understand this process, we analyzed all the organizations involved in the SKL and KA process.

Firstly, we identified whether KA was done by some of the players that were in the SKL or whether it was done by external organizations KS. KS happens when none of the organizations that worked on the scientific paper were an applicant in the patent. We defined owner appropriation when the CA of SKL was also part of the appropriation and exploitation. We understand that the CA organization gives more knowledge to SKL development ;for this reason, we defined CA as an SKL owner. Partner appropriation happens when the owner does not conduct KA but when an SKL partner does this.

Our analysis showed that the most common type of outcome is a KS of 95%. Furthermore, 5% of KA is represented by 39% of foreign KA, 38% of local KA, and 20% by partner KA.

Figure 13 (left) Ks and type of KA (right) type of local KA



#### 6.4.4.1. When appropriation happens by local applicants

Based on our data, our last analysis showed that KA done by local applicants in emerging countries can be considered atypical, local applicants developed only 1.76% (50) of patents. We decided to delve into these cases and segment the KA local cases into different categories:

KA done by all organizations that are involved in SKL

KA done by local organizations where foreign organizations are not in the patent

KA done by a local organization that is the unique organization in SKL

KA done by a new local organization that is not involved in SKL,

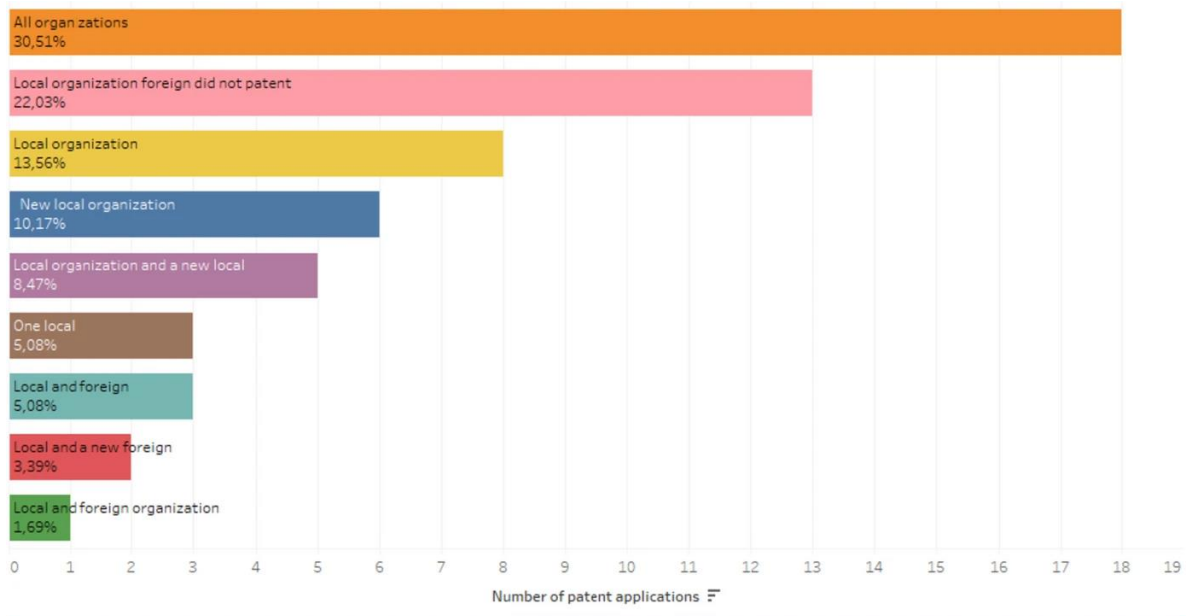
KA done by a SKL organization and a new local organization

KA done by local organizations that are involved in SKL

KA done by some of the local and foreign in SKL organizations

We identified that the most common type of local KA was participation by all organizations that were in SKL in the patent development (30.51%). Another common scenario has been that only the local organizations filed a patent without the aid of foreign organizations; however, in SKL, they had coauthorship with international organizations (22%). In addition, another relevant scenario has been the patent application by only the local organization (13%) and the patent application done by a different local organization that was not a coauthor in the SKL (10%).

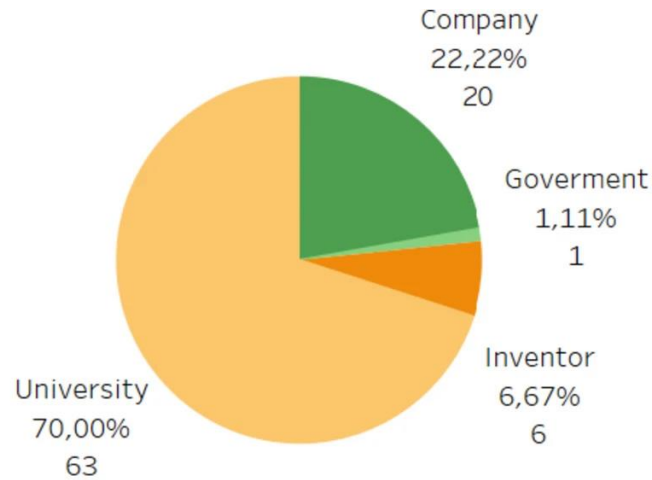
Figure 14 Comparison between SKL and appropriator organizations



Regarding the organization type that was done in this KA, we found that it was done mainly for universities (70%), companies (22%) and inventors (6.67%).

Our outcome indicates that appropriation is done mainly for the same type of organizations that produce the SKL.

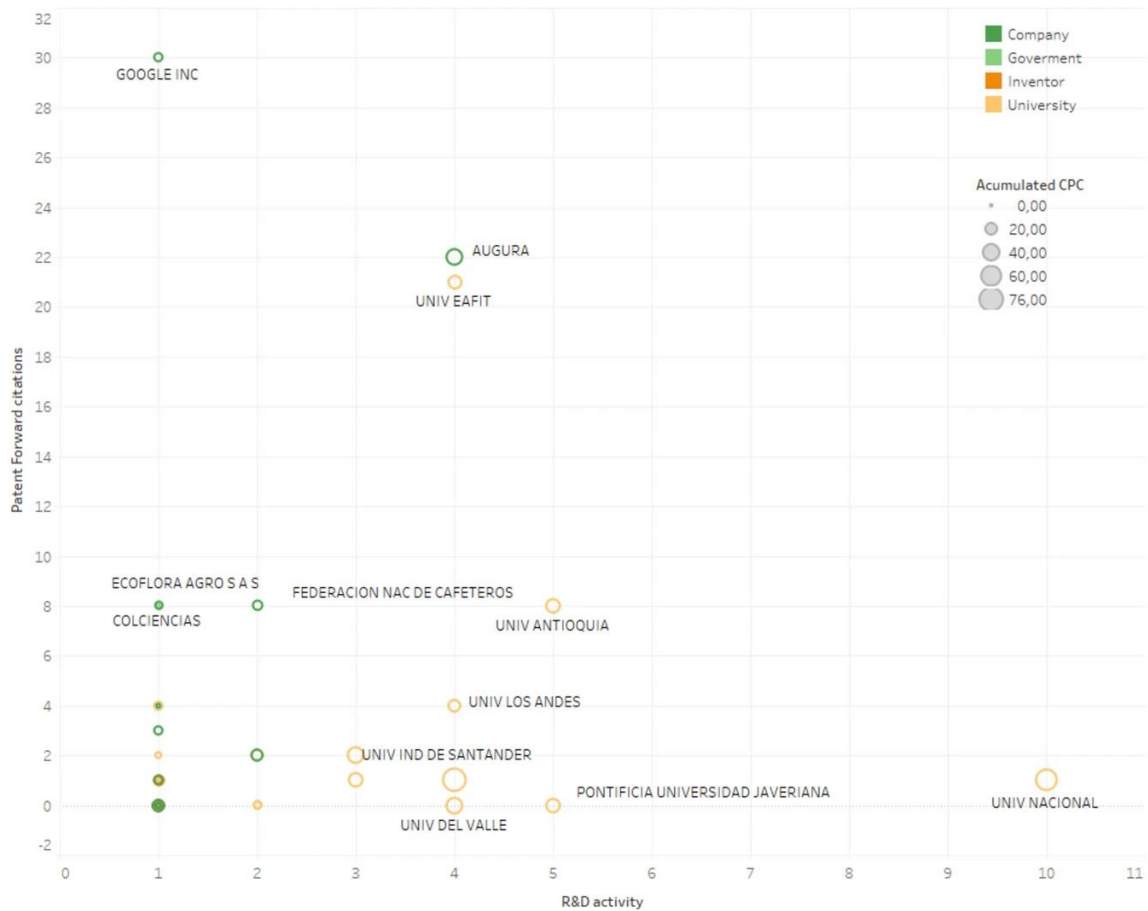
Figure 15 type of triple helix Organizations that have appropriated and exploited the knowledge




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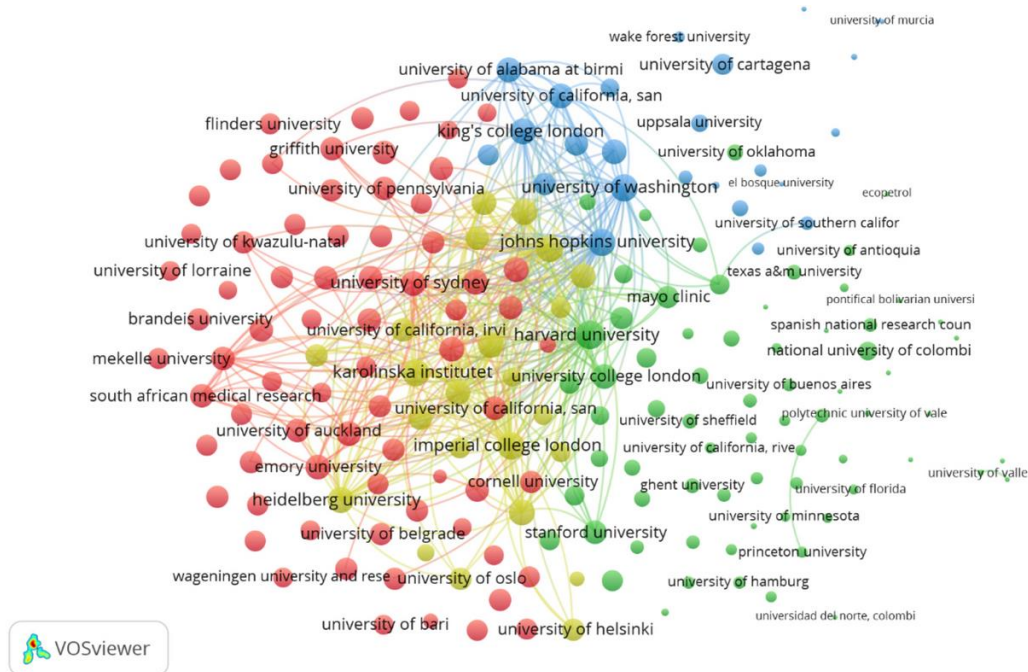
The following figure demonstrates which kinds of local patent applicants have participated in KA. Applicants were segmented using R&D activity and FC. The principal organizations for R&D were the most recognized universities in the country for R&D (Incites, 2022). These universities are Universidad Nacional, Pontificia Universidad Javeriana, Universidad de Antioquia and Universidad de los Andes. FC analysis showed the main leaders to be Google, Augura, and Universidad Eafit. The last analysis confirms the relevance of Colombian universities in the KA of the SKL that they have produced.

Figure 16 Local appropriators



On the other hand, we tried to understand the relevance of AC in appropriation at an organizational level. We analyzed the SKL collaboration network to see if the local organizations that have appropriated and exploited knowledge were prominent in the SKI community. We found that critical organizations shown in our last analysis were part of the main scientific communities in SKL and although they did not have the most substantial cohesion with other SKL organization, they have been part of these communities.

Figure 17 SKL Coaffiliation network



RQ4 shows that in emerging economies the main outcome is a KS where SKL is not absorbed or appropriated by the country and when it is appropriated, it is by the same SKL organization. A weak link between quintuple helix ecosystem players (Carayannis & Campbell, 2010) can be seen in Colombia where knowledge is not transferred to companies or government and it stays stagnant in universities.

## 6.5. Discussion and limitations

Our study shows a novel approach to measuring AC and KA at macro and meso levels that can be used to understand the relationship between AC and KA. Our tool does this by analyzing the SKL that patents have cited. We took all the SKL from Colombian organizations that have been cited by patents (FC) throughout the world. One of the advantages of this methodology is that it can be replicated by other countries. Therefore, this process can be used to help evaluate and compare different regional innovation systems between different countries.

We opted to utilize bibliometric methods to examine KA and AC in countries. Bibliometric techniques, with their quantitative orientation, enable the systematic collection of scientific and patent data. Furthermore, such methodologies offer a comprehensive view that encompasses thematic analysis, participant analysis, and more (Florêncio et al., 2020). In addition, bibliometric methods facilitate the measurement of productivity and impact related to scientific and technological outputs (Soares et al., 2019).

On the other hand, bibliometrics allow for the analysis of large data sets that may not be feasible with surveys and interviews. Bibliometrics enable the collection, processing, and analysis of information, providing a comprehensive and representative landscape of scientific and technological production (Ribeiro et al., 2023). Additionally, bibliometric methods offer a historical perspective of the data, effectively illustrating trends, patterns, and connections within the information (Huang et al., 2021).

Our methodology starts by analyzing appropriation grade, comparing foreign and local KA from an S curve analysis (Ernst, 1997), which allows us to identify the different stages of KA. Other authors have used this approach in different countries to measure the role of the technological regime and technological catch-up and the link with life cycle and KA (Park & Lee, 2006).

Knowledge flows is a topic that has been studied few in KA literature, for instance, the role of KA in knowledge flows between multinationals and their subsidiaries in Portugal, Germany (Faria & Sofka, 2008) and China (Wu et al., 2005), or the role of KA over knowledge flows and KS in Japan and the US (Cohen et al., 2002). The relationship between AC and knowledge flows has been analyzed using patent data and a citation analysis from USPTO patent database. Other authors have analyzed the influence of AC over the knowledge flows in incubators firms (Rothaermel & Thursby, 2005b) and the role of AC in capturing US business models of three Australian companies (Bailey, 2017). Our novel approach uses backward -BC- and forward -FC- citation using visual analytics (Ebert et al., 2021) that permit researchers to analyze and clarify knowledge flows between the countries of origin of BC, SKL, and FC. This methodology allows researchers to measure AC of the

countries involved in the generation of SKL literature and recognize the countries scanned in the environment (BC countries) to generate SKL. Furthermore, the methodology measures knowledge assimilation by analyzing country collaboration networks and their influence over KA and knowledge exploitation from the patents generated from SKL. The relationship between knowledge acquisition and KA was done by using bibliographic coupling analysis showing the influence of BC countries over FC countries. Finally, we made a zoom to recognize the appropriation process when a country was the primary developer of the SKL that was identified using the correspondence author (CA). The last two approaches are novel in the literature of KA and AC and could make a significant contribution to both fields.

Regarding the measurement of AC and KA at a meso level, our tool can analyze a whole country or region. For instance, our methodology allows for the understanding of specific cases of KS, KA done by the corresponding authors, KA done by a partner in SKL, or KA done by SKL organizations that were not the CA.

KA and KS are topics that have been studied but not at a whole country level as we did in our research. Other authors have analyzed other perspectives from KA and KS. For instance, the relevance of both in product innovation in Belgium, Germany, and Spain (Spithoven, 2013), the relevance of KA and alliances to product innovation in Colombia (Caldas et al., 2021), or the relevance of KA in KS from Germany and Portugal Multinational companies. Our paper complements this literature showing the relevance of AC for KA and the positive effect of a low AC in KS.

In addition, we analyzed the local KA deeply and analyzed whether the KA was done by the CA organization or if KA was done by all the organizations that were in the SKL. Our tool also measures the types of organization that have participated in appropriation (company, university, governmental) to understand the role of the innovation ecosystem players (Carayannis & Campbell, 2010) and the influence of AC over KA based on the organizational co-authorship network, identifying the importance of local organizations in these networks. Other authors have analyzed the influence of AC in regional innovation system for instance, in China (Li et al., 2018), the impact of foreign direct investment over regional innovation at

a city level can identify the positive impact of AC (Jiang et al., 2021) and the relevance of AC in the interaction between companies and universities in the Spanish regional Andalusia innovation system (Pinto et al., 2013).

Our main contribution to this topic was the segmentation done by a type of player segmenting it by local or foreign organizations and by identifying the roles they played in SKL.

Regarding our case of study, to the best of our knowledge, no former studies have analyzed AC and KA at the country level based on the whole R&D landscape, although both topics exhibit a significant relationship and considerable convergence (Cuéllar et al., 2022; Cuéllar, Fernández-Bajón et al., 2023; Cuéllar, Grisales et al., 2023). For instance, Barros (2021) studied only a sample of 505 companies in the Brazilian ecosystem, as well as Andreeva et al. (2021) who analyzed the link between intellectual capital and appropriability in Finland, Spain, and Russia based on 649 firms, or Arvanitis and Bolli (2013) who identified the relevance of AC and KA in Belgium,

In addition, our business case also fills a large gap in the Colombian knowledge management and innovation literature where there are only a few studies as Caldas et al.(2021), who studied AC and KA in 913 manufacturing firms.

Other studies have used similar approaches to us to understand KA . For instance,(Huang, 2016) used scientific and technology knowledge flows in the genomic industry. Nevertheless, the scope was different. Our study opens different possibilities to do research associated to this field. For instance, to use the same approach to understand a country's KA and AC relationship and to compare regional innovation systems. In addition, other indicators can be adhered to our methodology as the measurement of novelty or originality (Harrigan et al., 2017a) indicators required to identify innovation or to use granted patents that would be a better proxy for KA.

Our outcome can be used as measurements to recognize the weaknesses of emerging countries to retain and exploit their own knowledge.

Our analysis showed that KA is not common in these types of economies. In addition, this local KA is done mainly by universities showing that the cohesion between the triple helix is an important task that should be done by governments to improve KA.

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## Capítulo 7. Resultados preliminares

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En esta sección se presentan los resultados inéditos que complementan algunas de las conclusiones desarrolladas a través de la tesis. Dentro de la información que no está publicada se encuentra un análisis que se realizó de los textos completos de los artículos relacionados con capacidad de absorción y de los artículos relacionados con apropiación del conocimiento. Posteriormente se separó por frases usando la librería Spacy de Python y se identificaron las frases que incluían ambos temas. Estas frases fueron embebidas utilizando la herramienta Sentence Transformer de la librería Bert de Python (Reimers & Gurevych, 2019) y, esto generó una vectorización de las oraciones que luego permitió generar clústeres, utilizando la herramienta de clusterización K-means (Jain, 2010).

Posteriormente se analizaron estos clústeres y se identificó de cada uno el tema específico y las subtemáticas que los componían.

*Tabla 3 Clusters identificados de la capacidad de absorción y la apropiación del conocimiento usando Spacy y Bert*

Titulo	Cluster	Definición	Elementos clave
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<p>Mecanismos de apropiación y la capacidad de absorción</p>	<p>cluster_0</p>	<p>Este Cluster estudia la relación entre la capacidad absorción y los mecanismos de apropiación para impactar el rendimiento de las empresas y su impacto en la fuga de conocimiento</p>	<p>La capacidad de absorción y los mecanismos de apropiación aparecen como clave para gestionar el intercambio de conocimientos y superar los problemas con relacionados con cooperación internas y externas.</p> <p>La capacidad de absorción aporta en la creación de valor utilizando el intercambio de conocimiento y a través de mecanismos de apropiabilidad.</p> <p>Los mecanismos de apropiabilidad aportan en el desarrollo y desempeño de las organizaciones e influye en la penetración del mercado y son habilitados por la capacidad de absorción.</p> <p>Ambos la capacidad de absorción y la apropiación influyen positivamente el desempeño de las empresa.</p>
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			<p>Altas capacidades de absorción y de apropiación evitan las fugaz de conocimiento.</p>
<p>Capacidad de Absorción apropiabilidad y políticas de Innovación</p>	<p>cluster_1</p>	<p>Este clúster explora la relación entre la capacidad absorción, la apropiación del conocimiento y las políticas de innovación</p>	<p>La capacidad absorción del tipo <i>market -pull</i> genera más impacto que el modelo <i>Tech Push</i> y se deben impulsar políticas que conlleven a este modelo</p> <p>Hay una relación directa entre innovación, mecanismos de</p>

			<p>apropiación y la capacidad de absorción en las empresas.</p> <p>La relación de la triple hélice aumenta la capacidad de absorción ya que utiliza las capacidades de absorción de cada una de las hélices.</p> <p>La brecha en la capacidad de absorción entre los socios de una colaboración puede influir en la búsqueda activa de apropiación de valor y en la creación de oportunidades.</p> <p>Los regímenes de apropiación y las dinámicas de poder afectan la capacidad de absorción y la innovación en modelo de negocio</p>
Redes , apropiación y capacidad de absorción	cluster_2	El cluster presenta la relevancia de las redes de I+D (Investigación y Desarrollo) en el desarrollo de la capacidad de absorción y la apropiación	Los regímenes de apropiación afectan el proceso de capacidad de absorción y en la innovación dentro de las organizaciones.

			<p>La capacidad de absorción y la apropiación afectan las redes de I+D.</p>
<p>Interacción entre capacidad de absorción, régimen de apropiación y la innovación</p>	<p>cluster_3</p>	<p>El cluster estudia la capacidad de absorción y el régimen de apropiación y su influencia en el desempeño innovador</p>	<p>La capacidad de absorción de la competencia y la capacidad de apropiación de las organizaciones definen la facilidad de imitación y copia.</p> <p>Cuando la capacidad de absorción de la competencia es alta el régimen de apropiación juega un papel clave para evitar fuga del conocimiento</p> <p>Las empresas deben adaptar sus regímenes de apropiación según la capacidad de absorción de la competencia</p> <p>Evidencian falta de estudio en conjunto entre ambas temáticas</p>
<p>Interacción entre la</p>	<p>cluster_4</p>	<p>El cluster estudia también la relación entre</p>	<p>La capacidad de absorción y el régimen de apropiabilidad generan</p>

<p>Capacidad de Absorción y el Régimen de Apropiabilidad en la Innovación</p>		<p>capacidad de absorción, apropiación e innovación</p>	<p>una gran influencia en la competitividad y la performance de la innovación de las organizaciones</p> <p>La capacidad para absorber del ambiente, el conocimiento y la generación de propiedad intelectual de las tecnologías desarrolladas, generan ventajas competitivas</p> <p>La capacidad de absorción se ve afectada por el tipo de industria y los regímenes de apropiación de las mismas</p> <p>Evidencia también falta de estudio entre estos temas</p>
<p>gestión de redes de I+D:+i</p>	<p>cluster_5</p>	<p>El cluster estudia la capacidad de absorción, la estabilidad de la red y la apropiación del conocimiento</p>	<p>La capacidad de absorción afecta positivamente la estabilidad de las redes</p> <p>La estabilidad de la red tiene un impacto significativo en el éxito de las alianzas.</p>

			<p>Una alta capacidad de absorción y de apropiación mejora las alianzas en I+D</p> <p>Los modelos de gobernanza y el tipo de red también son factores clave</p>
<p>Capacidad de Absorción e Innovación en sectores industriales</p>	<p>cluster_6</p>	<p>Estudia la capacidad de absorción en sectores empresariales</p>	<p>Mayores regímenes de apropiación, mayor inversión en capacidad de absorción</p> <p>La coo-petencia juega un papel clave en la innovación.</p> <p>Se evidencia un alto impacto de la capacidad absorción en sectores altamente tecnológicos y en turismo</p> <p>Las alianzas con las universidades afectan la capacidad de absorción y el aprendizaje organizacional</p>

<p>Barreras y Facilitadores de la Capacidad de Absorción en Innovación e Internacionalización</p>	<p>cluster_7</p>	<p>Estudia las barreras internas y externas de la capacidad de absorción y el efecto como driver de la apropiación del conocimiento y de la gestión</p>	<p>Baja apropiación y bajas capacidades gerenciales afectan la capacidad de absorción</p> <p>Estos factores también afectan la capacidad de innovar</p> <p>Capacidades de absorción, capacidades de apropiar y capacidades gerenciales afectan positivamente la internacionalización</p> <p>Recomiendan la inversión en estos factores para ser competitivos</p>
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Por otro lado, se utilizó una técnica de reducción de dimensiones llamada T-SNE (Huroyan et al., 2022) la cual permitió reconocer la similitud entre clústeres. Los resultados de ese análisis pueden ser vistos en la siguiente figura.



*Ilustración 8 Principales clústeres de oraciones relacionadas con capacidad de absorción y apropiación del conocimiento*

## Capítulo 8. Conclusiones e investigación futura

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En este capítulo se presentan las principales conclusiones de la tesis y se discuten de manera global los resultados obtenidos en las publicaciones incluidas en ella, los cuales se enfocan en la generación de una metodología para medir la capacidad de absorción y apropiación del conocimiento. Además, se ofrecen recomendaciones y sugerencias para la implantación de políticas públicas, así como para la comunidad académica y los profesionales. Por último, se proponen posibles líneas de investigación futuras.

1. En el marco de esta investigación doctoral, se ha diseñado y puesto a prueba una metodología innovadora destinada a evaluar de manera integrada (cuantitativamente y cualitativamente) la capacidad de absorción y apropiación de conocimiento en países. Este enfoque se fundamenta en la utilización de elementos convergentes de ambos campos de estudio. El método propuesto facilita la medición de las distintas fases de la capacidad de absorción, segmentándola en tres niveles esenciales: la asimilación, la adquisición y la absorción efectiva del conocimiento. Además, el modelo permite evaluar el grado de apropiación del conocimiento.

Adicionalmente, el procedimiento brinda la capacidad de explorar aspectos fundamentales, como el análisis de flujos de conocimiento el cual incluye la capacidad para identificar la transición del conocimiento científico de un país hacia avances tecnológicos, ofreciendo una perspectiva valiosa sobre la evolución de la innovación dentro de un contexto nacional. Asimismo, la metodología es capaz de abordar un aspecto crítico en el ámbito de la innovación a nivel macroeconómico: el estudio de los derrames de conocimiento o 'knowledge spillovers'. Los derrames de conocimiento son de gran importancia para ambos campos de estudio, permite determinar si el conocimiento generado es transformado y aprovechado por sus creadores iniciales o si, por el contrario, es explotado por organizaciones de otros países. Según Cuéllar et al. (2022), es una dimensión crucial para comprender la dinámica de distribución y aprovechamiento del conocimiento a nivel global, y representa

una herramienta esencial para evaluar el impacto de la innovación en el desarrollo económico y tecnológico de las naciones.

2. El diseño metodológico desarrollado se fundamenta en la producción científica de un país, tomando como caso de estudio a Colombia. La identificación de esta literatura científica se realizó considerando el país de origen de las organizaciones responsables de las publicaciones científicas, es decir, el "Affiliation Country". De manera estructurada, la metodología distingue tres niveles clave en el proceso de absorción de conocimiento:

**Asimilación:** Se analizan los desarrollos científicos generados dentro del país, identificados a través de la producción científica nacional, identificando actores macro -países involucrados

**Adquisición:** Fase del proceso que se centra en determinar el origen del conocimiento científico que se ha integrado en la literatura científica nacional. Implica un análisis detallado de las referencias citadas por los trabajos científicos evaluados, con el objetivo de identificar la procedencia geográfica de este conocimiento. El análisis permite trazar un mapa de las influencias externas e internas que han contribuido al cuerpo de conocimiento dentro del país en estudio

**Transformación y Explotación:** Define a partir de la conversión del conocimiento científico en desarrollos tecnológicos, observable a través de las patentes que han utilizado dicho conocimiento científico como base para la creación de nuevas tecnologías o productos.

Adicionalmente, extiende su análisis a la apropiación del conocimiento científico a través de los desarrollos tecnológicos y las patentes resultantes lo cual permite medir cómo el conocimiento científico no solo se absorbe y transforma, sino también cómo se capitaliza y se retiene dentro del país o se fuga ese conocimiento a otros países.

3. El enfoque propuesto facilita la identificación de los distintos actores que participan en el proceso de adquisición de conocimiento, operando tanto a un nivel macro, representado por los países que originan los artículos científicos, como a un nivel meso, que se centra en las organizaciones implicadas en la asimilación del conocimiento. La metodología detalla cómo estas organizaciones participan en la asimilación, destacando el papel crucial de las redes de

colaboración en el desarrollo de este proceso. Por otra parte, destaca a aquellos actores encargados de la transformación del conocimiento que se logra mediante el análisis de las organizaciones que han referenciado la literatura científica nacional, en este caso de Colombia, dentro de sus patentes. De igual manera, se subraya la interacción entre la producción científica y su aplicación tecnológica, permitiendo una comprensión más profunda de cómo se gesta la innovación a partir del conocimiento existente.

4. Para el desarrollo del procedimiento de medición se llevó a cabo una revisión sistemática de la literatura sobre ambos temas por separado, con el fin de comprender sus raíces y vínculos más estrechos, así como las dimensiones de cada uno y su alcance (Cuéllar et al., 2022). A partir de esta revisión, se identificó que ambos temas están estrechamente relacionados en sus orígenes basándose en un análisis de las citas, en la comparación de los conceptos e identificando si pudiera ser considerado un tema parte del otro o viceversa.

Los resultados de esta etapa permitieron reconocer que ambos temas deben ser considerados como diferentes y que, aunque para algunos autores un tema es una dimensión del otro, no es la tendencia en la academia (Cuéllar et al., 2022). Esta aproximación permitió reconocer que desarrollar una metodología que midiera ambos temas en conjunto es algo que no es divergente y que otros autores han explorado.

5. Uno de los elementos críticos identificados en la búsqueda de este procedimiento fue la identificación de los puntos de convergencia (Cuéllar et al., 2023a). Esta permitió identificar que posibles fuentes de datos que deberían ser usadas en la construcción de la metodología y que elementos deberían medirse.

6. Así mismo, se analizó a profundidad la literatura de medición de ambos temas lo que permitió identificar los diferentes indicadores que han sido utilizados y una brecha en el desarrollo de indicadores que permitan hacer los análisis de ambos temas a nivel país (Cuéllar et al., 2023a)

7. El método desarrollado para la medición de la capacidad de absorción es replicable a cualquier tipo de país ya que utiliza fuentes de información de acceso público y en algunos casos de libre acceso. Los indicadores propuestos pueden ser utilizados para complementar indicadores de medición de la innovación como por ejemplo el desarrollado por la

Organización Mundial de la Propiedad Intelectual -OMPI- (Dutta et al.,2023). Estos mismos indicadores pueden ser utilizados para comparar clústeres de empresas, sectores, o empresas de manera individual.

8. Otro de los aspectos clave de la investigación es que es incluyente en los tipos de publicaciones que analiza. Nuestro modelo de medición presentado en Cuéllar et al (2023b) utiliza como base Lens una fuente que incluye documentos indexados y no indexados en Scopus y Web of Science. Esto permite hacer comparaciones de capacidad absorción y apropiación del conocimiento entre todo tipo de países, incluyendo aquellos que publican la mayoría desarrollos científicos en revistas no indexadas.

9. Varias de las metodologías pueden ser replicables en otros estudios como la utilizada para analizar textos completos que se publicó en (Cuéllar et al., 2022) que puede utilizarse para realizar revisiones sistemáticas y desarrollada para el análisis de convergencia (Cuéllar et al., 2023a) es otro gran aporte de la tesis ya que pueden ser replicadas en otras áreas del conocimiento.

10. Para la literatura de la capacidad de absorción y apropiación del conocimiento, la tesis cierra una gran brecha, ya que en primer lugar hace mediciones que no se habían contemplado a profundidad antes como la medición del grado de apropiación y el grado de pérdida o fuga de conocimiento de un país (Cuéllar, et al., 2023b). Así mismo, el estudio llena una brecha identificada en la literatura que pedía estudios que entendieran la relación directa entre la capacidad de absorción y la apropiación del conocimiento. Así mismo, da evidencias relevantes para no considerar uno como parte del otro, pero si como elementos clave.

11. La tesis tiene grandes implicaciones para los gobiernos ya que al ser la capacidad de absorción y la apropiación del conocimiento elementos clave para la innovación (Martínez-Senra et al., 2015), se deben generar mecanismos que mejoren ambos elementos en los países ya que los impactos en innovación también impactan la competitividad de los países (Dereli, 2015). Por lo mismo, el no tener herramientas para hacer esta medición genera que por falta de información no se pueda tener un diagnóstico adecuado de estos elementos. La metodología al utilizar fuentes secundarias de libre acceso permite que sea replicable a cualquier tipo de gobierno.

12. El diagnóstico de capacidades también permite hacer priorización por áreas temáticas reconociendo las áreas en donde hay mayor oportunidad, en donde existen debilidades, en donde existen fortalezas y las diferentes oportunidades. Esto permitirá asignar recursos a aquellas que se consideren estratégicas. Este procedimiento es flexible y permite los análisis de forma periódica lo que puede generar una mejora continua en los procesos de absorción y apropiación del conocimiento. De igual manera, la metodología permite comparar sistemas de innovación entre países e identificar mejores prácticas.

13. De igual modo, permite medir la apropiación local o fugaz del conocimiento que se da cuando un externo nacional o internacional utilizando el conocimiento científico para su beneficio. El análisis de este tipo de prácticas de países desarrollados frente a países en desarrollo permitiría determinar las diferencias entre los flujos de conocimiento de los países. Esta información también podría ser de gran utilidad para la toma de decisiones entre los diferentes actores de la quintuple hélice.

14. Finalmente, nuestro método al usar información de ciencia y tecnología limita el estudio a solo una parte del ecosistema de innovación. La medición de apropiación a partir de creación de empresas o desarrollo de emprendimientos es una línea de investigación potencial derivada del estudio. De igual manera, la inclusión de otros mecanismos de apropiación, como los derechos de autor y las marcas es otra línea que podría complementar esta metodología. Así mismo, otra posibilidad para medir la capacidad de absorción son el análisis de redes de colaboración entre las organizaciones de diferentes países. Las metodologías actuales de minería de datos y de inteligencia artificial permiten hacer uso de la Big Data para analizar estos elementos a nivel país, usando por ejemplo como fuente de información a las redes sociales. Esa es otra posible línea de investigación que se puede derivar de este estudio. De igual manera, la aplicación de otros indicadores de análisis de patente, como el análisis de patentes concedidas, alcance internacional de las patentes (Ernst, 2003), novedad u originalidad (Harrigan et al., 2017b) podrían medir otros elementos clave en los análisis de apropiación.

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