TESIS DOCTORAL

ESTUDIO DEL DESARROLLO ECONÓMICO URBANO CON METODOLOGÍA GSV TIME-LAPSE

Doctorando:

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Directores:

Dr. Agustín Molina Morales

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UNIVERSIDAD DE ALMERÍA

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STUDY OF URBAN ECONOMIC DEVELOPMENT WITH GSV TIME-LAPSE METHODOLOGY

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Programa de Doctorado:

Ciencias Económicas, Empresariales y Jurídicas

UNIVERSIDAD DE ALMERÍA

Nada tiene tanto poder para ampliar la mente

como la capacidad de investigar de forma sistemática y real

todo lo que es susceptible de observación en la vida.

(Marco Aurelio)

Agradecimientos

En primer lugar, me gustaría expresar mi más profundo agradecimiento a todas las personas que han dedicado parte de su tiempo y dedicación a la elaboración de esta tesis doctoral.

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Alejandro Galindo Durán - Almería, 2022

Solicitud del Doctorado.

Estimado Coordinador del Programa de Doctorado:

Alejandro Galindo Durán, alumno del programa de Doctorado:

Solicita que se tenga en consideración la información aportada en este documento con el objetivo de poder presentar la tesis con título "*ESTUDIO DE DESARROLLO ECONÓMICO URBANOS CON METODOLOGÍA GSV (GOOGLE STREET VIEW) TIME-LAPSE*" mediante el formato de por compendio de publicaciones (Modalidad A). La información aportada se corresponde con lo establecido en el procedimiento para la presentación de la tesis doctoral en la Universidad de Almería en el Formato correspondiente:

A continuación, se detallan los documentos adjuntos en esta solicitud:

- Página Inicial especificando que la tesis corresponde a un compendio de trabajos previamente publicados detallando para cada uno de ellos: referencia de la revista, editorial y DOI.
- Una introducción que describe la unidad temática y estructura del trabajo, indicando las publicaciones que abordan cada elemento de la misma.
- Conclusiones generales, indicando de qué publicación se desprenden.
- Otras aportaciones científicas derivadas directamente de la tesis doctoral.
- Copia completa de las publicaciones originales que conformarán la Tesis Doctoral.
- Para cada uno de los 3 artículos presentados, un resumen y las conclusiones finales.

ÍNDICE

RESUMEN - ABSTRACT

Las nuevas tecnologías aplicadas en el campo de la planimetría urbana han evolucionado en los últimos años sustancialmente ofreciendo gran cantidad de datos, permitiendo una obtener información de forma instantánea, automática y real. Ejemplo de ellas es la que ha servido para el desarrollo de esta investigación, Google Street View (GSV). El desarrollo de una metodología propia para la toma de datos obteniendo valores en un periodo de tiempo de la evolución que ha tenido un local comercial, ha permitido atender a la pregunta de si la puesta en valor del patrimonio arquitectónico tiene una influencia en su entorno comercial más inmediato iniciando procesos de desarrollo local y gentrificación. Así mismo se ha desarrollado un estudio que aporta información sobre la ubicación óptima de los pequeños comercios complementando así a las teorías clásicas cuya metodología es estática en el tiempo usando mapas de redes neuronales autoorganizadas con arquitectura matricial y aprendizaje competitivo, Vinculando los resultados obtenidos y analizándolo bajo el paraguas de la economía circular, se ha buscado la relación entre la supervivencia y la resistencia de un negocio con la circularidad de sus servicios o productos. Como conclusión, se ha demostrado que el grado de éxito y supervivencia está directamente relacionado con el índice de circularidad del comercio, así como de su influencia recibida por la intervención del patrimonio arquitectónico cercano.

New technologies applied in the field of urban planimetry have evolved substantially in recent years. Throughout, this technology information is obtained instantaneously, automatically and in real time. This research has been development using google street view (GSV). In this research whether the enhancement of architectural heritage has an influence on its immediate commercial environment, initiating the processes of local development and gentrification. For this propouse a new methodology for data collection was made. The optimal location for retail and circularity of its services or products were analiced using maps of self-organised neural networks with matrix architecture and competitive learning. In conclusion, it has been shown that the degree of success and survival is directly related to the circularity index as well as its influence received by the intervention of the nearby architectural heritage.

1. COMPENDIO DE TRABAJOS PREVIAMENTE PUBLICADOS

La gota de agua perfora la roca,

no por su fuerza sino por su constancia

(Ovidio)

La presente tesis doctoral, autorizada por los directores de Tesis y el Órgano Responsable del Programa de Doctorado, se presenta como un compendio de tres artículos previamente publicados. Las referencias completas de los artículos que constituyen el cuerpo de la tesis son:

- Uribe, J., **Galindo, A.**, De Pablo, J. y Ruiz, J.L. (2021). How to use Google street view for a time-lapse data collection methodology: potential uses for retailing. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-021-03586-y

- Uribe, J., **Galindo, A.**, Torres, J.A., De Pablo, J. y Ruiz, J.L. (2021). Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks. *Remote Sensing*, 13 (8), 1500. https://doi.org/10.3390/rs13081500

- Uribe, J., Ruiz, J.L., **Galindo, A.**, Torres, J.A. y De Pablo, J (2022). The Circular Economy and retail: using Deep Learning to predict business survival. *Environmental Sciences Europe* 34, 2. https://doi.org/10.1186/s12302-021-00582-z

A continuación, se detalla información referida a índices de impacto en la Journal Citation Index (JCR) y la Scimago Journal Rank (SJR) de cada uno de ellos:

Journal of Ambient Intelligence and Humanized Computing

- Journal Rank: JCR – **Q1** Computer Science, Artificial Intelligence
  Q1 /D1 Telecomunications
  Q1 Computer Sciences
  Factor de impacto: 7.104 (2020); 5-Year Impact Factor: 6.163 (2020)

- Scimago Journal Rank **Q1** Computer Science
- Factor de impacto: 0.589

Remote Sensing

- Journal Rank: JCR – **Q1** Geosciences, Multidisciplinary
- Q2 Imaging Science & Photographic Technoloy
- Q2 Environmental Sciences
- Q2 Remote Sensing
- Factor de impacto: 4.848 (2020); 5-Year Impact Factor: 5.353 (2020)

- Scimago Journal Rank **Q1** Earth and Planetary Science
- Factor de impacto: 1.285 (2020)

Environmental Sciences Europe

- Journal Rank: JCR – **Q1** Environmental Sciences
  Factor de impacto: 5.893 (2020); 5-Year Impact Factor: 6.664 (2020)

- Scimago Journal Rank **Q1** Pollution
  Factor de impacto: 1.248

Aceptación por escrito de los coautores para que el doctorando presente el trabajo.

ACEPTACIÓN DE LOS COAUTORÍA EN TESIS DOCTORAL

- Uribe, J., **Galindo, A.**, De Pablo, J. y Ruiz, J.L. (2021). How to use Google street view for a time-lapse data collection methodology: potential uses for retailing. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-021-03586-y

Los coautores del trabajo titulado "HOW TO USE GOOGLE STREET VIEW FOR A TIME-LAPSE DATA COLLECTION METHODOLOGY: POTENTIAL USES FOR RETAILING" con D.O.I: https://doi.org/10.1007/s12652-021-03586-y, hacen constar que Don Alejandro Galindo Durán con DNI 75260522-Z es el autor principal de la investigación recogida en este artículo y que conocen y dan su consentimiento para que el artículo sea utilizado para que D. Alejandro Galindo Durán presente su tesis doctoral denominada ESTUDIO DEL DESARROLLO ECONÓMICO URBANO CON METODOLOGÍA GSV TIME-LAPSE en el formato de compendio de artículos:

D. Juan Uribe Toril D. Jaime De Pablo Valenciano D. José Luis Ruiz Real

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– Uribe, J., **Galindo, A.**, Torres, J.A., De Pablo, J. y Ruiz, J.L. (2021). Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks. *Remote Sens*, 13 (8), 1500. https://doi.org/10.3390/rs13081500

Los coautores del trabajo titulado "LOCAL DEVELOPMENT AND GENTRIFICATION RESULTING FROM THE REHABILITATION OF SINGULAR BUILDINGS: ANALYSIS OF NEURAL NETWORKS" con D.O.I: https://doi.org/10.3390/rs13081500, hacen constar que Don Alejandro Galindo Durán con DNI 75260522-Z es el autor principal de la investigación recogida en este artículo y que conocen y dan su consentimiento para que el artículo sea utilizado para que D. Alejandro Galindo Durán presente su tesis doctoral denominada ESTUDIO DEL DESARROLLO ECONÓMICO URBANO CON METODOLOGÍA GSV TIME-LAPSE en el formato de compendio de artículos:

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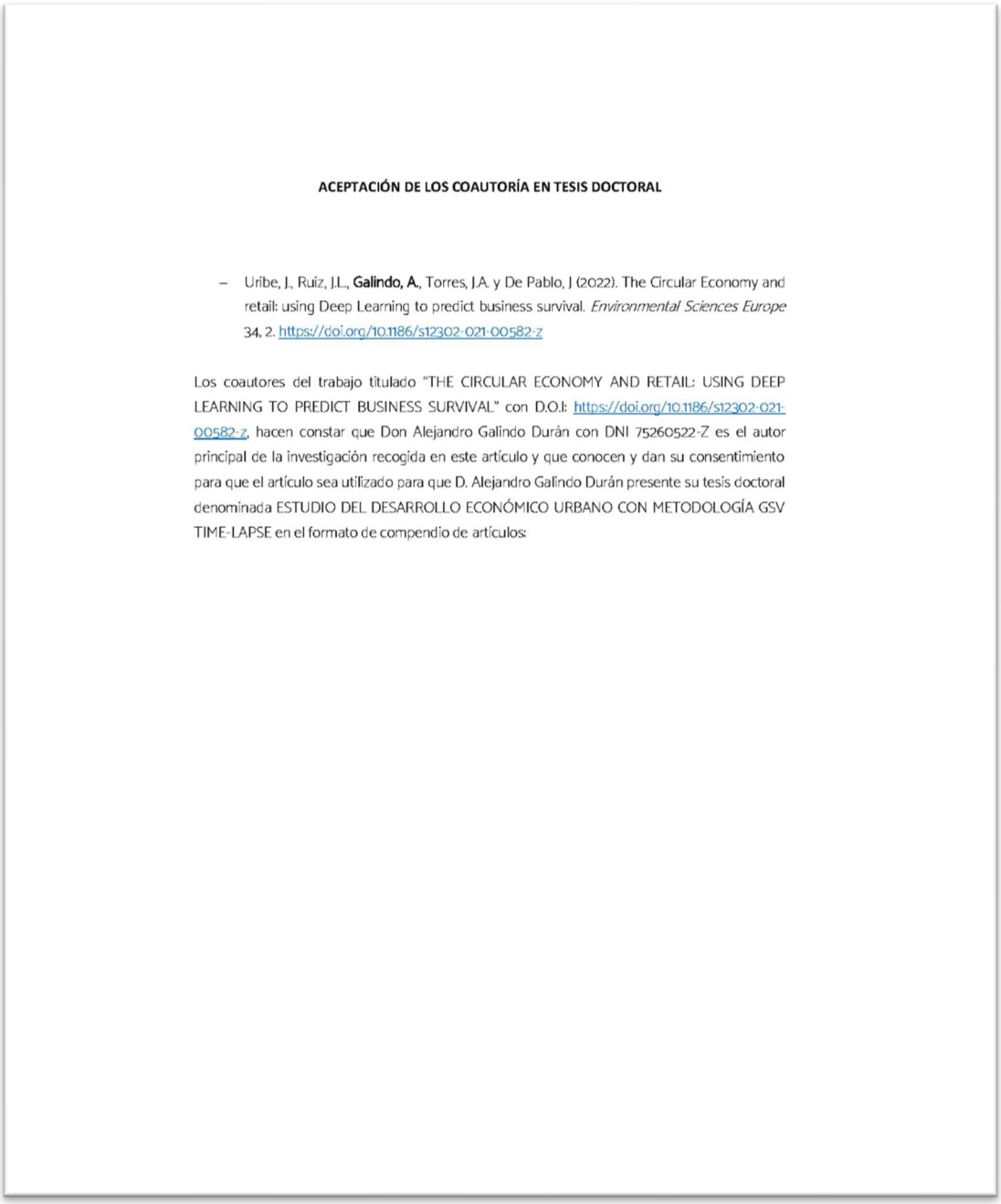

ACEPTACIÓN DE LOS COAUTORÍA EN TESIS DOCTORAL

– Uribe, J., Ruiz, J.L., **Galindo, A.**, Torres, J.A. y De Pablo, J (2022). The Circular Economy and retail: using Deep Learning to predict business survival. *Environmental Sciences Europe* 34, 2. https://doi.org/10.1186/s12302-021-00582-z

Los coautores del trabajo titulado "THE CIRCULAR ECONOMY AND RETAIL: USING DEEP LEARNING TO PREDICT BUSINESS SURVIVAL" con D.O.I: https://doi.org/10.1186/s12302-021-00582-z, hacen constar que Don Alejandro Galindo Durán con DNI 75260522-Z es el autor principal de la investigación recogida en este artículo y que conocen y dan su consentimiento para que el artículo sea utilizado para que D. Alejandro Galindo Durán presente su tesis doctoral denominada ESTUDIO DEL DESARROLLO ECONÓMICO URBANO CON METODOLOGÍA GSV TIME-LAPSE en el formato de compendio de artículos:

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2. INTRODUCCIÓN GENERAL

En algún lugar, algo increíble está esperando ser conocido.

(Carl Sagan)

En los últimos años, las nuevas tecnologías aplicadas en el campo de la cartografía han mejorado sustancialmente la calidad y cantidad de información que ofrecen al usuario, especialmente aquellas que están centradas en zonas urbanas, donde la toma de datos, así como la obtención de resultados en una búsqueda de información se puede realizar de forma instantánea, automática y real. Ejemplo de ellas son: Google Maps y sus visores y utilidades interconectadas como Google Street View (GSV), (herramienta disponible dentro de Google Maps que permite visualizar una ubicación mediante fotografías panorámicas a pie de calle), Google Earth, sistema de información geográfica que muestra un globo terráqueo virtual que permite visualizar múltiple cartografía, basado en imágenes satelitales; Waze, app basada en el tráfico a tiempo real combinando cartografía urbana y movilidad para ofrecer el trayecto de un punto a otro más rápido; ViaMichelin, calculador de rutas mediante mapas urbanos con la que se puede obtener un coste estimado del trayecto; entre otras.

El avance de esta tecnología y del desarrollo de aplicaciones relacionadas con Google Maps, Application Programming Interfaces (API), dónde además de ofrecer información geográfica de una búsqueda en concreto interactúan entre otras aplicaciones relacionadas de bases de datos combinando la información para obtener una matriz de datos combinada, ha permitido que se pueda aplicar a la investigación como fuente primaria de datos ya que nos permiten posicionarnos en un lugar en concreto, en una fecha determinada y comprobar el estado real de la zona objeto de estudio.

Como herramienta principal de trabajo para la investigación ha sido la utilización de una de las herramientas de Google, GSV, que proporciona panorámicas a nivel de calle (360 grados de movimiento horizontal y 290 grados de movimiento vertical), lo que permite a los usuarios ver partes de ciudades seleccionadas y sus áreas metropolitanas circundantes. Esta aplicación, en los últimos años, ha invertido numerosos recursos en

cartografiar digitalmente a base de múltiples fotografías 360º un mapa completo del mundo urbano. Exploran constantemente el territorio urbano, recopilando grandes cantidades de datos y proporcionando información geográfica actualizada y completa lo que posibilita trabajar con un mapa que brinda a los usuarios finales herramientas de búsqueda, no solo de rutas, sino también de tiendas, equipos y cualquier tipo de información georreferenciada.

El uso de GSV como herramienta para analizar aspectos urbanos o sociales ha tenido un crecimiento exponencial, muestra de ello, una de las revisiones bibliográficas más recientes sobre el uso de GSV como fuente de datos importante para la recopilación de datos geoespaciales y el análisis urbano (Biljecki, Filip & Ito, Koichi, 2021). Un aumento de artículos de investigación tomando esta herramienta como fuente de datos primaria con numerosas aplicaciones, desde el análisis de la vegetación y el transporte hasta estudios de salud y socioeconómicos.

Estas aplicaciones junto con las API, pueden ser innovaciones tecnológicas de gran utilidad para la investigación social aplicada tal y como reflejan Pérez et al, (2019) en su estudio "*Potencialidades de Google Maps en la investigación social aplicada*" en el que utilizan esta tecnología para estudiar la presencia y el uso del valenciano en el ámbito comercial, concretamente, en el mercado, el pequeño comercio y las grandes superficies.

Otros usos de esta tecnología, cuyo acceso está en la palma de la mano de todo usuario mediante un smartphone, o cualquier dispositivo electrónico con acceso a internet, ha sido en el ámbito didáctico, donde uno de sus principales logros es el elevado nivel motivacional que tienen los alumnos sirviendo como un instrumento eficaz de interacción geográfica (Fombona et al., 2016).

Estudios realizados a nivel sociológico, con información recogida en las Redes Sociales Basadas en Localización, donde se analizan pormenorizadamente aspectos urbanos y sociales como el cambio en cantidad y calidad de las actividades económicas existentes en los locales comerciales, el uso real que tienen las vías urbanas analizando quién y cómo se transita por ellas así como la percepción que tiene el usuario de la propia vía

urbana (López et al., 2016) han demostrado la gran capacidad de esta herramienta aplicándola a diversos ámbitos.

El uso de las herramientas de Google aplicada al ámbito social también ha sido extendido al área del urbanismo y del paisajismo y a los espacios verdes, tal y como demuestran Taylor et al., (2010) analizando la calidad del espacio urbano.

Relacionando el aspecto social con el urbano y con un enfoque novedoso como es la infancia y el riesgo social, con la premisa de que los niños que crecen en barrios pobres frente a los barrios ricos tienen más probabilidades de pasar tiempo en prisión, desarrollar problemas de salud y morir a una edad temprana. Analizando las condiciones del vecindario y su influencia en el comportamiento, Odgers et al., (2012), ofrecen un estudio de observación social sistemática virtual para probar si GSV podría usarse para capturar de manera confiable las condiciones del vecindario concluyendo que el uso de GSV es apta como una herramienta confiable y rentable para medir las características negativas y positivas de los vecindarios locales.

Es importante destacar, que el uso de GSV para la investigación no solo se ha centrado en el aspecto urbano, analizando comercios, edificios o infraestructura, sino que se ha utilizado en elementos móviles, tal y como lo muestra Gebru et al., (2017), donde su foco se puso en los vehículos aparcados o en tránsito por determinados barrios, estableciendo una relación social y demográfica en los atributos socioeconómicos como los ingresos, la raza, la educación y los patrones de votación. Un modelo analítico que funciona estableciendo asociaciones entre automóviles y personas.

Un inconveniente importante para la toma de datos, sobre todo en los primeros años del desarrollo de esta tecnología, es la dependencia del salto temporal que GSV nos ofrece en determinadas áreas, ya que no existen imágenes tomadas cada año, sino que podemos encontrar fotografías con una variación en el tiempo de 2, 3 incluso 4 años, lo que provoca el tener que imaginar lo ocurrido en estos años desconocidos. Tal y como describe Curtis et al, (2013), GSV ofrece numerosos beneficios sobre investigaciones en entornos construidos, sin embargo, existe una limitación en cuanto a que las fechas de

las imágenes pueden cambiar con frecuencia. Se debe tener precaución en las intersecciones donde es más probable que ocurran estas interrupciones al usar GSV como una herramienta de recopilación de datos.

Debido a los inconvenientes planteados, con la metodología propuesta se unifican los criterios para la toma de datos facilitando por tanto la toma de decisiones y que lo trascurrido en esos años pueda ser lo más parecido a la realidad.

Tratando de responder a la cuestión que ha motivado esta investigación, sobre si una intervención arquitectónica en un espacio, en concreto la rehabilitación de un elemento del patrimonio, tiene una repercusión urbana, económica y social en un radio de acción, se ha utilizado esta potente herramienta enfocándola a diferentes ámbitos, económicos, sociales, urbanos, desarrollo local, gentrificación y economía circular. Para poder atender y desarrollar la investigación y dadas las peculiaridades ya mencionadas del uso de GSV y sus inconvenientes en cuanto al salto temporal y espacial, surge la necesidad de desarrollar una metodología.

La metodología planteada resuelve con criterios unificados el proceso y desarrollo de toma de datos de las imágenes ofrecidas por Google, ya que a lo largo del proceso de la investigación y de la toma de información se encuentran saltos temporales, saltos espaciales ya que no siempre se toman las imágenes desde la misma posición lo que imposibilita realizar una misma toma en su variación temporal. No obstante, al ser imágenes 360º, permite simular distintas posiciones geográficas y por tanto poder recopilar la información necesaria con un grado de acierto bastante alto. El artículo "*How to use Google street view for a time-lapse data collection methodology: potential uses for retailing*" atiende y desarrolla la metodología que abre un campo de investigación infinito y que servirá para numerosas cuestiones urbanas y sociales y más con los futuros avances tecnológicos que año tras año se realizan desde las API de Google.

Paralelamente y tratando de responder a la cuestión principal, se estudia el comercio local y la ubicación, ya que es una de las decisiones estratégicas más importantes en la apertura de un local comercial. Hay afirmaciones que demuestran que estas decisiones son críticas y más si nos centramos en el comercio minorista (Kuo et al, 2002). Así mismo

está directamente relacionada con la satisfacción del cliente, por lo tanto, identificar las mejores ubicaciones para los negocios es una de las tareas más complicadas. Existen diferentes formas de medir la "ubicación ideal" para establecimientos comerciales partiendo de (Hotelling, 1929), donde sostiene que el factor más importante es la relativa proximidad a otras tiendas que ofrecen bienes o servicios similares; o el concepto de centralidad de la ubicación como función principal de suministrar bienes y servicios a la población circundante. Por tanto, las ubicaciones más cercanas al centro de demanda del cliente garantizan un mejor posicionamiento frente a las más alejadas. Sin embargo, (Nwogugu, 2006) añade factores de comportamiento sociales, así como las características de la zona.

Recientemente se han desarrollado diferentes métodos (Hsieh et al., 2015) que modelan la correlación espacial y temporal entre las tiendas existentes y las ubicaciones. Tal y como se muestra en los artículos, existen numerosos métodos para la correcta elección de ubicación de un comercio minorista. Sin embargo, desde la aparición de GSV, en 2007, surgen nuevas oportunidades metodológicas para la investigación sobre este tema, por lo que esta nueva herramienta se puede utilizar para mejorar el análisis de la ubicación del comercio minorista, entre muchas otras utilidades.

Todas las metodologías presentadas anteriormente son estáticas en el tiempo lo que conlleva un cierto error en su planteamiento. Ya que representan una "imagen" de la realidad en un momento determinado. Por lo tanto, la técnica de time-lapse puede ser una excelente oportunidad para un análisis más completo y profundo de la ubicación de la tienda minorista. Nuestra metodología dinámica combina GSV y la técnica time-lapse ayuda a predecir la potencial popularidad de las ubicaciones a lo largo del tiempo, lo que facilita el proceso de toma de decisiones sobre la ubicación de la tienda minorista, permitiendo seleccionar aquellas que son potencialmente más rentables. Esta metodología ayuda a identificar la rotación de locales comerciales y reformas de establecimientos, evaluar procesos de gentrificación, estudiar los factores que inciden en el valor de alquiler de la propiedad residencial, entre otros.

Una vez atendida la metodología para poder analizar y realizar una toma de datos ordenada y con criterios similares, surge una de las primeras cuestiones urbanas y arquitectónicas. Relacionando la puesta en valor de un elemento arquitectónico con la gentrificación y desarrollo local se plantea su radio de influencia y de qué manera ha podido afectar al comercio local de su entorno. Para ello, y dado que un inmueble ejerce influencia sobre su entorno en el ámbito social o económico, se plantea hasta qué punto la rehabilitación de un edificio genera sinergias capaces de impulsar el desarrollo local o procesos de gentrificación.

El proceso de desarrollo local y gentrificación se suelen abordar por separado, siendo el primero la mejora continua de los recursos del patrimonio histórico y cultural, (Vázquez Barquero, 2009) posibilitando el nacimiento de nuevas empresas y empleos y, por ende, una transformación social y la gentrificación se suele centrar en la expulsión o salida en un barrio de las clases sociales con menos recursos, por el aumento de los alquileres, cambios en la estructura comercial de la zona y, en definitiva, incremento generalizado de los precios. Ambos procesos tienen un factor común, la transformación económica y social local.

La puesta en valor de un elemento arquitectónico y su éxito no solo radica en el propio edificio en sí, sino en cómo afecta a su entorno más cercano, y por tanto, se ven implicados diferentes agentes, desde la participación ciudadana hasta entidades públicas y privadas (Garre, 2001).

La correcta interpretación de las relaciones entre patrimonio, sociedad y empresa, es uno de los retos que debe superar la política de recuperación urbana y por tanto se hace necesario conocer los mecanismos que llevan al desarrollo económico local asociado a elementos arquitectónicos singulares.

El desarrollo local ha sido estudiado por la comunidad científica ya que forma parte de proceso de globalización, aunque bien es cierto, que en los últimos años tal y como muestran Ruiz Real et al, (2019) "*un análisis profundo de las palabras clave de los autores identificó nuevas tendencias, vinculando el desarrollo local con el turismo, la educación, el geoturismo, el cambio climático, el desarrollo local sustentable, la innovación social y*

la creatividad, lo que brinda a la academia potenciales nuevas líneas de investigación. tales como ciencias sociales, medio ambiente, negocios, economía y agricultura." (p. 1).

El efecto generado por una actuación ajena sobre el desarrollo local ha sido estudiado desde diversos frentes, uno de ellos, la influencia de viveros empresariales (De Pablo y Uribe, 2016), entidades que promueven el desarrollo empresarial facilitando el proceso de creación de nuevas empresas a nivel local, donde queda demostrado que un cambio de mentalidad de las autoridades públicas promoviendo estas acciones fomenta el desarrollo. En línea con esta premisa, y potenciando la figura del emprendedor como agente de desarrollo local, estudios han analizado la formación como factor clave para la creación de nuevas empresas (Uribe et al, 2013)

El artículo "*Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks*" responde a estas cuestiones y pretende servir como punto de partida de numerosas investigaciones relacionadas con el comercio y la influencia que tienen con determinadas actuaciones en el patrimonio arquitectónico.

Paralelamente al análisis urbano-arquitectónico y su estudio de gentrificación y desarrollo local nace la idea inversa. Si previamente se estudia si una rehabilitación de un edificio puede mejorar un entorno, ¿Puede un entorno que se vuelve más "rehabilitado" mejorar y potenciar el comercio local? Ordenando estos conceptos, surge el concepto de economía circular y su estudio en los comercios locales. Respondiendo a cuestiones de si a lo largo de los años el comercio ha ido evolucionando a procesos que responden a conceptos de economía circular, si estos tienen mayor supervivencia, etc. Y para ello, es necesario enmarcarlo en un contexto global.

El cambio climático, la acumulación de plásticos y otros problemas medioambientales tienen como una de sus principales causas el método industrial en su forma de producción lineal.

El concepto de economía circular, está cobrando día a día mayor importancia tanto a nivel económico, político y social en el desarrollo de estrategias hacía un itinerario cada vez más sostenible.

La economía circular pretende alcanzar un modelo productivo y por tanto económico en el que los materiales, productos y recursos empleados en la producción de un elemento se mantengan en mayor tiempo posible en el ciclo vital de ese elemento o en sus futuras aplicaciones, usos o reciclajes con objeto de que se reduzca al mínimo la generación de residuos.

La Comisión Europea desarrolló en 2015 las 54 acciones en un plan de puesta en marcha para contribuir a impulsar la competitividad de Europa, modernizar la industria y su economía, protegiendo el medio ambiente y, por tanto, crear líneas que favorezcan la creación de empleo generando con ello un crecimiento sostenible. La economía circular, tal y como refleja Frans Timmermans, vicepresidente primero de la Comisión Europea desde 2014, es un factor clave con objeto de convertir nuestra economía en sostenible y por tanto cumplir con los Objetivos de Desarrollo Sostenible. También refleja la dificultad existente debido al sistema actual de producción, así como de las propias limitaciones de nuestro planeta para conseguir cerrar el círculo para que no se desperdicie ninguno de los recursos tan valiosos de los que disponemos.

Las acciones que plantea la Comisión Europea quedan enmarcadas en diversos ítem tales como realizar una transición de la economía lineal a una circular, realizar estrategias para limitar, reducir y eliminar el uso del plástico, como aquellos que son de un solo uso, realizar inversiones altas en innovación industrial, realizar un cambio en nuestra forma de entender los residuos convirtiéndolos en futuros recursos, modificar procesos de diseño industrial para poder adaptarlos a producciones circulares, realizar acciones de concienciación a los consumidores, etc.

La idea de "cerrar el círculo", en referencia al ciclo de vida de los productos, implica a todos los agentes de la cadena de valor, no solo a aquellos en relación directa con los residuos, sino también a productores o a los propios consumidores.

Al realizar este cambio hacia un nuevo modelo de producción circular persiguiendo eliminar al máximo los residuos generados, se deja atrás una producción lineal tradicional con objeto de obtener un uso más eficiente de los recursos.

Tal y como se muestra en el artículo, el concepto de economía circular está paulatinamente obteniendo mayor importancia y relevancia en los nuevos modelos de negocio en el que últimamente están implementando en su sistema de producción acciones como reutilizar, reducir, reciclar, recuperar, etc. Estas acciones, no solo se están implementando y potenciando en la producción como agentes primarios, sino también en los agentes finales o consumidores donde la concienciación y las estrategias a nivel político para lograr un mejor desarrollo sostenible en la lucha contra el cambio climático así lo demuestran.

El sistema de economía circular, favorece una mejora en el ciclo del producto y provoca un cambio de sistema y mentalidad, tanto para la producción como para el consumidor (Pohle & Chapman, 2006; Ellen MacArthur Foundation, 2015), y por tanto es un sistema industrial regenerativo y de restauración en diseño e intención, que elimina los desechos a través de un buen diseño de los materiales, productos, sistemas y modelos de negocios (Hobson, 2016). Este nuevo modelo de desarrollo económico apunta a la protección del ambiente y prevención de la contaminación (Ma et al., 2014), concibiendo un sistema de producción y consumo con pérdidas materiales y energéticas mínimas a través del reúso, recuperación y reciclaje extensivo (Haupt, Vadenbo, & Hellweg, 2016).

Siguiendo estos conceptos, se han categorizado y clasificado los principios y acciones de circularidad, con una ampliación clara y notoria de las tres R (reducir, reutilizar, reciclar) para alcanzar una categorización de diferentes estrategias que definen la economía circular. Se presenta por tanto una gama de estrategias ordenadas desde alta circularidad hasta baja circularidad, las cuales permiten acelerar, en mayor o menor grado, el éxito de los procesos de transición a efectos de reducir el consumo de recursos naturales y materiales y minimizar la producción de residuos. Desde un punto de vista estratégico, la mayor capacidad para preservar el valor de los productos reside en dar preferencia a los

«círculos interiores», que proporcionan mayor valor añadido y la integridad del producto, que el círculo exterior del reciclado de los materiales. (Jiménez, 2020).

Atendiendo a las diferentes categorías, se ha considerado tomar estrategias de menor a mayor nivel de circularidad (Potting et al, 2017; Reike et al, 2018; World Economic Forum, 2018), donde R9 corresponde a la estrategia de menor nivel de circularidad y R1 al mayor nivel de circularidad. A su vez, estas estrategias quedan enmarcadas en 3 grupos, Uso y fabricación más inteligente del producto (R0-R2), Prolongación de la vida útil del producto y sus partes (R3-R7) y Aplicación útil de materiales (R8-R9).

Analizando y enmarcando las diferentes R en cada una de las actividades económicas localizadas a lo largo del tiempo, el artículo: "*The Circular Economy and Retail: Using Deep Learning To Predict Business Survival*" pretende analizar y dar respuesta a las cuestiones planteadas previamente utilizando la metodología propia de GSV sobre la supervivencia de las actividades económicas de un entorno urbano y su evolución a lo largo de los últimos años.

El objetivo principal del estudio es analizar y comparar la importancia de la relación entre circularidad y retail, utilizando diferentes técnicas. La investigación se ha desarrollado utilizando un enfoque bibliométrico y el análisis del estado del arte de la Economía Circular y el comercio minorista. La clave de este estudio se trata de la vinculación de la tecnología GSV con una metodología aplicada para analizar y recopilar datos que permite obtener modelos en diferentes espacios temporales, sirviendo para generar modelos predictivos. El uso de plataformas con imágenes en 360º panorámicas de GSV y la aplicabilidad de un modelo de redes neuronales permite analizar la supervivencia de un local en determinadas situaciones y por tanto obtener ciertas predicciones. Para predecir y anticipar patrones, así como comportamientos en un escenario futuro, se ha aplicado una metodología propia de toma de datos.

La presente tesis deja abierta la posibilidad de analizar contextos urbanos aplicándolos a diferentes campos, como la salud, urbanismo, medioambiente, social, demográfico, etc.

2.1. JUSTIFICACIÓN DE LA INVESTIGACIÓN

Investigar es ver lo que todo el mundo ha visto,

y pensar lo que nadie más ha pensado

(Albert Szent-Györgyi)

¿Actúa la rehabilitación del patrimonio arquitectónico como agente de desarrollo local y gentrificación?

Para abordar esta cuestión, la cual ha sido el germen de esta investigación, se ha tomado como fuente de datos primaria los obtenidos mediante GSV para aportar una visión distinta de lo analizado por otros estudios. Dicha cuestión, que ha sido abordada por la comunidad científica en otros artículos, tal y como lo demuestra Romero (2010) donde recoge las Actas del XI Congreso para la defensa del patrimonio geológico y minero, un congreso enfocado a la rehabilitación del patrimonio minero y su puesta en valor. Otros estudios de rehabilitación de patrimonio y su impacto como agente de desarrollo sostenible en la ciudad histórica y la comunidad son los aportados por Đukanović y Polić, (2013) donde afirman que las intervenciones en el patrimonio en ciudades con un valor histórico y cultural son una parte fundamental del desarrollo de la zona, así como generadores de sostenibilidad urbana, desarrollo cultural y económico.

Las autoridades, en línea con lo anteriormente mencionado, avanzan en esta premisa y apuestan por acciones de rehabilitación y puesta en valor de zonas urbanas atendiendo a los objetivos de descarbonización del 80-95% en 2050 que plantea la Unión Europea. Muestra de ello son las herramientas que surgen de planificación para diagnosticar y realizar un plan de acción, definiendo objetivos, y generando una hoja de ruta para su intervención en edificios (Arcas et al, 2021). Estas intervenciones no solo actúan como agentes de desarrollo local, sino que son eficientes medioambientalmente y por tanto ayudan a la conservación del medio ambiente reduciendo así el efecto del cambio climático.

Para el desarrollo de esta investigación se ha aprovechado la oportunidad de estudiar las diferentes aplicaciones que puede tener el uso de GSV como toma de datos primaria aprovechando la gran ventaja del time-lapse creando para ello una metodología aplicada a la recogida de datos.

Se pretende responder a diversas cuestiones urbanísticas, sociales, económicas o medioambientales que afecten a un territorio en un margen temporal pudiendo observar su evolución para, según qué casos, poder establecer un patrón o predecir el comportamiento urbano o económico de dicho territorio.

Con las evoluciones de internet y las posibilidades de poder obtener información del estado real de un entorno en determinadas fechas y por tanto poder comprender su evolución a lo largo de los años mediante GSV se abre una ventana nueva a futuras líneas de investigaciones que puede resultar muy interesante ya que no era posible realizar anteriormente este tipo de análisis ya que no se disponía de dicha información.

Se busca, por tanto, explorar esta herramienta para poder sacarle el máximo rendimiento a la hora de obtener datos que sirvan para atender a cuestiones urbanas. El límite temporal que puede valorarse como un hándicap por la imposibilidad de retroceder más allá de 2008 provoca un valor añadido si se contempla como la gran oportunidad de poder estudiar con todo lujo de detalle, como si de un viaje en el tiempo-espacial se tratara cualquier zona, mapeada previamente por GSV, del mundo.

2.2. OBJETIVOS DE INVESTIGACIÓN

El conocimiento no es una vasija que se llena,

sino un fuego que se enciende

(Plutarco)

El objetivo que se plantea con esta tesis consiste en realizar un estudio de desarrollo económico urbano a través del uso de una metodología de elaboración propia para las ciencias sociales basada en GSV Time-Lapse. Se ha pretendido dar respuestas a cuestiones que relacionen áreas enfocadas con el impulso de zonas urbanas, la gentrificación, la economía circular, etc.

Para ello, se ha aplicado la experiencia adquirida en mi profesión como arquitecto, la formación académica recibida en el Máster de Desarrollo y Codesarrollo Local Sostenible de la Universidad de Almería, así como mis conocimientos como formador certificado de Google.

El hilo conductor de la tesis se ha vertebrado a través de un análisis y planteamiento de una metodología adaptada a nuestro estudio; la aplicación de esa metodología en el análisis del alcance de una rehabilitación de patrimonio arquitectónico como agente moldeador del territorio y posteriormente y siguiendo la sistemática anterior, se estudió la evolución y supervivencia de empresas según su actividad desde el punto de vista medioambiental.

Figura 1: Esquema del desarrollo de la investigación

Fuente: Elaboración propia.

El objetivo que se plantea con esta tesis consiste en realizar un estudio de desarrollo económico urbano a través del uso de una metodología de elaboración propia para las ciencias sociales basada en GSV Time-Lapse.

Como objetivos generales que persiguen enmarcar esta investigación con el fin de dar respuestas a las cuestiones planteadas se plantean los siguientes:

- Analizar la importancia y relación entre la intervención arquitectónica de una zona y el comportamiento del pequeño comercio colindante.
- Compilar mediante un estudio bibliométrico la literatura existente sobre el uso de la aplicación de GSV como herramienta de análisis urbano-socioeconómico.
- Proponer una metodología de toma de datos unificada utilizando las imágenes ofrecidas por GSV como fuente primaria de datos.
- Evaluar la supervivencia de los locales comerciales en un área determinada en función de su circularidad.
- Explicar el comportamiento de los locales cercanos ante una rehabilitación del patrimonio arquitectónico.
- Establecer la relación que pueda haber entre la intervención arquitectónica de un inmueble y el desarrollo local y la gentrificación de la zona.
- Probar la viabilidad del uso de redes neuronales para determinar un patrón de comportamiento de los locales comerciales ante determinadas situaciones con los datos obtenidos mediante la metodología propuesta.
- Diseñar una estrategia de toma de datos que sea unificada para solventar los saltos temporales que se encuentran en GSV.
- Demostrar la importancia de la circularidad en la supervivencia del pequeño comercio.
- Desarrollar una línea de investigación con la metodología propia que sirva para crear futuras líneas y abra el campo de estudio para futuras investigaciones.

Planteados los objetivos generales, se detallan los objetivos específicos atendiendo a las premisas anteriormente mencionadas.

- Categorizar las actividades comerciales en criterios unificados para agrupar por sectores facilitando así la toma de datos y mejorando los resultados del posterior análisis por redes neuronales.
- Deducir el comportamiento del pequeño comercio en función de parámetros como circularidad, entorno, etc.
- Definir los criterios específicos para la toma de datos con la información obtenida de las imágenes de GSV.
- Demostrar la importancia de la economía circular en el pequeño comercio vinculándola con su supervivencia.
- Detallar los parámetros clave a estudiar con objeto de establecer un vínculo entre la puesta en valor de un elemento arquitectónico y la mejora del área colindante afectando por tanto a los locales comerciales del entorno.
- Explicar el comportamiento urbano y socioeconómico de la zona ante una rehabilitación del patrimonio arquitectónico.
- Identificar los elementos clave que identifican al pequeño comercio para determinar su mejora empresarial, fachada, cartelería, escaparate, etc.
- Interpretar los resultados obtenidos con redes neuronales y matriz de autoaprendizaje.
- Relacionar el vínculo entre gentrificación, desarrollo local y la intervención urbana.
- Sugerir futuras líneas de investigación que aprovechen la metodología propuesta combinando los datos obtenidos con otras bases de datos más estáticas en el tiempo.

Para llevar a cabo este trabajo se han llevado a cabo las siguientes actividades:

- Se ha realizado un estudio bibliométrico sobre la aplicación de GSV como herramienta de análisis urbano y económico.
- Se ha elaborado una metodología propia de toma de datos que abra un abanico de líneas de investigación asociadas a la tecnología de GSV.
- Se ha realizado una revisión bibliográfica de los conceptos del campo de estudio.
- Se ha estudiado la influencia de las actuaciones arquitectónicas en materia de rehabilitación y puesta en valor del patrimonio en su entorno como agentes transformadores de los negocios adyacentes.
- Se ha analizado el impacto de estas intervenciones arquitectónicas en procesos de gentrificación y desarrollo local de su entorno.
- Se ha comprobado la viabilidad de los mapas autoorganizados de redes neuronales con arquitectura matricial y aprendizaje competitivo, así como el análisis de redes neuronales para identificar relaciones y comportamientos comunes en propiedades comerciales adyacentes a edificios singulares.
- Se ha comparado la importancia de la relación entre circularidad y retail.
- Se ha estudiado la supervivencia de un local comercial con el fin de obtener determinadas predicciones de éxito en cuanto a su actividad y localización.

2.3. METODOLOGÍAS UTILIZADAS

En la investigación es incluso más importante
el proceso que el logro mismo
(Emilio Muñoz)

Para el desarrollo de la investigación se ha optado por diferentes metodologías de análisis de los datos, adaptados a cada caso (influencia de la rehabilitación de un inmueble y supervivencia empresarial ligada a la sostenibilidad de su actividad).

El conjunto de técnicas, métodos y procedimientos que se han seguido para el desarrollo de esta metodología han permitido desarrollar, definir y sistematizar el proceso de investigación para generar los datos que se desean.

Ha permitido recopilar, analizar y categorizar los datos para que los resultados hayan sido válidos y relevantes cumpliendo así con los estándares requeridos por el rigor científico.

En este sentido, la propia metodología ha formado parte de un proyecto de investigación en el que se ha atendido y descrito racionalmente los criterios utilizados para la propia toma de datos, contando con aspectos cuantitativos y cualitativos.

La metodología para la toma de datos (creada ad hoc) para el análisis de locales comerciales de una determinada zona, comienza por la selección del área de influencia. Considerando el como epicentro el elemento arquitectónico a estudiar como agente de desarrollo local, estableciendo un radio de 150 metros. Esta distancia se basa en las investigaciones de Tan y Tan (1995); Waddell (2002), Nikilaos, Dimitra & Agapi (2011) o Ray (2017) que siguen este mismo criterio longitudinal atendiendo a elementos visuales, de transporte y de impacto visual. De esta manera se pueden observar redes de conexión directa entre locales y otros elementos arquitectónicos o no.

Asimismo, se ha realizado una tabla con un listado de todas las calles afectadas, enumerando los locales o edificios comprendidos en ese radio de acción para posteriormente registrar los datos.

El esquema realizado sigue los criterios de la notación gráfica estandarizada BPMN (Business Process Model and Notation) (Figura 2). BPMN está dirigida al modelado de procesos y es uno de los mejores sistemas de organización para seguir criterios de calidad y productividad (Chimosi & Trombetta, 2012).

Como se mencionó anteriormente GSV solo nos permite obtener imágenes a partir del año 2008 con diferentes saltos temporales de imágenes. Por tanto, los posibles escenarios en relación con la disponibilidad o no de imágenes en GSV en el año de estudio han sido objeto de generar una metodología propia con el fin de tener criterios unificados. Para ello, las distintas posibilidades que se pueden encontrar serían las siguientes:

- Imagen disponible para el año de estudio: se registrarán los datos de las variables para ese año.
- Imagen no disponible para el año de estudio:
    - Existe imagen con una diferencia temporal de menos de 2 años: se consideran los datos de la imagen más cercana temporalmente y, en caso de existir una anterior y otra posterior, se tomarán los datos de la imagen más antigua.
    - Existe al menos una imagen con una diferencia temporal mayor de 2 años: se considerarán los datos para el análisis de la imagen del tiempo anterior. En caso de no disponer de imagen pasada se indicará que no se dispone de información válida.
- Imagen no disponible para ningún año: no se obtendría por tanto ninguna imagen y se indicará “sin información”.

Una de las principales ventajas de la metodología de toma de datos es que deja a libre elección por parte del investigador la selección de variables a registrar, así como su clasificación.

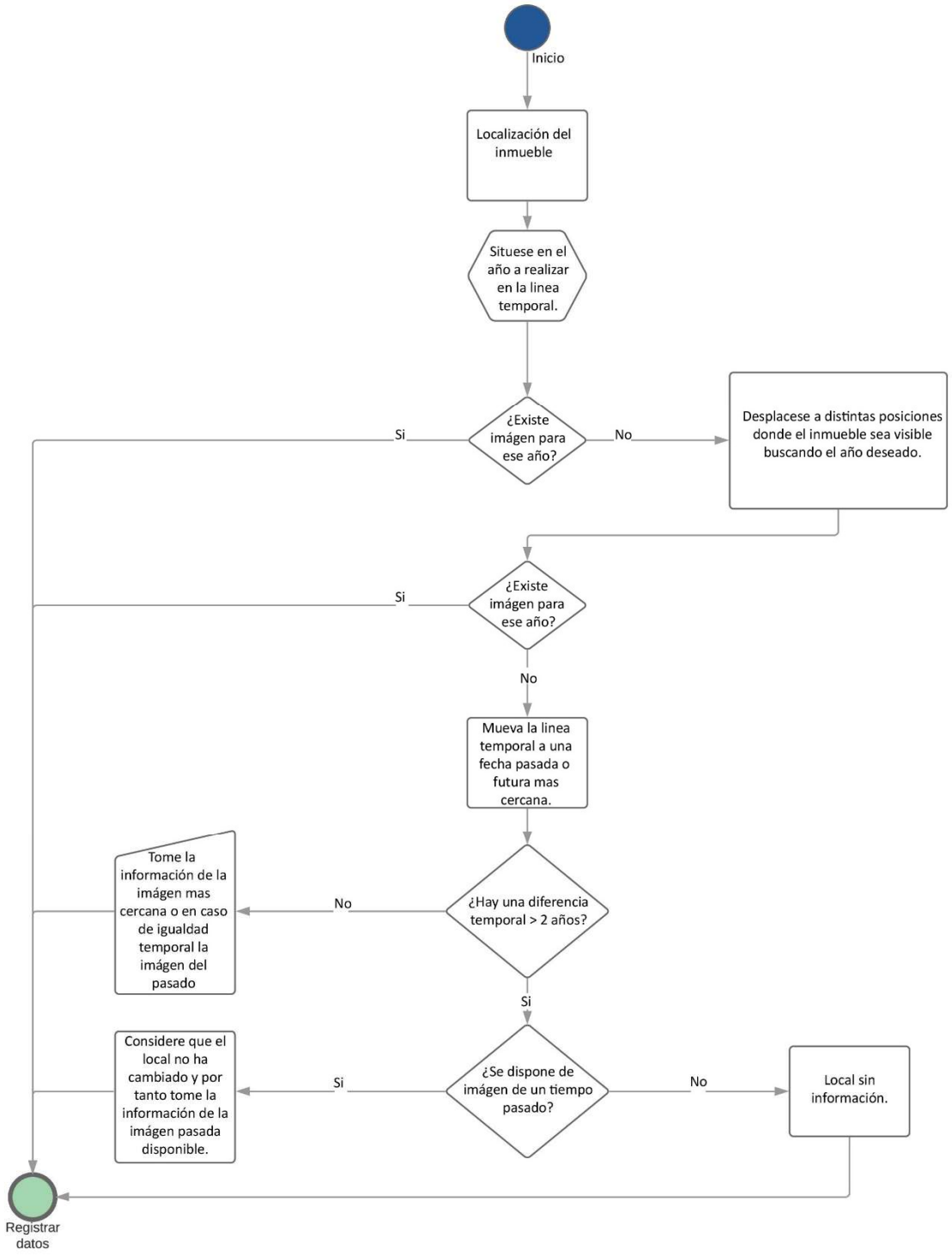
Para el caso del estudio de establecimientos comerciales, y a modo de ejemplo, algunas de las variables que pueden ser interesantes y cuyos datos pueden obtenerse sobre el establecimiento pueden enfocarse sobre:

- Actividad desarrollada (tipo de uso, actividad comercial, garaje, en venta, en alquiler, sin uso…)
- Elementos externos del establecimiento (rótulo comercial, color, forma, material, serigrafía, tipografía, iluminación…)
- Fachada del inmueble (número de metros, color, material, escaparates…)
- Estudio de la competencia (actividad de los negocios cercanos).

Asimismo, se puede recabar información sobre el entorno urbano:

- Tipo de acera (metros, material de pavimentación o color)
- Vegetación colindante (arbolado, maceteros, flores…)
- Circulación rodada (número de carriles, peatonalización, carril bicicleta, carril taxi, tranvía…)
- Aparcamientos (en línea, en vado, prohibición…)
- Mobiliario urbano (farolas, asientos, papeleras, parques infantiles…)
- Condiciones externas (iluminación, limpieza, estética de las fachadas)
- Mercado inmobiliario (carteles de se vende o alquila)
- Aspecto de la fachada colindante (carteles publicitarios pegados, grafitis, etc.)

Figura 2: Diagrama para toma de datos en variables temporales en GSV



Fuente: elaboración propia

A modo ilustrativo, se muestra un ejemplo donde se analiza el establecimiento seleccionado (Figura 3) como epicentro del área para el periodo comprendido entre 2008-2019 y sobre cuatro variables: actividad comercial, rótulo comercial, espacio

disponible en la entrada y, por último, el perímetro de todo el contorno en m^2. A continuación, se observa una imagen de las varias disponibles con una línea temporal con bastante información (Figura 4), no obstante, se observa cómo cabe la posibilidad de que algunos años no estén disponibles. Seguidamente, se puede comprobar la evolución temporal del local a lo largo de los años (Figura 5). Un claro ejemplo de la toma de datos siguiendo los criterios anteriormente mencionados quedan reflejados en la (Tabla 1).

El local seleccionado a modo de ejemplo, corresponde con el situado en Plaza de San Miguel, Nº 4, 28005 Madrid. Un lugar estratégico ya que se encuentra enmarcado entre la Plaza Mayor de la capital de España y el Mercado San Miguel, situados ambos en el centro de Madrid, en pleno barrio de Sol cuya actividad turística y comercial se puede considerar como una de las más interesantes de la ciudad. Este pequeño comercio, como se puede apreciar en los siguientes esquemas ha sufrido diversas modificaciones, tanto en fachada como en la actividad.

Figura 3: Selección de inmueble y área de influencia

Fuente: Elaboración propia a partir de Google Maps (2019)

Figura 4.- Inmueble seleccionado y línea temporal

Fuente: GSV (2021)

Figura 5. Distintas variaciones del inmueble

Fuente: GSV (2008,2013,2016,2019)

Tabla 1: Recogida de datos

	Actividad comercial	Rótulo comercial			Entorno entrada	Superficie de acera
		Texto	Color de texto	Color de fondo		
2008	Alimentación	Autoservicio GAMA	Naranja – Blanco	Negro	35 m²	104 m²
2009	Alimentación	Autoservicio GAMA	Naranja – Blanco	Negro	35 m²	104 m²
2010	Alimentación	GAMA	Blanco	Naranja	35 m²	104 m²
2011	Alimentación	GAMA	Blanco	Naranja	35 m²	104 m²
2012	Alimentación	GAMA	Blanco	Naranja	35 m²	104 m²
2013	Alimentación	UNIDE	Blanco	Azul	35 m²	104 m²
2014	Alimentación	UNIDE	Blanco	Azul	35 m²	104 m²
2015	Alimentación	UNIDE	Blanco	Azul	35 m²	104 m²
2016	Alimentación	UNIDE	Blanco	Azul	35 m²	104 m²
2017	Moda regalos y decoración	ALE-HOP	Blanco	Negro	50 m²	127 m²
2018	Moda regalos y decoración	ALE-HOP	Blanco	Negro	50 m²	127 m²
2019	Moda regalos y decoración	ALE-HOP	Blanco	Negro	50 m²	127 m²

Fuente: Elaboración propia

Una vez obtenida la metodología de toma de datos, y tras haber analizado más de 550 locales comerciales tomando datos de cada uno de ellos a lo largo de los años comprendidos entre 2008 y 2019 para desarrollar la investigación que desarrollaría en el artículo "*Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks*" así como casi 700 locales en la misma franja temporal para el artículo de "*The Circular Economy and Retail: Using Deep Learning*

To Predict Business Survival" lo que supone recopilar en torno a 10.000 datos manualmente por cada una de las investigaciones, se abordan cada una de ellas mediante Redes Neuronales y Deep Learning respectivamente.

El uso de técnicas de computación neuronal no es nuevo en la literatura científica. Desde los años 90, el uso de estas técnicas se ha hecho extensivo a todos los campos de las ciencias y de la tecnología. Las redes neuronales son una serie de neuronas conectadas entre sí y que trabajan en conjunto, sin que haya una tarea concreta para cada una. Con la experiencia, las neuronas van creando y reforzando ciertas conexiones para "aprender" algo que se queda fijo en el tejido. Son sistemas de clasificación sobre modelos en los que no se conoce la distribución de la muestra y en los que existe conocimiento escaso, cambiante y, en algunos casos contradictorios. Su arquitectura está basada en el conocimiento que se dispone del sistema nervioso animal, de modelos matemáticos relacionados con la aproximación de funciones, la estadística y la teoría de la información, y físicos, relacionados con la mecánica estadística.

Una característica relevante de este tipo de herramientas es su capacidad de generalizar y de encontrar la representación subyacente en la muestra del dominio objeto de estudio.

Los actuales sistemas de interpretación y análisis de datos hacen uso de arquitecturas de redes neuronales muy diversas.

Los mapas autoorganizativos son redes neuronales con arquitectura matricial y aprendizaje competitivo. La estructura de esta técnica de clasificación (Kohonen, 1990, 1997) ha sido desarrollada a partir del modelo perceptivo de la visión en el ser humano y se han revelado como una potente herramienta de clasificación y clusterización cuando no existe un conocimiento de la distribución de probabilidad de la muestra a clasificar e, incluso, cuando el dominio de aplicación usa una métrica diferente a la euclídea siguiendo el esquema de (Martínez et al, 2014).

La estructura de un mapa autoorganizativo es una matriz de elementos en los que cada uno de ellos responde a un tipo de entradas en función de la similitud con esta. El grado de similitud y la medida de esta característica son elementos diferenciales del mapa

autoorganizativo. La respuesta de cada uno de los elementos de la red se configura mediante un proceso de entrenamiento.

El proceso de entrenamiento es de tipo iterativo y consiste en comparar, de manera cíclica, cada elemento de una muestra del dominio objeto de estudio, con los vectores de referencia que definen a cada neurona, y adaptar los valores de estos acercando a los valores de la muestra a aquel vector que más se parezca a ella y alejando de los valores de la muestra a aquellos vectores representantes de neuronas cercanas a la neurona que ha resultado más parecida.

Los mapas autoorganizativos han tenido una aplicación intensiva en el campo de la ciencia y la tecnología. Así, en los trabajos de Deboeck (1998) y Hung y Tsai (2008) para el análisis modelos económicos, Hewitson y Grane (2002) en estudios de climatología y Villmann y Bauer (1998) y Alhoniemi et al (1999) en análisis de problemas en la ingeniería y la teoría de sistemas.

La hipótesis de partida es que cuando se realiza la rehabilitación de edificios singulares en cascos urbanos, se provoca un doble proceso: por una parte, desarrollo local como forma de impulso económico sostenible, y por otra una gentrificación comercial con una renovada actividad empresarial.

Para comprobar la validez de la premisa, se han observado y recogido datos significativos de la actividad empresarial como las variaciones en los comercios, las reformas de los locales, el grado de ocupación de los mismos o el precio medio de las viviendas en el área de influencia del inmueble. Se han obtenido datos y analizado 565 locales del área comercial de ciudades españolas, Barcelona, Valencia, y Almería.

La elección de los inmuebles, que sirven como base del estudio, hemos tenido en cuenta los siguientes parámetros:

- Ubicación: Para tener un más estudio homogeneizado, donde las externalidades pudiesen ser similares, se han buscado capitales de provincia españolas localizadas en la zona costera mediterránea. Se pretende que elementos como la presión turística, la meteorología o condicionantes sociales, no distorsionaran la investigación. Dentro de la ciudad, están localizados en el centro de la ciudad o cerca del mismo.
- Demografía: Las tres ciudades han sido escogidas por su representatividad en cuanto a su número de habitantes. Barcelona, supera ampliamente el millón de personas residentes, mientras que Valencia es algo menos de la mitad. Almería por su parte, representa a la ciudad media (López, 2008). De este modo, los resultados podrán ser extrapolables a poblaciones independientemente de su tamaño
- Tipo de inmueble: Se han seleccionado edificios del s. XIX, restaurados total o parcialmente con anterioridad al 2013, considerado año final de la crisis económica y durante el periodo de estudio (2008-2018). Por otra parte, se han buscado características similares en cuanto a estilo artístico y arquitectónico.

Por otra parte, se ha empleado la técnica de Deep Learning para predecir la resistencia de los negocios ubicados en los locales objeto de estudio en función de su actividad, su calificación de circularidad, y el histórico de apertura y cierres que ha tenido el local en los periodos estudiados.

Se pretende estudiar si la información de actividad y de circularidad es suficiente, junto con la posición del local, para determinar su resistencia.

Se ha dividido la predicción de la resistencia del local en dos periodos: el relativo a la gran depresión de 2008, y el periodo postdepresión, siendo en el intervalo de 2014 a 2018.

Se han obtenido datos y analizado 658 locales del área comercial de ciudades en UK y España: Londres, Barcelona, Valencia, y Almería (Figura 6).

Figura 6. Detalle de la tabla de datos, los datos se corresponden, por columnas, a la información de Actividad (Axxxx), Índice de circularidad (Cxxxx) y Ocupación (OCxxxx): Abierto o cerrado.

A2008	C2008	OC2008	A2009	C2009	OC2009	A2010	C2010	OC2010	A2011	C2011	OC2011	A2012	C2012	OC2012
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Servicios	NP	Abierto	Servicios	NP	Abierto	Servicios	NP	Abierto	Servicios	NP	Abierto	Servicios	NP	Abierto
Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto
Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto	Industria	R5	Abierto
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado
Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto	Tiendas	R2	Abierto
Educación	NP	Abierto	Educación	NP	Abierto	Educación	NP	Abierto	Educación	NP	Abierto	Educación	NP	Abierto
Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado	Cerrado	NP	Cerrado

Fuente: Elaboración propia

Dicha información está estructurada en una tabla que presenta el formato (ayicyioyi...aykcykoyk), donde a es la actividad del local, c es el índice de circularidad, y o es la ocupación de dicho local, en los años yi...yk.

Evaluaremos la resistencia de los locales de los periodos 2008 a 2011 en 2012 y en 2014, y en el periodo 2014 a 2017, para predecir la supervivencia de actividad en 2018.

Con la explosión de nuevas tecnologías y el Big Data y con la necesidad de obtener resultados a la gran cantidad de información de la que se dispone, la Inteligencia Artificial ayudado al desarrollo del Deep Learning, el cual nace de la necesidad de mejorar los procesos de reconocimiento usando modelos de redes neuronales preentrenadas para tareas más simples (Sainath et al., 2015)

Esta técnica ha tenido gran aceptación tras desplazar al resto de las técnicas en labores de identificación, clasificación y análisis de datos en problemas de imágenes, video y texto. El uso del Deep Learning está ampliamente extendido en el análisis de información simbólica (no numérica) y en el procesamiento de mensajes de texto (Yu & Deng, 201; Kowsari et al., 2017; Liang et al., 2017).

El Deep Learning es un enfoque de aprendizaje automático no supervisado funciona similar al comportamiento neurológico humano. Se trata de una red neuronal jerárquica, que disponen de conjuntos de neuronas especializadas en determinados tipos de inteligencias o acciones específicas.

Muchos de los problemas con los que nos encontramos en el mundo real son entendibles si se tiene la evolución de sus estados a lo largo del tiempo. Las series temporales son un caso clásico de este tipo de problemas. Un problema similar nos lo encontramos cuando se pretende desarrollar sistemas que entiendan un texto, o la evolución de un determinado mercado.

2.4. PRINCIPALES RESULTADOS

La satisfacción radica en el esfuerzo, no en el logro.

El esfuerzo total es una victoria completa

(Mahatma Gandhi)

En este capítulo se exponen a continuación los resultados más importantes que aparecen en el contenido de los artículos presentados.

En el artículo "*How to use Google street view for a time-lapse data collection methodology: potential uses for retailing*" no procede obtener resultados cuantitativos al estar basado en la generación de una metodología para la toma de datos, no obstante, cabe destacar su importancia, ya que las metodologías tradicionales que debaten sobre la correcta elección de un local para una actividad comercial o aquellas que se basan en aspectos de geoposicionamiento, en general, son estáticas en el tiempo, representando la situación en un momento muy concreto.

La técnica del time-lapse, secuencia de fotografías tomadas con un cierto tiempo de separación entre una y otra, ofrece nuevas oportunidades para la investigación, favoreciendo un análisis más profundo, así como la obtención de información dinámica, observando así la evolución en el tiempo de diferentes variables que el investigador puede personalizar y adaptar al análisis.

El desarrollo de una metodología propia, incorporando la técnica time-lapse para aplicaciones prácticas, es el principal aporte de esta investigación, ya que casi no hay investigación sobre este tema, y ningún estudio examina el sector minorista.

Los datos obtenidos son primarios, conseguidos directamente por el investigador de la observación del entorno y se pueden obtener para distintos periodos de tiempo.

La metodología de datos mostrada dota de libertad de elección en la horquilla temporal de 2008 hasta la actualidad y permite tener autonomía espacial, ya que cubre la casi

totalidad de los núcleos urbanos y libertad de parametrización sobre los elementos que se quieren estudiar.

Como se ha comentado, GSV es una herramienta gratuita, disponible y enmarcada bajo el paraguas de Google Maps, aplicación que nos permite buscar ubicaciones geolocalizadas en un determinado punto, permitiendo trasladarse virtualmente a una dirección en concreto mediante fotografías reales en 360º. Dicho contenido que nos ofrece la aplicación está desarrollado por el propio equipo de Google, aunque es posible colaborar enviando imágenes por lo que se ha convertido en un proyecto colaborativo donde la sociedad colabora en la construcción de este mundo virtual. La ventaja de esta aplicación es que la confección de los datos no tiene coste y queda en manos de la carga de trabajo que asuma el investigador.

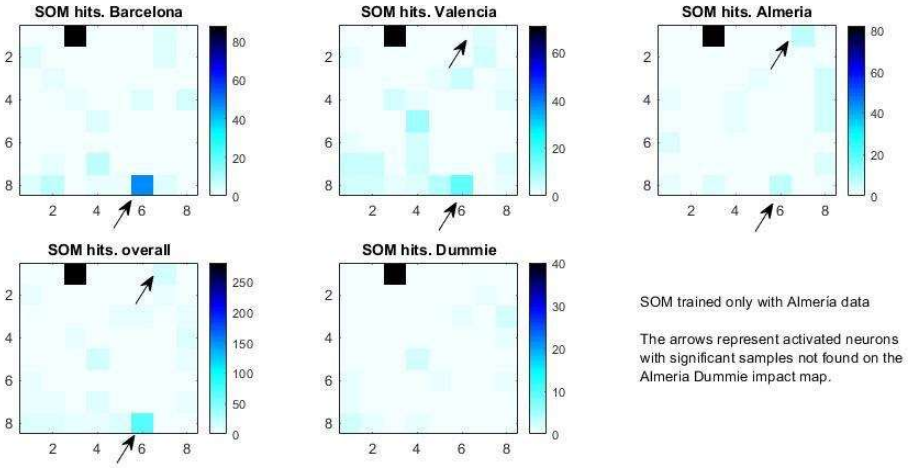
Por otro lado, se muestra en el artículo "*Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks*" a través del análisis de redes neuronales las relaciones y comportamientos comunes en los locales comerciales adyacentes a edificios singulares y que comparten patrones y características comunes.

Se puede comprobar como de las 4 hipótesis de trabajo que se enmarcaban los análisis, Nivel de ocupación, nivel de variación, tipo de ocupación, la suma de la variación, la ocupación y la moda de ocupación solo en 2 de ellas las redes neuronales han mostrado resultados significativos.

- Modelo de ocupación

El proceso de entrenamiento de la red neuronal usando como datos los modelos de ocupación de los locales muestra agrupaciones de activaciones en determinadas neuronas que son características de las muestras en las que se ha rehabilitado un edificio singular. La distancia crece de manera importante alrededor de la neurona de referencia: esto indica que nos encontramos con la referencia a una clase muy separada del resto de las muestras. (Figura 7).

Figura 7. Mapa de impactos para los datos recogidos en cada ciudad, y para los datos no significativos (Dummie).



Fuente: Elaboración propia

La activación de la neurona representa al 12,3% de la muestra, un número significativo de locales. Estos inmuebles se encuentran agrupados con una característica en común, comparten la misma secuencia de ocupación.

Los locales han permanecido cerrados en los trienios 2009-2011 y 2015-2017. A su vez, durante los años 2012 a 2014 han tenido una única apertura, que cierra al año siguiente.

Por otra parte, la activación de otra neurona muestra locales que comparten como común denominador que han mantenido siempre alguna actividad empresarial, pero entre los años 2013 y 2014 han tenido algún tipo de transformación en su actividad, cerrando y volviendo a abrir en el mismo año.

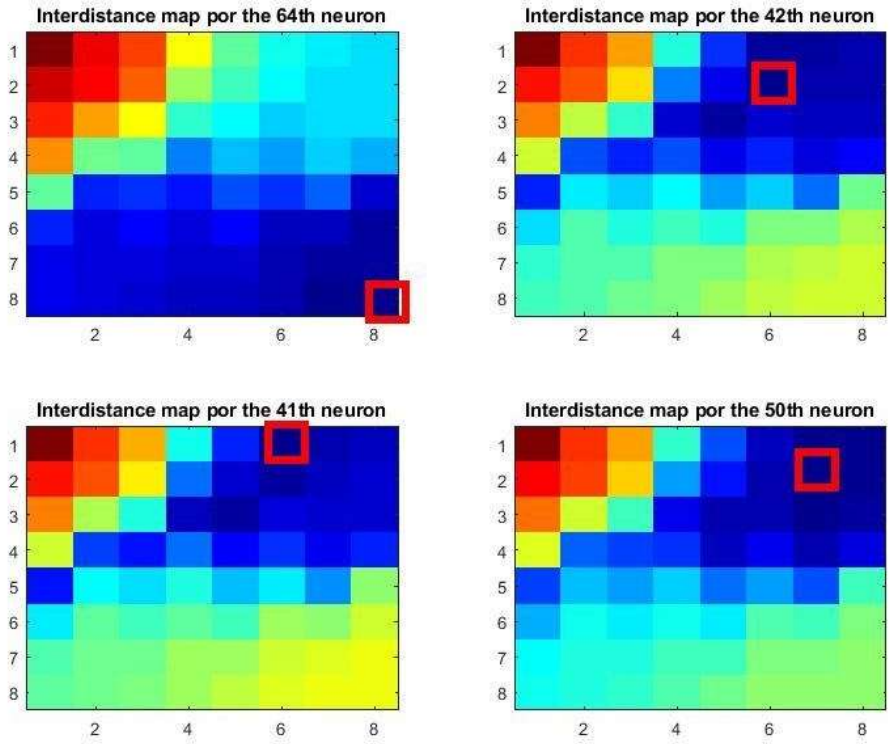
- Clasificación en base a la ocupación total, variación total y tipo de uso más usado para un determinado local.

Se han realizado, al igual que en los otros casos, una clasificación usando exclusivamente los datos de una ciudad para poder extrapolar la clasificación a datos no conocidos (el resto de las ciudades). Los resultados muestran, como en el caso anterior, agrupaciones

de impactos correspondientes a locales que aparecen en las zonas objeto de estudio y que no aparecen en la muestra DUMMIE.

De igual manera, se ha realizado un estudio de las distancias entre las neuronas que agrupan aquellos impactos distintivos, en relación con el resto de ellas y para conocer la distancia que dichos elementos tienen respecto a otros focos de agrupamiento. El mapa de interdistancias (figura 8) de las neuronas como impactos distintivos se muestra según el siguiente esquema:

Figura 8. Mapas de distancia de las neuronas 41, 42, 50 y 64.



Fuente: Elaboración propia

Se pueden observar las distancias calculadas de las neuronas con impacto distintivos. En el caso de las neuronas 41, 42 y 50 se puede encontrar que el mapa de distancias es muy parecido y que las distancias entre ellas son pequeñas. Esto nos permite afirmar que las tres agrupaciones pertenecen a locales con alguna característica común y que la activación de una de estas tres neuronas es resultado de alguna característica secundaria. En el caso de la neurona 64, la distancia se marca exclusivamente con las neuronas de la esquina opuesta.

Esto nos indica que la característica dominante de los locales que activan dicha neurona es también dominante en la mayoría de los locales salvo en aquellos que activan la esquina superior izquierda del mapa.

Las neuronas 41 y 50 corresponden con menos del 1% del total de la muestra, por lo que los consideramos poco significativos. La neurona 42 por su parte, su característica es que su actividad principal ha sido la de moda. No obstante, al no llegar a ser un porcentaje elevado de la muestra, no permite establecer una hipótesis.

Sin embargo, el comportamiento de la neurona 64 puede dar resultados interesantes ya que se han activado 78 locales de los 565 (13,8%), 50 situados en Barcelona, 21 en Valencia y 7 en Almería.

Su comportamiento es similar en cuanto a grado de ocupación: han estado siempre o casi siempre cerrados: 64 locales de esos 78 (82%) no han tenido nunca actividad, 7 locales (9%), abrieron y cerraron en un año y los locales restantes abrieron en 2018. Como verificación de este resultado, solo existen 3 locales de los 565 que siempre han estado cerrados y no pertenecer a la neurona 64, pero pertenecen a la muestra de control (dummi).

De igual forma, se muestra en el artículo "*The Circular Economy and retail: using Deep Learning to predict business survival*" unos resultados que han permitido establecer unos criterios que permiten predecir parte del comportamiento de la actividad comercial en función de su circularidad.

Se desarrolla un experimento usando LSTM para determinar si existe una relación entre la resistencia de los locales objeto de estudio, su situación en anteriores periodos de tiempo, el tipo de actividad y su calificación en el plano de la economía circular. Este estudio se va a realizar describiendo cada uno de los locales con una serie de etiquetas

que van a ser interpretadas como un vector de características no numéricas por el clasificador.

Se dispone de un total de 686 entradas de datos correspondientes a locales, en distintas ciudades europeas (Almería, Valencia, Madrid, Barcelona, Londres) que han sido sometidas a estudio mediante la herramienta de Google Street View.

Dicha información es particionada en dos conjuntos: por un lado, el periodo de 2008 hasta 2012, que se corresponde con la gran depresión de 2008. Y por otro, el periodo de 2014 hasta 2018. De todos ellos se tiene información sobre su actividad, su índice R de acuerdo con la economía circular, y su situación (abierto o cerrado) en cada uno de los años objeto de estudio. Como son dos los periodos, construimos dos predictores. Uno para cada periodo.

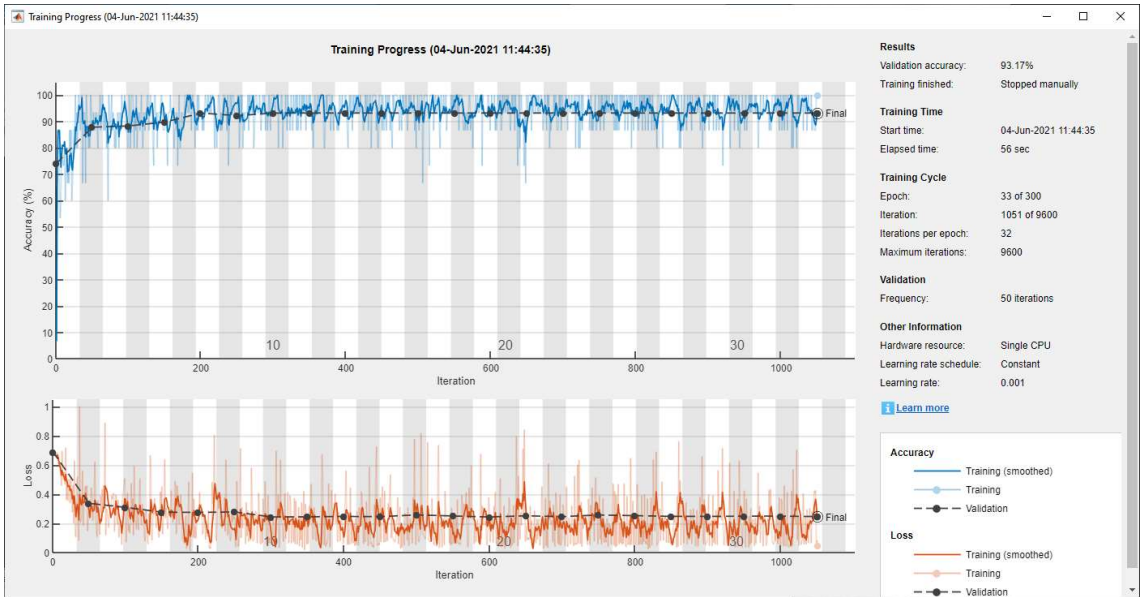
La construcción del predictor requiere de la partición de cada conjunto de datos de los anteriores en dos partes: un conjunto de entrenamiento y un conjunto de validación de datos, que será usado para probar la precisión de este.

Del conjunto total de datos, se ha utilizado un 70% de estos para el proceso de construcción del predictor, y un 30% de acuerdo con los criterios de validación cruzada, para construir el conjunto de validación, que nos permita testear el resultado obtenido.

El primer experimento toma como información de partida, la situación de los locales, y su índice de economía circular en los años posteriores a 2008 hasta 2011.

Tras realizar el entrenamiento de las redes. Las figuras 9 y 10 muestran la siguiente información:

Figura 8. Resultado del entrenamiento para el predictor de la crisis de 2008.



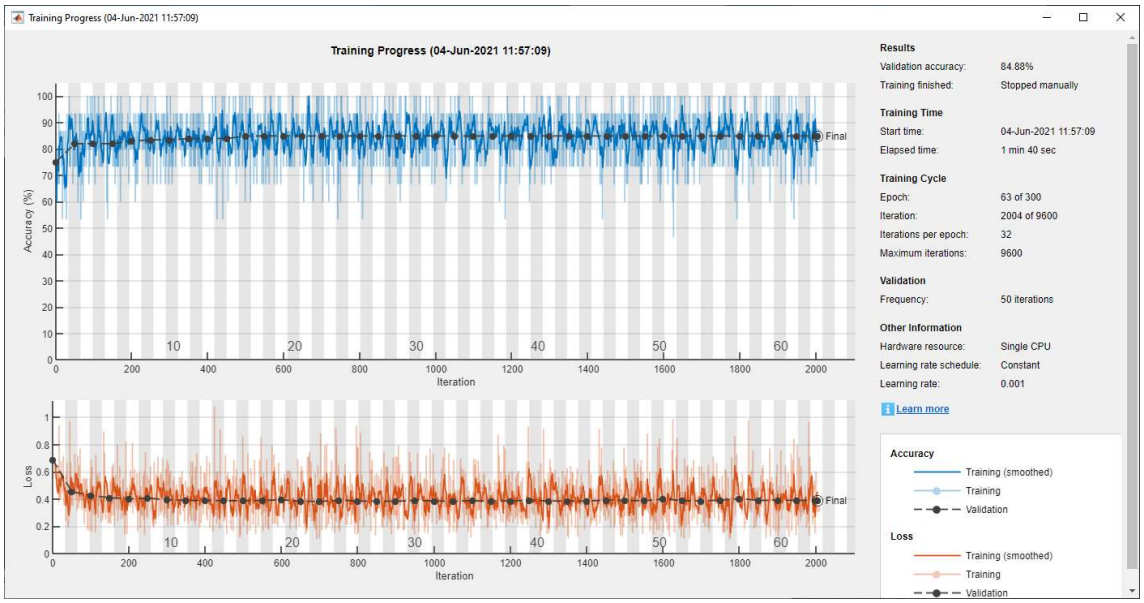
Fuente: Elaboración propia

La precisión obtenida para este predictor es del 93.17%. Este valor significa que, el sistema predice, sobre el conjunto de pruebas, con un 93,17% de acierto, la supervivencia de un local en base a la información de actividad y circularidad de años anteriores a 2012.

Si realizamos el entrenamiento para una predicción a 2014.

La precisión obtenida baja hasta el 84,88%, lo que sigue mostrando la fuerte relación entre la situación del local en los años de la crisis y su evolución posterior. Esto es consecuente con el hecho de que, conforme se avanza en el tiempo, la pervivencia del local está afectada por otros condicionantes que escapan a lo aprendido por el predictor.

Figura 10. Resultado del entrenamiento para 2014



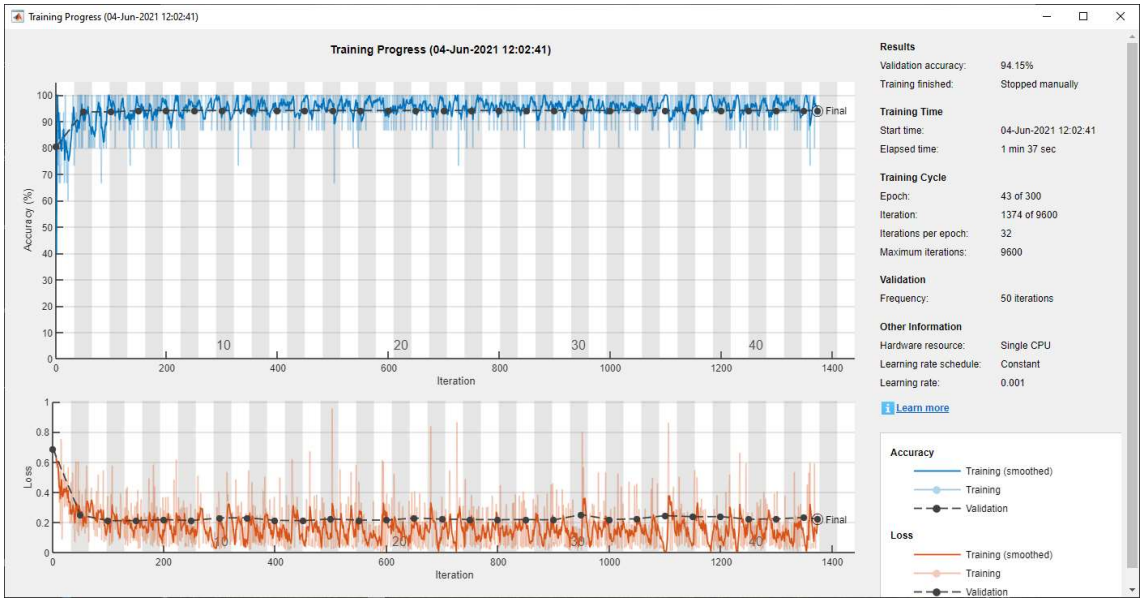
Fuente: Elaboración propia

El segundo experimento toma como información de partida, la situación de los locales, y su índice de economía circular en los años posteriores a la gran depresión de 2008, en particular, los años 2012 a 2017 y pretende relacionar esta información con su situación en 2018.

Se utiliza el mismo tipo de predictor y se entrena en las mismas condiciones que los anteriores, con los datos del periodo post depresión.

Los resultados del entrenamiento arrojan valores de precisión muy significativos también (figura 11), del orden del 94,15%.

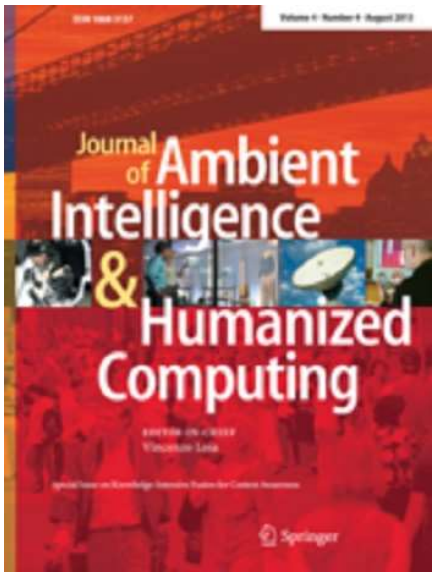
Figura 11. Resultado del entrenamiento para 2012-17

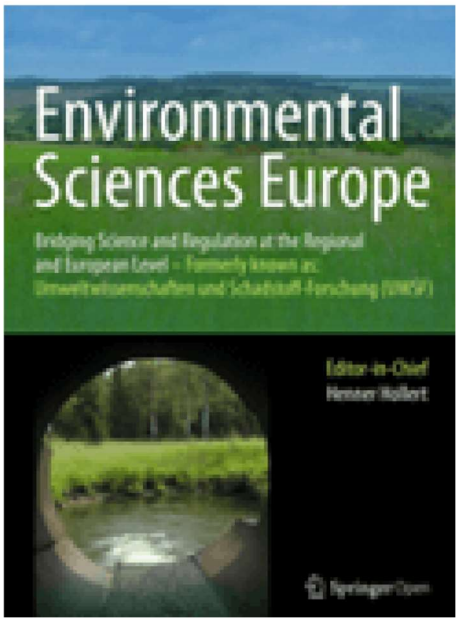


Fuente: Elaboración propia

Esto nos induce a pensar que la relación entre la situación del comercio, su actividad y el índice de circularidad en un intervalo de tiempo pasado condicionan, de manera decisiva, la supervivencia de este en años posteriores.

3. PUBLICACIONES ORIGINALES QUE CONFORMAN LA TESIS DOCTORAL





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ORIGINAL RESEARCH

How to use Google street view for a time-lapse data collection methodology: potential uses for retailing

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Abstract
Finding the optimal location is a relevant strategic decision for retailers. The classic theories of retail location offer complementary perspectives, and later models include new variables, although they present methodological problems, these methodologies are static in time. Google Street View (GSV) allows extending the analysis of predictive models to different fields by a time-lapse collection data offering new opportunities to research and providing dynamic information. The development of a customized methodology, incorporating the time-lapse technique for practical applications, is the main contribution of this research, since there is almost no research on this topic.

Keywords Methodology · Store location · Retailing · Time-lapse · GSV

1 Introduction

This article aims to show a new methodology for data collection based on Google Street View (GSV) using the time-lapse function, which allows planning and decision-making based on direct observation of a certain environment, generally urban. As an example of the development of the data collection methodology, its potential use will be applied to the location of retail stores.

To study the state of the art regarding the existence or not of a similar methodology prior to the publication of this article, we have carried out a systematic study based on bibliometric techniques for literature review, mainly through the Web Science (WoS) Core Collection database and as an accessory and to verify the validity of the search, the Scopus database.

"Google Street View" has been used as a keyword since in this way it includes similar formulations such as *Street-view* or *Street-view*. Following this initial step, a process of data cleansing is performed. The databases contain different types of documents that contain the three words in the title, abstract, keywords included by the author himself or Keywords Plus.

The total number of documents retrieved in the 12-year time range (2009–2020) is 458, a number very similar to that of Scopus, with 546 documents retrieved for the same period.

For our study, we delimited the number of publications by eliminating certain types of documents, either because they are not complete investigations, or because they are reviews that do not develop new methodologies. Thus, the following document types were excluded: proceedings paper (142), literature reviews (7), editorials (5), and poetry (1). On the other hand, we retain research areas, categories, languages and other search criteria, resulting in 303 documents. The results are essentially repeated in Scopus with 301 documents.

By analyzing the documents through their summaries and / or reading the complete texts, we can highlight the following characteristics:

- In all cases, the treatment of the GSV results is static over time and the temporal correlation is not used.

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- In most cases, it has been used as an alternative or comparative to traditional physical exploration.
- No document has been found that focuses on GSV as its own methodology, but rather always as part of previous methodologies.

Following the traditional structure of bibliometric analysis and with reference to their evolution over time, the most prolific authors and journals, as well as the main categories and areas of knowledge, are analyzed in order to obtain an overview of the state of the art.

Regarding the temporal evolution of these articles, from 2010 to 2019, the number of articles that include GSV has multiplied by 10, evidence that it is a tool whose utility has spread to academia.

With regards to the scientific production by authors, we can highlight Xiaojiang Li and Carlo Ratti, from the Massachusetts Institute of Technology (MIT), who, with 17 registered documents, are the researchers who have most focused their studies on GSV as a methodology. Their work "show a methodology using GSV panoramic images to estimate and predict the appearance of sun glare.

However, it is the article "*Where, When, Why, and For Whom Do Residential Contexts Matter? Moving Away from the Dichotomous Understanding of Neighborhood Effects"*, by Professors Sharkey and Faber, which has received the greatest number of citations (207) (Sharkey and Faber 2014). While this article does not address the use of GSV directly, it is widely used in its bibliography. The article titled *"Using Google Street View to Audit Neighborhood Environments"* (Rundle et al. 2011), with 203 citations, is the most cited.

The five main areas of knowledge, according to the WoS classification system, are Public Environmental Occupational Health (58); Geography (42), Urban Studies (35); Environmental Studies (30) and Physical Geography (26), practically coinciding with the research areas of the documents studied. Similar results are obtained when applied to the searches on Scopus.

To confirm the previous analysis carried out using WoS and Scopus, the search was expanded to Google Scholar, finding 13,300 results. This tool does not allow effective selection and refinement of results. However, the search for documents that contained "Google Street View" in the document title yielded 244 results, consistent with the results obtained with the other databases, thus confirming their validity.

As the design of the new methodology will fundamentally be used for urban elements, we have analyzed the 35 documents in the Urban Studies knowledge area and the 7 in Economics (Table 1).

To find out if similar methodologies exist, the following criteria have been considered:

- The object of study: investigations that focus on commercial premises or on building typologies, or that are related to the practical application developed for the new methodology.
- Whether the use of the GSV images has been static (photographs with a single reference year), or dynamic (the temporary functionality has been used).
- Whether the use of GSV is part of a new technique or development of a methodology.

Ewing and Clemente (2013) present an interesting analysis of the intangible elements of cities, studying the case of New York. Similarly, the analysis by Monteiro and Turczyn (2018) of Google Earth and GSV images, complemented by street level observations and photographs, adapts them to the categories of pattern identification in metropolitan territories.

The study by Lee and Talen (2014), in turn, contributes to the literature on walkability measurement by proposing a hybrid auditing method that combines a GIS-based approach with GSV.

Hipp et al. (2017) propose a dynamic application similar to that of Grubesic et al. (2018). In the case of the former, their study does not use GSV images but rather employs data obtained from images shot every 30 min by surveillance cameras in order to look for patterns of physical activity. In the case of the latter, their study raises the issue of frequency of images as an added difficulty of the study, since temporality is given by the use of two different tools, Google and Microsoft (Bing) showing multi-year temporary gaps.

In 2019, two methodological investigations are published. While Zhang et al. rely on open data to measure the quality of life and health of neighborhoods in Atlanta (USA), and use GSV as a data source; Middel et al. use GSV imagery to assess urban form and composition of cities from a human-centric perspective.

As can be seen in Table 1, none of the references study the three variables considered in this study at the same time. That is, none of them consider urban planning or building as an object of study, development of a new methodology, and that it be a temporarily dynamic analysis in the same study.

2 Retailing location choice theories

The location of a store is one of the most relevant strategic decisions for retailers. Kuo et al. (2002) claim that choosing a location is one of the most critical decisions of a small retail establishment. Moreover, the choice of location may be a determining factor for the success or failure of a retailer (Scarborough and Zimmerer 2004). Jaravaza and Chitando (2013) study the role of store location as an influencing factor in customers' store choice, furthermore, Ilbahar

Table 1 Literature on GSV in the fields of Urban Studies and Economics. Source: own compilation

Authors and year	Main object of study	Knowledge area	Use of GSV	Dynamic (Timelap)/ Static
Ewing and Clemente (2013)	Urban Design	Urban studies	Method	Static
Guo (2013b)	Parking		Tool	
Gordon and Janzen (2013)	Suburbs			
Guo (2013a)	Parking	Economy		
Hanson et al. (2013)	Transport			
Lee and Talen (2014)	Walkable Environments	Urban Studies	Method	Static
Li et al. (2015a, b) (a)	Vegetation	Urban Studies	Tool	Static
Li et al. (2015a, b) (b)	Vegetation			
Sedano (2016)	Advertising			
Li et al. (2016)	Vegetation	Urban Studies	Tool	Static
Mygind et al. (2016)	Vegetation			
Moniruzzaman and Paez (2016)	Walkable Environments	Economy		
Hipp et al. (2017)	Physical Activity	Urban Studies	**Method**	**Dynamic**
Berland and Lange (2017)	Vegetation		Tool	Static
Goodspeed (2017)	Walkable Environments			
Seiferling et al. (2017)	Vegetation			
Grubesic et al. (2018)	Drones	Urban Studies	Tool	**Dynamic**
Freemark (2018)	**Building**			Static
Li and Ratti (2018)	Vegetation			
Li et al. (2018)	Vegetation			
Monteiro and Turczyn (2018)	**Urban Spaces**			
Rigolon et al. (2018)	Vegetation			
Ruggeri et al. (2018)	Livability			
Zhang et al. (2018)	Urban Objects			
Chen and Sekar (2018)	Travel	Economy		
Glaeser et al. (2018)	Big Data			
Shatu and Yigitcanlar (2018)	Walkable Environments			
Middel et al. (2019)	Metrics	Urban Studies	**Method**	Static
Foster and Newell (2019)	Footpaths		Tool	
Hong et al. (2019)	Vegetation			
Lakhotia et al. (2019)	Bus-stops			
Li and Ratti (2019)	Pollution			
Li et al (2019)	Pollution			
Lu et al. (2019)	Cycling			
Lu (2019)	Vegetation			
Wang et al. (2019)	**Building**			
Ye et al. (2019)	Vegetation			
Zhang et al. (2019)	Livability			
Tanas et al. (2019)	**Building**	Economy		
Nesse and Airt (2020)	Streetscapes	Urban Studies	**Method**	**Dynamic**
Gobster et al. (2020)	Stewardship programs		Tool	Static
Tang et al. (2020)	Greenways			

and Kahraman (2018) state that retail store selection is an important decision for both customers and retailers since it is directly linked to customer satisfaction and retailers´ profit. Given the extensive and multidisciplinary array of literature on the issue of store site selection (Nwogugu 2006), there exists a variety of ways to measure the "ideal location" for commercial establishments.

The three classic theories of retail location propose different ways of measuring the potential of commercial locations. The *Principle of minimum differentiation* (Hotelling 1929), argues that the most important factor is the relative

proximity to other stores that offer similar goods or services; i.e., the tendency of businesses or products to cluster. Thus, proximity to competitors is considered more critical than proximity to customers. The other two classic theories of retail location focus on locational centrality. Thus, *Spatial interaction theory* (Reilly 1929) assumes that customers compensate for differences in store-specific product and service relative to the appeal of the place of purchase. This is the case, for example, of small convenience stores, which offer fewer standardized goods and services (Jones et al. 2003). Finally, *Central place theory* (Christaller 1933) focuses on the relationships between establishments of different sizes and relates their economic activities with the population. It states that its main function is to supply goods and services to the surrounding population. Geographical distance and transportation costs acquire a relevant role in the analysis, since demand for a good or service will decline with distance from the source of supply. Consequently, the locations closest to the customer's demand center guarantee a better positioning, in contrast to those located further away. This theory is considered to have significant predictive power, primarily for single-purpose shopping trips.

Since the appearance of GSV in 2007, new methodological opportunities appear for research on this topic. Wilson et al. (2012) show a precise and consistent agreement between observation field audits and image-based interpretation using GSV. Both academic research and companies have found that GSV offers an excellent opportunity for practical implementation and solving numerous problems.

However, GSV is not limited to the world of retailing as it offers many other possibilities for analysis and development of predictive models. Thus, Odgers et al. (2012) find it a reliable and cost effective tool for measuring both negative and positive features of local neighborhoods. Rundle et al. (2011) develop an exploratory study and find that GSV can be used to audit neighborhood environments. Wood and Reynolds (2012) study how retailers can take advantage of location research in order to better leverage geographical insights and assist in the realization of appropriate customer propositions and marketing strategies. Griew et al. (2013) develop a street audit tool using GSV to measure environmental supportiveness for physical activity. Hara et al. (2013) combine crowdsourcing and GSV to identify street-level accessibility problems in a city. Using GSV is a reliable method for assessing characteristics of the built environment (Kelly et al. 2012).

All these methodologies present a problem, they are static in time. In other words, they represent a "snapshot" of reality at a certain moment. Therefore, the time-lapse technique can be an excellent opportunity for a more thorough and in-depth analysis of retail store location. Time-lapse is a technique in which images are captured in sequence with a photo (or video) camera, which offers opportunities to obtain dynamic information about reality through its evolution over time. To our best understanding, there is almost no research incorporating the time-lapse technique for practical applications, and no study examines the retail sector. One of the few exceptions that includes dynamic analysis using GSV is Ilic et al. (2019) that present a Siamese convolutional neural network that automatically detects gentrification-like visual changes in temporal sequences of GSV images. Cohen et al. (2020) also use GSV images and their evolution over time to provide current and historical food retail data from 2007 to the present. The study shows how GSV can be used to analyze changing food environments that affect health.

For this paper, the main contributions are as follows: (1) this methodology allows researchers obtain data from a primary source, based on direct observation of a certain environment. (2) our dynamic time-lapse methodology will help to predict the potential popularity of locations over time, facilitating the process of decision making on retail store location, (3) this methodology may also help guide urban planners in designing commercial zones and transportation networks, to analyze spatial concentration of retailers, as well as study the factors affecting the rental value of residential property.

3 Development of the methodology for data collection and practical application

The methodology for collecting data for the analysis of commercial premises in a certain area begins with the selection of the area of influence.

It will be considered a radius of 150 m for the analysis. This distance is based on the investigations of Tan and Tan (1995); Nikilaos et al. (2011) or Ray (2017) who follow this same longitudinal criterion attending to visual, transport and visual impact elements. In the case of previously delimited areas (the intention is to study a street, district or singular area) it is recommended to create grids of approximately 900 m^2.

Likewise, it is advisable to create a table with a list of all the streets affected, list the premises or buildings within that radius of action to later record the data, as shown in the diagram (Fig. 1).

It should be noted that GSV imagery allows us to access spatial and temporal data, only in those places and times where the technology was employed. In most cases, this data is available from 2008 onwards with an increasing number of images and data available for research.

The data collection scheme was carried out following the criteria of standardized graphic notation system, BPMN (Business Process Model and Notation). BPMN is aimed at process modeling and is one of the best organization

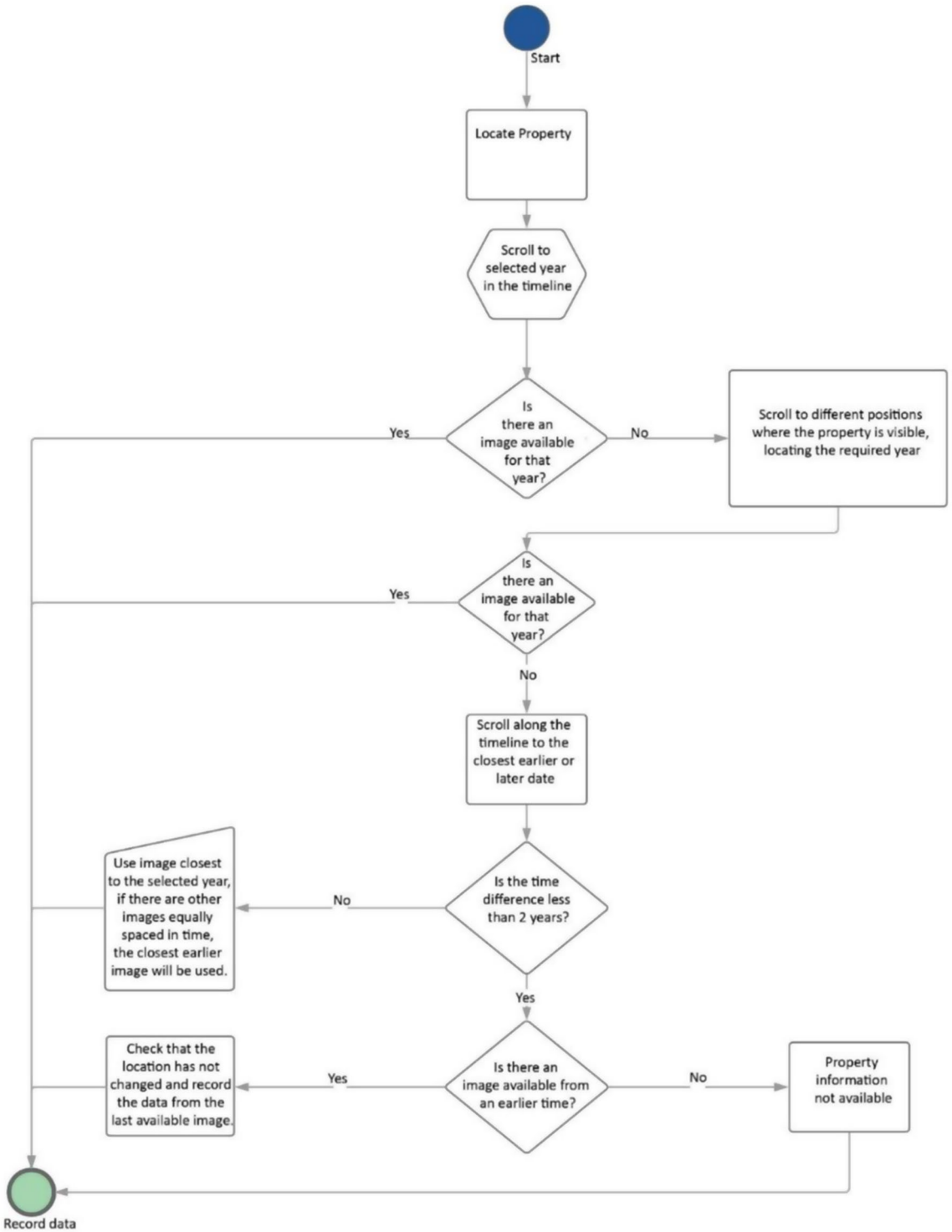


Fig. 1 Diagram for data collection in temporal variables in GSV. Source: own compilation

London – Madrid

Fig. 2 Selected property and its area of influence. Source: own compilation based on Google Maps (2019)

systems to follow quality and productivity criteria (Chinosi and Trombetta 2012).

4 Data considerations and treatment

The possible scenarios regarding the availability (or not) of images in GSV in the year of study are the following:

(1) Image is available: the data of the variables for that year is recorded.
(2) No image is available for the year being studied:
    (a) There is an image available within 2 years of the year being studied: the data of the closest image in time is considered. Should there be both an earlier and a later image available, the data from the earlier image will be used.
    (b) There is at least one image with a time difference greater than 2 years: the data from the earlier year will be considered for the image analysis. If there is no earlier image available, the data record will state that there is no valid information.
(3) Image not available for any year: as no image was obtained, the data record will state "Property information not available".

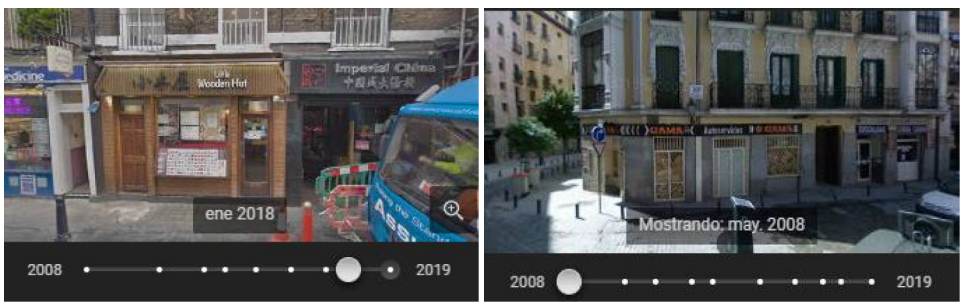
One of the main advantages of the data collection methodology is that the researcher is free to select the variables that will be registered, as well as their classification.

In the case of the study of commercial premises, and by way of example, some of the variables that may be of interest and data that can be obtained about the property include: the economic activity carried out; external elements of the establishment; facade of the property; competitive analysis. Likewise, information about the urban environment can be collected.

By way of example, an analysis of a commercial area located in the center of Madrid (Spain) and London (UK) is carried out (Fig. 2). From the starting position, the steps and instructions laid out in the diagram will be followed, in order to make position shifts or make decisions about years where information was not available.

The starting point offers us a timeline with sufficient information (Fig. 3), although, as will be seen, in some years there was no available images. In this example, we will analyze the selected commercial property as the epicenter of the area for the period between 2008 and 2019 using four variables: commercial activity (type of business), commercial signage, the space surrounding the entrance and, finally, the total surface area of the sidewalk around the property. (Figs. 4 and 5).

Data such as those provided by this research, of a specific location in London and Madrid, simply as an example of the type of quantitative and qualitative information that this methodology can provide, allow you to have a very complete



London – Madrid

Fig. 3 GSV timeline for selected property. Source: own compilation from GSV

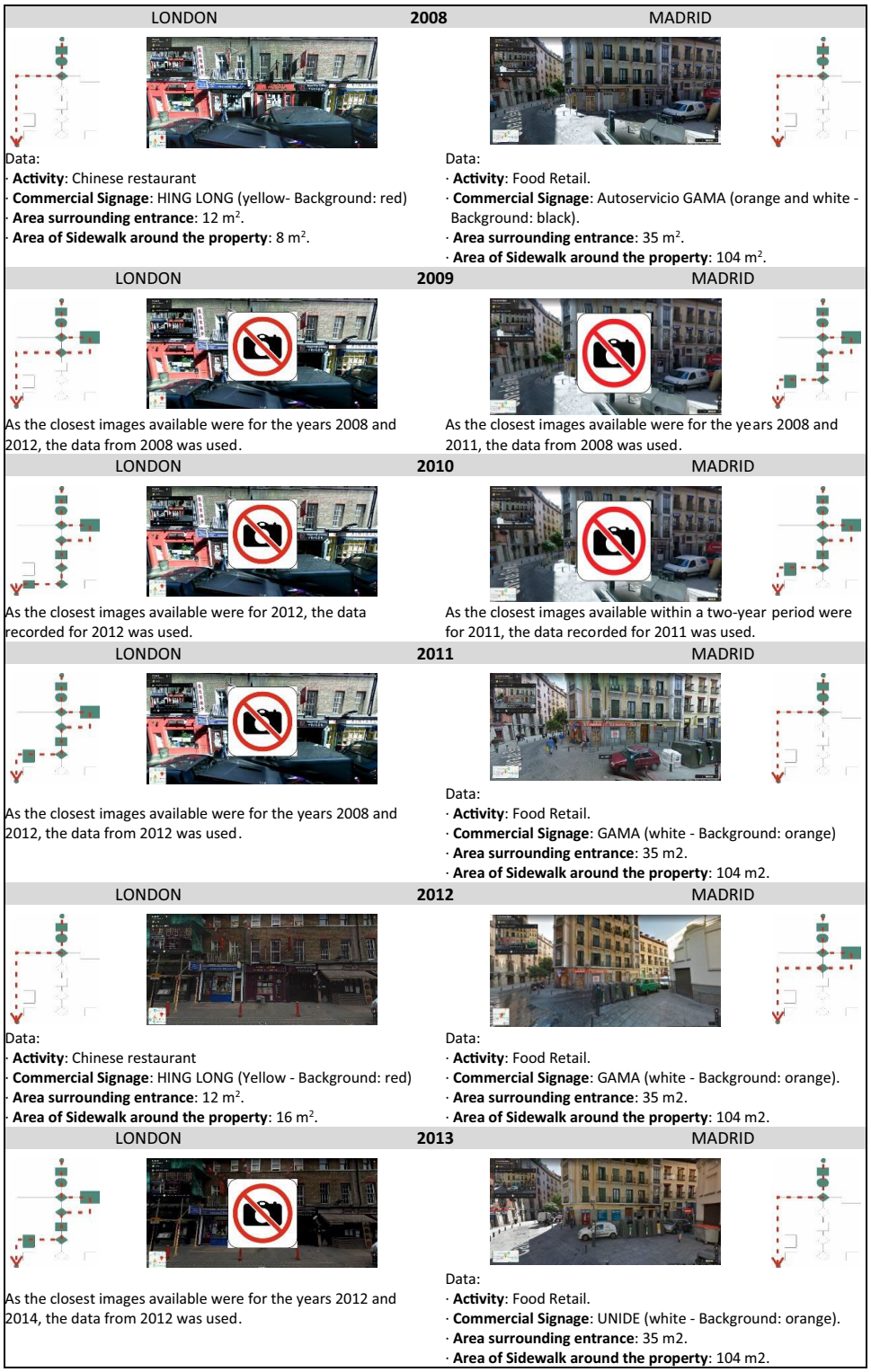


Fig. 4 Flow diagram, sequential images, and recorded data (2008–2013)

perspective of the location and movements that occur in the retailers and surrounding areas over time. It is not simply a matter of having information at a specific moment, but also allows us to observe the temporal evolution and analyze possible interactions between the different observed variables.

These data can be valued from different perspectives. Thus, for example, it offers useful information to be considered by the three classic theories of retail location, which propose different ways of measuring the potential of commercial locations. In this sense, for example, for the analysis

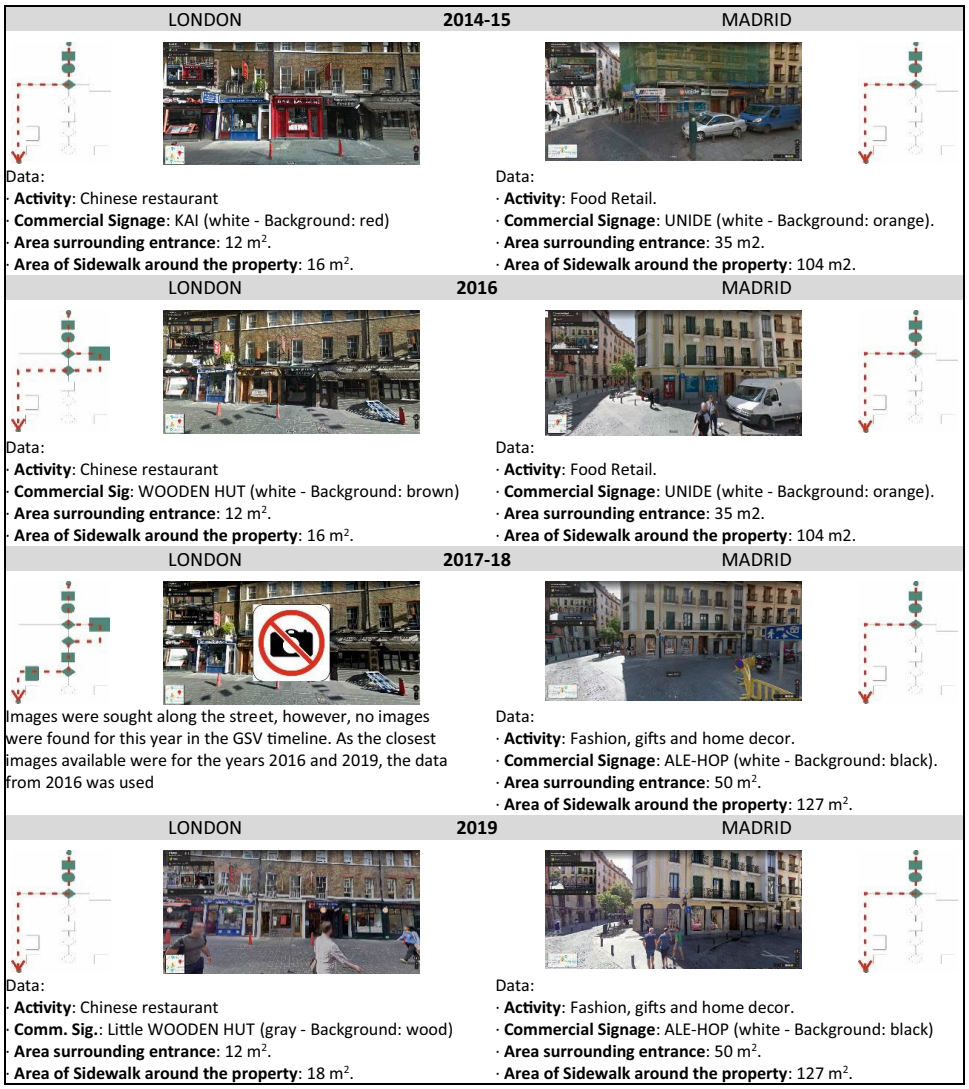


Fig. 5 Flow diagram, sequential images, and recorded data (2014–2019). Source: own compilation

from the Principle of minimum differentiation, it is very important to know the openings and / or closings of the retailers around the central point of analysis. The density of competitors is key and knowing if there are retailers that offer similar goods or services can be decisive in the decision process.

5 Conclusions and potential applications

Store location is one of the most relevant strategic decisions for retailers since it may be a determining factor for success, even being directly linked to customer satisfaction. However, identifying the best locations is a complex decision for businesses to make. In this regard, there are different ways to evaluate store location. The three classic theories of retail location, *Principle of minimum differentiation*, *Spatial interaction theory*, and the *Central place theory* offer different and complementary perspectives. However, as described in this paper, many authors add different variables to these models when presenting some methodological problems inherent to them (e.g., the characteristics of the site is scarcely considered; the distance is over-emphasized; factors such as: the effect of site-specific operating costs, competing stores, or the economic value of customer's time on the location decision are not considered). In this way, different retail store location models are developed, with some research even focusing on specific retailers. In addition, since the development of GSV, new methodological opportunities appear for research which are not limited to retail stores, but rather extend the analysis and development of predictive models in different fields.

Nevertheless, these methodologies are static in time, representing the situation at a very specific moment. Therefore, time-lapse techniques offer new opportunities to research, favoring a deeper analysis, as well as obtaining dynamic

information, thus observing the evolution over time of different variables that the researcher can personalize and adapt to their analysis. The development of a customized methodology, incorporating the time-lapse technique for practical applications, is the main contribution of this research, since to our best understanding, there is almost no research on this topic, and no study that examines the retail sector.

One of the most common problems that researchers face is the difficulty in finding available data, and on numerous occasions, the high cost of said data. In this article, we present a proposed methodology for obtaining spatio-temporal data through GSV as applied to commercial properties. New data that, when analyzed in combination with other methodologies, should broaden research horizons.

The data related to zoned commercial establishments aids the decision making process with regards to choosing the optimal location, competition studies, commercial gentrification movements or real estate investments, among others.

One of the advantages of the methodology applied to the study of commercial premises is that it allows the economic data of the establishments, which is easily identified (price of the land, rentals, turnover…), to be combined with other qualitative data (color of the facade, proximity to other establishments or width of sidewalk).

The primary data is a result of the direct observations of the researcher of the environment, and unusual in terms of research methodology, for different periods.

The data methodology shown allows the researcher the freedom to choose the desired time periods, and facilitates spatial autonomy, since it covers almost all of the urban centers.

As previously mentioned, GSV is a free tool, and consequently, the data preparation is free and remains in the hands of the researcher who can thus adapt their workload.

In addition to the obvious lines of research related to urban planning and construction, the possibilities offered for research are vast. As a guide, and without implying an exhaustive list of options, some possible uses in different areas of knowledge could be: archeology, to analyze the deterioration of buildings or exploitation of heritage; in health sciences in studies of different diseases and their relationship with neighborhoods or residential areas; on depopulation and its effects on rural municipalities; analysis of the consequences of climate change or even to compare some of the effects of the most recent pandemics in certain geographical areas.

As limiting factors of this tool, we must point out that GSV shows images of reality at a given moment, and sometimes it would be advisable to have shorter periods than are currently available. Moreover, the quality of the image may not be optimal and sometimes obstacles appear that prevent an adequate analysis.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks

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Abstract: The recovery of a built heritage and specifically of singular buildings is a key aspect of local development. The aim of this study was to understand the influence of these regenerations on their environment by transforming adjacent businesses and initiating parallel processes of gentrification and local development. The renewed attraction of these new businesses to the area can result in increased employment and production. The methodology used was based on self-organizing maps of neural networks with matrix architecture and competitive learning. Through the analysis of neural networks, we were able to identify common relationships and behaviors in commercial properties which are adjacent to singular buildings and that share common patterns and characteristics or attributes. The singular buildings analyzed are located along the Spanish Mediterranean coast in the cities of Almería, Barcelona, and Valencia. The results obtained were based on the following hypotheses: occupancy model and the classification based on total occupancy, total variation in occupancy, and the most common types of usage of a given ground floor commercial property. Among the conclusions, we highlight the existence of commercial premises that display anti-cyclical economic behavior and the presence of commercial premises considered to be "unfortunate" or with low potential.

Keywords: Google Street View; singular building; neural networks; urban revitalization

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1. Introduction

The development of an architectural element is usually based on public planning aimed at preserving and bringing citizens closer to the restored element, but in a parallel and inherent way, it can also become the epicenter of a series of economic and social activities. That a property influences its environment in the social or economic field is clear, but the extent to which the rehabilitation of a building generates synergies capable of boosting local development or gentrification processes is not so obvious.

Local development and gentrification have been studied separately as almost antagonistic processes. Local development is based on the continuous improvement of available resources and particularly of natural resources and of historical and cultural heritage buildings, because this can contribute to the area having a greater competitive advantage and the well-being of the population [1] by enabling the establishment of new businesses and jobs and, ultimately, a social transformation. Gentrification processes, in contrast, tend to focus on the expulsion or exit of social classes with fewer resources from a neighborhood due to the increase in rents and changes in the commercial structure and, ultimately, a general increase in prices. Both of these processes have a common factor, namely, local economic and social transformation.

The success of the rehabilitation of a property from the local and social economic standpoint lies in the participation of citizens and public and private entities that, within

their scope of action, can make decisions about their own assets that have a direct impact on their surroundings [2].

The aim of this article is to study the influence that the recovery of buildings can exert on their surroundings, transforming adjacent businesses and initiating parallel processes of gentrification and local development. A correct interpretation of the relationship between heritage, society, and business is one of the challenges that urban recovery policy must overcome and it is thus necessary to understand the mechanisms that lead to local economic development associated with unique architectural elements. Within the framework of the research that supports this article, economic and architectural analysis of source documents prepared by local administrations was used. This is in addition to sampling as a result of direct observation.

To study these processes, the article is structured as follows: first, the theoretical debate between local development and gentrification is described. Secondly, an analysis is carried out regarding the transformation of the adjacent area following the rehabilitation of a singular building located in one of three cities located on the Spanish Mediterranean coast (Barcelona, Valencia, and Almeria). Finally, the conclusions and limitations of the investigation are presented.

2. State of the Art: Gentrification and Local Development

The literature which studies gentrification and local development as part of the same process is not abundant because these processes have generally been investigated as opposite sides of the same coin. Studies on gentrification processes have generally considered them to be harmful or contain detrimental elements that cause loss of social identity and commercial transformation in a society primarily based on economic factors. In contrast, studies on local development are usually associated with the gradual enhancement of material or intangible elements of an area which improve the quality of life of its residents.

The term gentrification, coined in 1964 by Ruth Glass [3] after observing changes in the social structure and the real estate market of London when the working classes were displaced by a thriving middle class, has since been used to refer to movements linked to its economic development that provoke the entry and exit of different populations in neighborhoods. Thus, gentrification processes are considered from two perspectives—the social and the economic.

A notable part of the literature on gentrification has considered that social and cultural patterns form the foundation of changes in neighborhoods that are not merely economic [4–7]. However, a significant number of researchers have argued that gentrification is a capital movement, highlighting the economic and commercial transformation of neighborhoods and cities [8–10].

Although the gentrification of a neighborhood can be a vital tool for urban renewal and can create opportunities by changing market forces through the establishment of new businesses and increasing the sales in existing businesses [11,12], as previously mentioned, most authors highlight the undesirable consequences of the process, such as unemployment or the increase in rental prices for ethnic and low-income minorities living in high-density neighborhoods [13,14]. However, it is important not to confuse gentrification with speculation, because whether or not there is a direct relationship between these terms remains controversial [3,15].

In contrast, local development is understood to be a set of ground-up actions from the area itself that promote socio-economic development [1,16], improve incomes, and increase employment opportunities and the quality of life of the inhabitants [17]. It also encompasses not only a chain of economic factors that influence the prosperity of a certain area, but also a series of geophysical, social, and economic characteristics that create a certain "breeding ground" that facilitates the proliferation of activities that result in the well-being of an area [18,19].

Local economic development strategies [5,20] envisage the geographical area, not as a simple space or a mere functional support, but as an agent of social transformation, where

the socially organized territory and its social, cultural, and historical features are also very important aspects.

The fact that development experiences in similar environments can produce totally different results shows the difficulty of finding a common thread in the activities that promote local development. Moreover, economic growth in areas, which in principle are not developed [21,22], can lead to optimal local development while at the same time be considered a clear failure in terms of the sustainable development model of that same region. Thus, development strategy plans must consider economic and social dimensions to obtain satisfactory results [23,24].

The above notwithstanding, even when the population enjoys a favorable geographical enclave, adequate raw materials, and sufficient institutional support, if the entrepreneurial population does not trust the generation of their own employment and the creation of companies that create opportunities for the future, all efforts will be in vain. This will result in businesses being forced to transfer to other locations as part of the classic gentrification process. The actions carried out on a property, from a holistic point of view, can affect the quality of life of the population and transform the local production system. Accordingly, entrepreneurial initiatives are stimulated as a result of the improvement in the quality of the basic infrastructures, thus signaling the beginning of a virtuous (or vicious) circle of development.

Gentrification and local development share common features because both are processes of social transformation which can lead to substantial improvements in the commercial fabric of an area. These processes can arise spontaneously, although they could also be planned. The biggest difference between the two processes is subjective. In contrast to local development initiatives, gentrification does not consider the settlement of the population in the territory, nor is their participation in the transformative process considered to be a priority.

From the perspective of the rehabilitation or enhancement of heritage structures, it is generally accepted that urban or local development needs to be accompanied by a program of actions and investments, agreed upon between the different administrations, in order to revitalize the historic space and a general development of the local area.

This multidimensional approach to the city brings together socio-spatial and political dimensions [25] and requires both intervention and recovery of the existing structures, in addition to social and political elements [26] (e.g., the quality of housing, the environment, or the real needs of the affected population).

Authors such as Friedmann [27], Campbell [28], Leigh and Blakely [29] and Jewson and MacGregor [30], among others, stress that, together with physical factors, the progress obtained by the exploitation of a resource is linked to the political attitude of local authorities because private activity is often attracted by the granting of subsidies and public aid.

Property itself is an endogenous resource available to local development, which itself promotes an economically attractive environment. Microenterprises housed within the renovated building are linked to the pre-existing commercial fabric of local businesses [31], encouraging change, innovation, and creative destruction.

One of the problems with urban rehabilitations is that the revaluation that an area experiences after a public investment usually has an economic impact by increasing the price of homes and rental properties [32], producing the expulsion or displacement of local businesses and the original resident population [33]. These businesses are later replaced by others with greater purchasing power that do not have roots in the area, endangering the intrinsic social networks in the neighborhood or locality, and generating a class conflict associated with urban transformation with an imposition of the dominant strata of social and market rules, that is, a negative gentrifying process. However, much more important than the destruction of jobs in obsolete activities, it is important to replace those activities with new ones, of higher quality and productive differentiation, which are more environmentally sustainable [34]; in short, a positive gentrification process [31,35].

When we add to all the above the phenomenon of the touristification of urban spaces [36], changes in the dynamics of neighborhoods occur which can interfere in the relationships of social actors, producing new forms of sociability. Thus, associated gentrification should be taken into account as a side effect characterized by uncertain results [37]. The key to the success of tourism as a sustainable activity from a social point of view does not lie in the transformation of society and local culture in favor of tourism development, but rather, the activity must be integrated into existing social and productive schema.

Urban recovery from the functional perspective needs clearly defined urban projects and an integral vision of the heritage system with business activity as their main ally. Local development policies that are committed to a potentiality based on architectural projects and the development of services and industries for urban revitalization [31] can engender entrepreneurial movements related to tourism-cultural sectors.

The rehabilitation of an architectural heritage structure may be the basis on which business or tourism activities are developed [38], but by itself does not constitute a process of business concentration or a gentrifying tourist attraction.

3. The Use of Neural Computing Techniques in the Scientific Literature

The use of neural computing techniques is not new in the scientific literature. The work in the fields of classification, approximation of functions, and identification of notable elements within images and complex data sets has become a distinctive feature of research in recent years. Since the 1990s, the use of these techniques has been extended to all fields of science and technology.

Neural networks are classification systems based on models in which the distribution of the sample is unknown and in which there is little, changing or, in some cases, contradictory knowledge (Figure 1). Its architecture is based on the available knowledge of the nervous system of animals, mathematical models related to the approximation of functions, statistics and information theory, and to the field of physics and statistical mechanics.

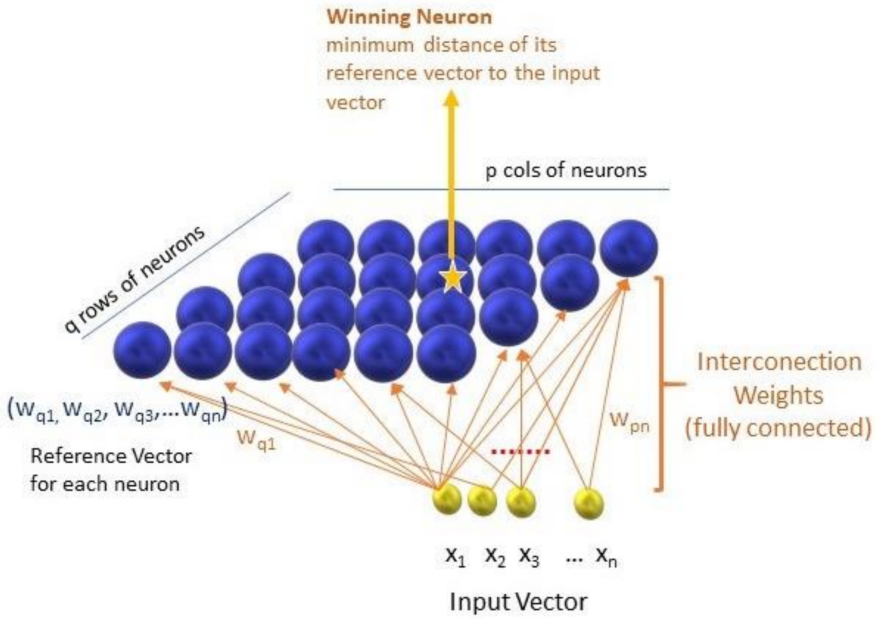

Figure 1. Process of neuronal connections. Source: Own elaboration.

A relevant feature of these types of tools is their ability to generalize and find the underlying representation in the sample of the content domain being studied.

Current data interpretation and analysis systems use a wide range of neural network architectures.

Self-organizing maps are neural networks with matrix architecture and competitive learning. The structure of this classification technique [39,40] has been developed from

the perceptual model of vision in humans and has proven to be a powerful classification and clustering tool when there is no knowledge of the distribution of probability of the sample to be classified even when the application domain uses a different metric from the Euclidean following the schema of Martínez et al. [41].

In an attempt to simulate the nervous structure of the retina of a mammal, a self-organizing map is formed by a set of elements, also referred to analogously as neurons, which are spatially arranged in a mesh and which exhibit, among others features, the property of locality, wherein every element of the mesh (neuron) has neighboring elements with which it shares common characteristics regarding how to act when an entry occurs. Each of these neurons has an internal structure (called a reference vector) with a dimension and structure identical to that of the input samples.

In a self-organizing map, for a given input, only one of these neurons can be activated. This is achieved by adapting their internal structure by means of an iterative training procedure, whereby each neuron, when presented with an input that has a similar internal structure, adapts its own structure to become even more similar, and modifies the structure of neighboring neurons to distance them from the activated neuron.

This process increases the probability that, for a given input, it is only that neuron that is activated, and not those in its vicinity.

It has also been shown to be convergent to a solution when the number of iterations is "high enough" to stabilize the modifications in the network.

The training of a self-organizing map is an iterative process in which a set of training samples are presented successively to the network, and, for each of these, the network reacts by adapting the internal structure of the element to one that more closely resembles the input while at the same time changing the internal structure of other elements in its vicinity in order to prevent them from being activated by said input.

This process is repeated for all the samples in a set, and a sufficient number of times so that the variations in the internal structure of the network elements are not significant. At that time, a state of equilibrium will have been reached and the network is ready to go into the operational phase.

Thus, it could be said that this iterative process is convergent and generates a consistent classification related to the distances of the vectors involved in the training.

4. Materials and Methods

Self-organizing maps have been applied extensively in the field of science and technology. They have been used by Hung and Tsai [42], Froement et al. [43], and Munoz [44] for the analysis of economic models; Hewitson and Grane [45] and Song et al. [46] in climatology studies; and Liu and Bai [47] for the analysis of problems in engineering and systems theory.

Our initial hypothesis is that when the rehabilitation of a singular building is carried out in an urban center, a double process is generated: first, local development as a form of sustainable economic impulse, and second, commercial gentrification due to renewed business activity.

To verify the validity of the proposition, significant data on business activity has been observed and collected, including variations in the commercial premises, their refurbishments, the degree of occupancy, and the average price of homes in the area of influence of the property.

4.1. Selection of Singular Buildings

The selection of properties (Table 1) that serves as the basis of this study took into account the following parameters:

- Location: To attain a more homogenized study, where the externalities could be similar, the selection was limited to Spanish provincial capitals located on the Mediterranean coast. The aim is that elements such as tourist pressure, meteorology, or social condi-

tions should not distort the research. In addition, the properties are all located in or near the city center.

- Demography: The three cities were chosen for their representativeness in terms of their population. Barcelona widely exceeds one million residents, whereas Valencia is slightly less than half a million. Almeria, meanwhile, represents the "middle" city [48]. Results were extrapolated to populations regardless of their size.
- Type of property: The buildings were constructed at the beginning of the 20th century and were totally or partially restored before 2013. The choice of this year is based on the fact that it is considered the final year of the economic crisis during the study period (2008–2018). In addition, buildings were sought which shared similar artistic and architectural styles.

Table 1. Factsheet about the singular buildings studied.

Name of Building		**Casa Fuster**	
Year of Construction	1910	Year of renovation	2004 and 2017
City	Barcelona	Population	1,620,809
Distance to City center	3 km	Current Use	Hotel
Other notable characteristics:			
- Facade restored in 2017.			
- Located in the Paseo de Gracia in Barcelona.			
- Luxury Hotel.			
Name of Building		**Marqués del Turia 12**	
Year of Construction	1920	Year of renovation	2012
City	Valencia	Population	787,808
Distance to City center	1 km	Current Use	Commercial and office space
Other notable characteristics:			
- Located in Gran Vía Marques del Turia, part of the Valencia's urban expansion plan of 1884.			
Name of Building		**Casa de las Mariposas**	
Year of Construction	1912	Year of renovation	2010
City	Almería	Population	195,389
Distance to City center	0 m.	Current Use	Corporate
Other notable characteristics:			
- Corporate headquarters of a financial entity.			
- Frequently used by the municipal council for public events.			

Source: Own compilation. Census data from INE.

4.2. Data Acquisition and Geographic Radius of the Study

As with the selection of buildings, information on the average price of rent and sale of commercial premises and flats in the area was prepared according to the data provided by companies specialized in property valuation and real estate web portals.

The control area was determined to be a radius of 150 m from the rehabilitated property. This distance was based on the investigations of Tan and Tan [49], Waddell [50], Nikilaos, Dimitra and Agapi [51], and Ray [52] that follow this same longitudinal criterion according to visual, transport, and visual impact elements.

Data on the activities of commercial premises at street level, including changes in occupancy, were obtained by means of direct examination using Google Street View®. This program allows us to transport ourselves in situ to a location in 2008 and check its real evolution (in images) and mechanize the search in two-year periods until 2018.

A total of 565 business premises were analyzed with the following distribution: 198 are located in Barcelona, 35% of the total sample (Figure 2); 174 are located in Valencia, which accounts for 30% (Figure 3); 138 in Almería, 25% (Figure 4); and 55 in a neutral area that we

named "Dummie" and accounts for 10% of the properties studied (Figure 5). This dummy area serves as a control and verification parameter of the results obtained.

Figure 2. Aerial view of the area around Casa Fuster in Barcelona. Source: Own elaboration.

Figure 3. Aerial view of the area around Gran Vía Marqués del Turia 12, Valencia. Source: Own elaboration.

Each of the 565 sample items was designated to 35 variables related to the type of occupation in each year, the sum of the years occupied, the variation in occupation, the size of said variation, and the type of occupation during the years studied (up to 131 different types of use after simplifying the type of occupation to eliminate spurious differences related to the name of the activity). The variables also included a time series, from 2008 to 2018 (11 years), and variables related to the street environment: type of road (whether open to vehicle traffic or pedestrian only); number of lanes of road traffic (one to four lanes); presence of parking spaces in front of the premises (yes or no); sidewalk dimension (narrow, less than 2 m; normal, between 2 and 5 m; wide, more than 5 m; and squares, open spaces).

Figure 4. Aerial view of the area around Casa de las Mariposas in Almería. Source: Own elaboration.

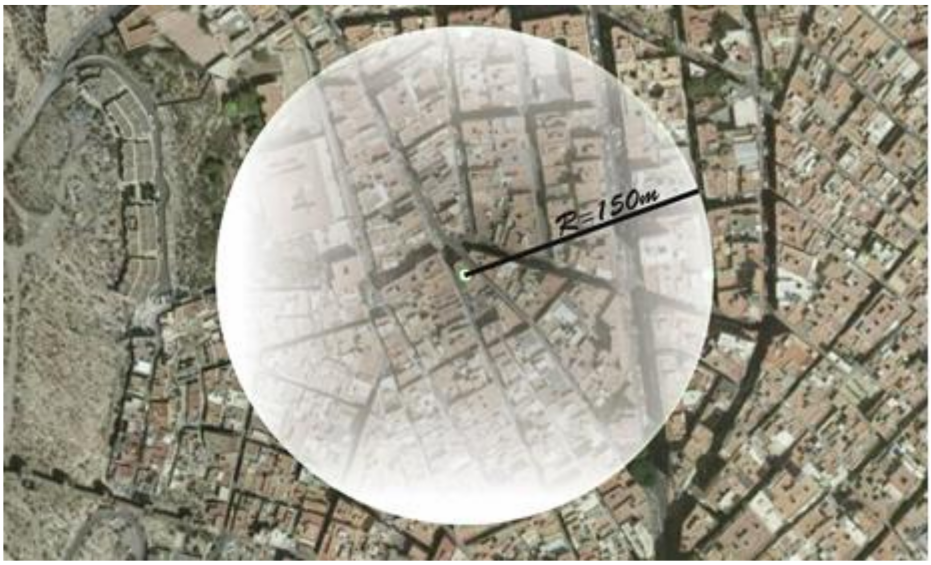

Figure 5. Aerial view of the control area in Almería. Source: Own elaboration.

With regards to the variable related to the types of occupancy of the commercial premises, a prior processing step was carried out which consisted of:

- Re-labeling of the type of use in each of the commercial premises. A numerical value was given to each type of use to facilitate further processing.
- Re-labeling using a numerical value to reflect changes in occupancy over time, again, necessary for further processing.
- Calculation of the variation in the occupancy of the commercial premises over time. Each change of use, from one year to another, is labeled with a 1.
- Sum of the total occupancy of each of the commercial premises, throughout the period of time studied.
- Sum of the total variation in both use and occupancy of the commercial premises throughout the period of time studied.
- Calculation of the mode of use, which takes into account both occupancy and use, of each of the commercial premises, for a specified time.

Once the aforementioned information was attained we proceeded to classify the premises using self-organizing maps with relevance to the following working hypotheses:

Hypothesis 1 (H1). *The level of occupancy is significant. A classification process will be developed using re-labeled occupancy data.*

Hypothesis 2 (H2). *The level of variation is significant. A classification system of similar commercial premises is developed.*

Hypothesis 3 (H3). *The type of occupancy is significant per se.*

Hypothesis 4 (H4). *The sum of the variation, the occupancy and the mode of occupancy, taking into account occupancy and use of the premises, are significant.*

The following procedure was carried out for all four working hypotheses:

1. To train the self-organizing map, we chose a set of characteristics from all those obtained in the analysis performed.
2. Using MATLAB as a tool, and its Neural Networks Toolbox, we carried out a series of experiments based on the number of items that each sample represents. We also needed a map that could explicitly represent the sample groupings of the impact maps. Given these assumptions, we used several structures (8×8, 10×10, and 12×12), although there was no obvious improvement in the representation beyond the 64 elements in the network or if a longer execution time was used to carry out the training. In addition, a hexagonal neighborhood model was used to improve the procedure for calculating the neighborhood between elements of the network, and carried out the training looking for stability in the operation of the network. This stability was achieved when the variation of the internal structure of the network elements was, on average, less than 0.1. After some tests with 1000, 2000, and 5000 iterations, we opted for the third option (5000) to carry out the training in order to ensure the stability of the network.

The training process consisted of two phases: a rapid phase, in which significant variation of the internal structure of the network elements was permitted, and a precision stage, in which there was very little variation in the internal structure of the network during the training process. To this end, 90% of the training process was carried out in the first stage and 10% in the second.

We created a self-organizing map with 64 neurons arranged in an 8×8 square mesh. In these, the neighborhood was measured using a Euclidean distance measure. We took the set of samples from each city and applied the training procedure 5000 times to stabilize the behavior of the network (that of one of the cities being studied, or failing that, the samples from Almería in which there was no proof of rehabilitation/construction of singular buildings). This training method was carried out to address the network with unknown data from other cities and to analyze their behavior.

3. Visualization of the results using impact maps. An impact map is a representation of how the self-organizing map is activated when presented with a set of samples. Each input generates an activation, and the count of all of them, by map element, and their representation using color indices, is a very useful tool to determine how the network behaves given a set of samples. Each element of the network is activated in one or more samples that have similar statistical characteristics. In addition to these maps, we used a distance map, indicating the Euclidean distance for each element of the network from its neighbors. These maps tell us how "far" from their neighbors each element has become after the training process. In this way we can observe the level of separation between the sample subgroups generated by the map. Both maps are invaluable tools for studying sample clustering generated by the neural network.

One common mistake that can often occur is when the distance between the different neurons is not taken into account when carrying out the analysis of the classification in the impact maps. As the accuracy of the classification is measured by the distance maps

between neurons in addition to the impact maps, it makes little sense to measure impact without also taking into account the second measurement regarding distance.

4. Detection of "distinctive" activation points in the self-organizing maps and characteristics of the locations of the commercial premises which could cause the activations on the maps. The distinctive activation points are those neurons that have been activated by a subgroup of samples, that appear in all cities with urban development and that do not appear in the impact map of the set of control samples.
5. Analysis of the characteristics or attributes of these commercial premises.

Not all hypotheses offered significant results. We will develop, therefore, those hypotheses that present relevant results, that is, Hypotheses 1 and 4.

5. Results

5.1. Hypothesis 1. Occupancy Model

For this work, we selected 11 characteristics corresponding to the representation of the occupation of each of the premises, throughout the period of time studied. Each sample, therefore, was characterized by a vector with a dimension of 11. The data set was used as a training set for a self-organizing network with the characteristics indicated above. After applying the training procedure to the data from one city, the data from the rest of the cities were used as test data of the trained network to observe how the network activations are arranged in each city. The impact maps of this analysis are shown in Figure 6.

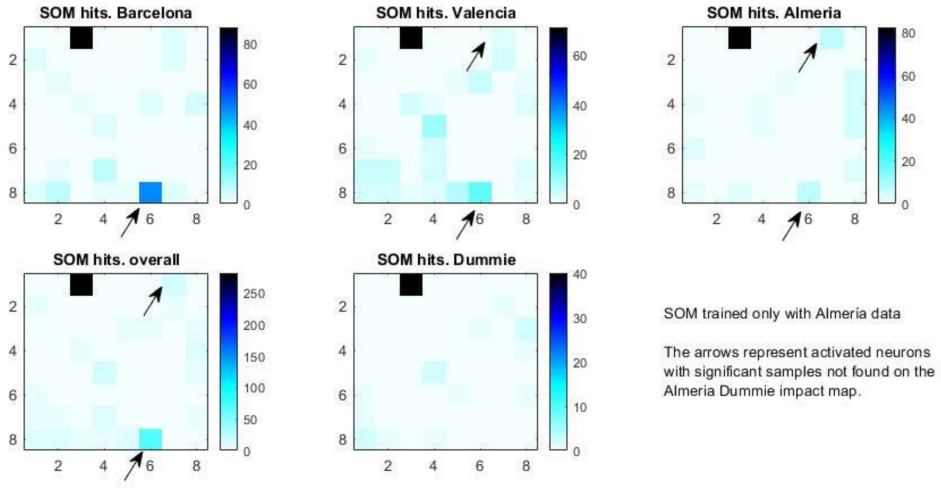

Figure 6. Impact maps of data collected in each city, and of non-significant data (Almería "Dummie").

The impact maps show activated groups in certain neurons that are characteristic of the samples in which a singular building has been rehabilitated. The distance grows significantly around the reference neuron, indicating a very different type of model from the rest of the samples. In order to understand the name of each element in the network, these are numbered from 1 to 64, arranged in 8 columns by 8 rows. The first element in the network (please note that the term neuron and network element are used interchangeably to refer to each of the elements that make up the self-organizing map) is in the upper left corner and the last element in the lower right corner.

The activation of element 48 in the network represents 12.3% of the sample, a significant number of commercial premises (70). Of these properties, 47 are located in the city of Barcelona, 16 in Valencia, and seven in Almería. These properties share similar patterns and sequences of occupancy.

In the triennium periods comprising 2009–2011 and 2015–2017, the commercial premises remained closed. With regards to the period between 2012 and 2014, there was a single opening which closed the following year.

In contrast, the activation of the network element 49 (Figure 7) corresponds to 14 commercial premises (2.4%), of which four are located in Barcelona, three in Valencia, and another seven in Almería. These premises share a common attribute in that they have always housed some type of business activity. However, between 2013 and 2014 the properties changed their business activity, closing and then reopening in the same year.

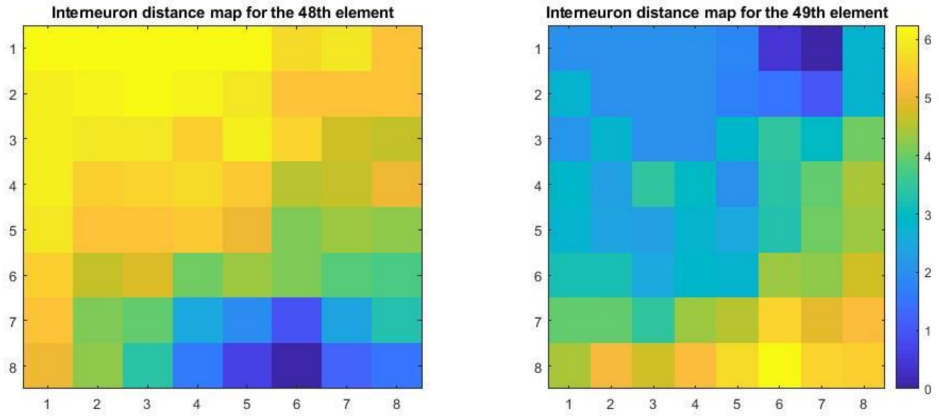

Figure 7. Distance maps for network elements 48 and 49.

The distance between neurons indicates the difference between the elements that activate that neuron and the rest of the elements of the problem area. This measure serves to quantify the difference between one set of data compared to the remaining sets. Thus, we can see that elements 48 and 49 of the network are relatively close together and that both are quite separated from the rest of the data groupings (which occur on the opposite part of the map).

5.2. Hypothesis 4: Classification Based on Total Occupancy, Total Variation in Occupancy and Most Common Type of Use of a Given Location

For this hypothesis, we analyzed the premises being studied with reference to the data on total occupation, total variation in use, and type of occupation. In this case, the dimension of the input vector is 3.

We then proceeded with the training of the neural network with the same characteristics as in the previous case (Figure 6). In this instance, the trained neural network generated the impact maps shown in Figure 8.

As in the previous case, a classification system was developed based exclusively on city data in order to extrapolate this classification to unknown data (the remaining cities). The results show impact groups related to the commercial properties being studied but that do not appear in the "Dummie" sample.

In relation to the remaining elements and with a view to understanding how the distance between these elements affects other clusters, a study of the distances between the neurons that group those distinctive impacts was carried out. The following images (Figure 9) depict the spacings (interdistance) between elements as distinctive impacts.

The calculated distances of neurons with distinctive impacts can be observed. In the case of elements 41, 42, and 50 of the network we find that the distance maps are very similar and the distances between them are small. This confirms that the three groups pertain to commercial premises with some common characteristics. It also confirms that the activation of one of these three neurons is the result of the existence of secondary characteristics. In the case of element 64, the distance is exclusively linked with the neurons in the opposite corner, which indicates that the dominant characteristic of the properties that activate this element is also dominant in most of the other properties that activate the upper left corner of the map.

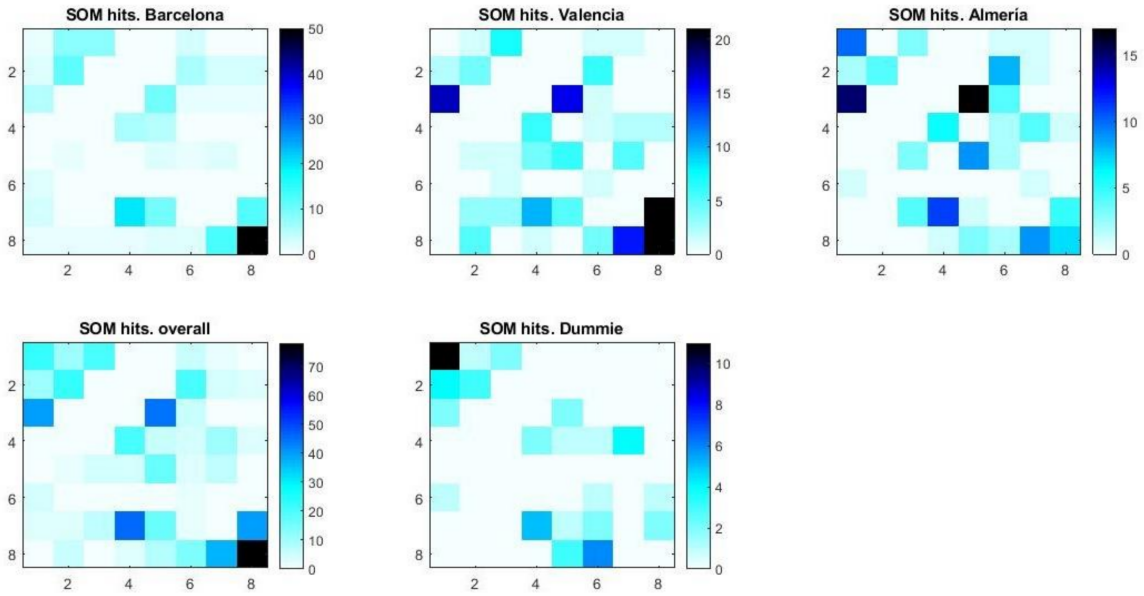

Figure 8. Impact maps of the trained neural network with information on total occupation, level of variation, and mode of use.

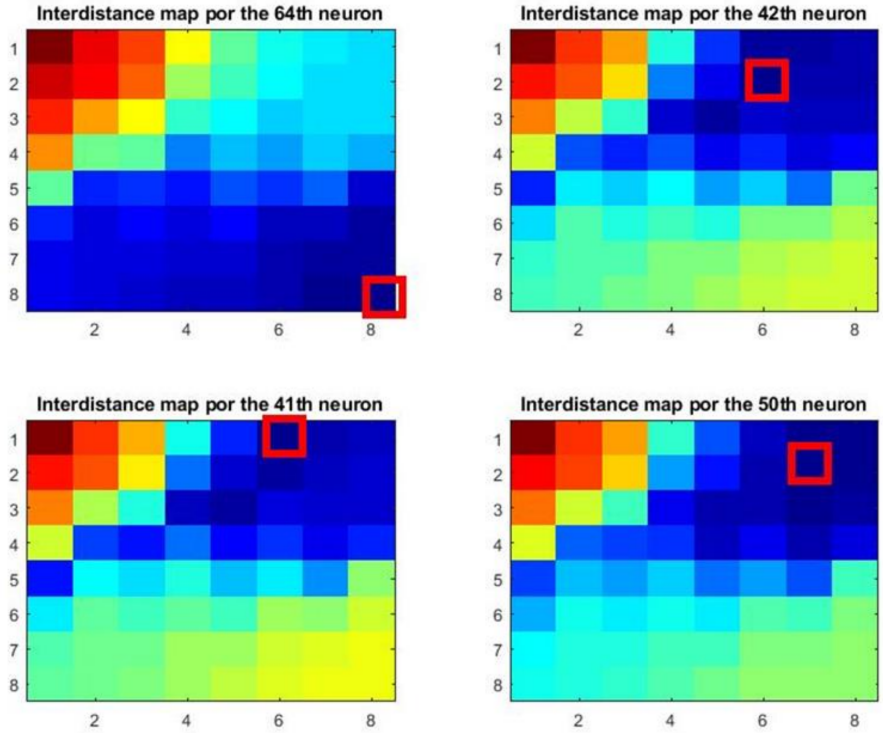

Figure 9. Distance maps of network elements 41, 42, 50 and 64.

Of the total 565 commercial properties, elements 41 and 50 correspond to five and four commercial properties, respectively. As this represents less than 1% of the total sample, these properties are considered to be non-significant. Element 42, in contrast, although corresponding to a total of 20 commercial properties, displays characteristics which are related to the business activity carried out in these premises, in this case, fashion retail. However, because it does not represent a high percentage of the sample it does not lend itself to establishing a hypothesis.

However, the behavior of network element 64 produced interesting results because 78 of the 565 commercial properties (13.8%) were activated with 50 premises located in

Barcelona, 21 in Valencia, and seven in Almería. Their behavior is similar, in terms of occupancy levels during the period being studied, with 64 of these 78 (82%) never having had any activity at all, while seven properties (9%) opened and closed in the same year. The remaining commercial properties opened in 2018. In confirmation of this result, it can be seen that only three out of the 565 properties have never opened and are not related to element 64, but rather belong to the control sample ("Dummie").

6. Conclusions

Local development and gentrification processes are linked and can be triggered by the actions, sometimes unintentional, of either public or private actors. Our study used a primary data collection methodology with Google Street View, which was later analyzed through neural networks, and verified that real estate undertakings engender similar economic patterns of behavior as in the other businesses in the areas of influence.

An understanding of these patterns can lead to more effective policies to revitalize city centers, tackle depopulation of rural towns or improve measures to boost local entrepreneurship and the commercial fabric of an area. As a result of the analysis via neural networks we have been able to find properties with common relationships and behaviors, and that share similar patterns and characteristics in the commercial premises adjacent to singular buildings.

The first conclusion is related to the existence of premises that behave in an anti-cyclical economic manner.

The commercial attractiveness of an area led to new businesses opening during the financial crisis (2012–2014) (element 48) in commercial premises that had previously not housed any type of business activity. That is, the properties had remained closed during the 2009–2011 and 2015–2017 trienniums, but then underwent both an opening and closing of a business between 2012–2014.

Commercial properties displaying such anti-cyclical behaviors are those that commenced their activity during the period of greatest economic decline. Paradoxically, this singular opening of premises also entails an almost immediate closure of the same. Thus, it can be deduced that the attractiveness of an area was a feature that appealed to businesses, making entrepreneurs think that, due to the particular location of these properties, they could achieve greater success. However, this attractiveness is not enough to save the business from the influence of other external factors (inadequacy of the property for a given activity, entrepreneurial inexperience, lack of foresight…).

This proposition is confirmed by the opposite behavior displayed by network element 49, which during the same period, showed commercial properties that enjoyed a constant and permanent business activity, closing and then reopening with a different business activity. This fact leads us to think that there are some premises that, regardless of the economic cycle, are always able to maintain an optimal level of business occupancy.

The second conclusion is related to the presence of low potential or "unfortunate" commercial properties.

Commercial premises with low occupancy levels, do not usually respond positively when a new business opens. This would seem to confirm the popular belief that there are unfortunate properties that are "jinxed", where the businesses that are housed within them do not thrive. The activation of network element 64, in terms of occupancy, variation, and use of the commercial premises shows that those properties that remain closed for a long period tend to be occupied for less than a year. This conclusion is also confirmed by the control sample ("Dummie").

Although it was not possible to directly verify the influence of a singular property on the commercial fabric of the area, it seems clear that the commercial behaviors in terms of occupancy and activity are similar. Therefore, this study will be useful for future research as an example of using this new methodology.

This study may be of special interest to investors and entrepreneurs, because it opens doors to future research areas that that could effectively identify real estate with business potential.

7. Limitations and Future Lines of Research

While we recognize that there are limitations in the investigation, it is hoped that these do not significantly alter the results obtained. For example, the data collection was limited to companies that have commercial premises located at street level and does not take into account businesses located on other floors of the buildings in the areas of influence. In addition, the temporality of the photos sourced from Google Street View does not provide a homogeneous view of all the streets studied.

Economic development and social integration resulting from the rehabilitation of buildings in urban centers depends on several factors, such as the alteration or continuity of use of the entire building. Nevertheless, this point was not taken into account in this article. This question could be addressed in future research.

As another possible future line of research, we propose the inclusion of sociological factors, which could take into account the characteristics of the social fabric and verify their influence on the survival of retail trade and on local development. In the same sense, it would be worth studying whether the influence of the gentrifying process can alleviate the urban exodus from the city center to the suburbs or other population movements.

Furthermore, it would be interesting to apply the methodology to the study of commercial trends and the evolution of the real estate market in areas of urban development or the impact of commercially motivated urban revitalization on specific urban spaces.

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RESEARCH Open Access

The Circular Economy and retail: using Deep Learning to predict business survival

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Abstract

Background: The Circular Economy system can improve the product cycle and changes the system and mentality, both for production and the consumer and has become a significant alternative to the classic economic model. The retail sector has also started to advance along these lines. Following an analysis of the state of the art of the Circular Economy and retailing, using bibliometric techniques, our research focuses on understanding if the relationship between circularity and retailing can help us determine a business' survivability and resilience. To this end, data pertaining to 658 commercial premises from four cities were studied over a period of 11 years. A Deep Learning technique is applied using Long Short-Term Memory to determine if there is a relationship between the resistance of the selected commercial premises, their status in previous periods of time, the type of business activity, and their classification in the Circular Economy plane.

Results: The system predicts, on the set of tests, with a 93.17% accuracy, the survival of a commercial premises based on the activity, and circularity information before 2012. The results of the training also show very significant precision values of the order of 94.15% with data from the post-depression period.

Conclusions: The results show that businesses with activities related to the Circular Economy are more likely to survive over extended periods of time.

Keywords: Circular Economy, Retailing, Business survival, Machine learning, Deep Learning

Introduction

The concept of the Circular Economy is gaining relevance in political and business thinking in developing strategies that support a transition to a more sustainable future [15]. A Circular Economy describes an economic system based on business models that replace the "end-of-life" concept [16] by reducing, reusing, recycling, and recovering materials in production/distribution and consumption processes. The Circular Economy can operate at the micro-level (products, companies, consumers), meso-level (eco-industrial parks), and macro-level (city, region, nation, and beyond). It aims to accomplish sustainable development, which implies creating environmental quality, economic prosperity, and social equity for current and future generations.

The Circular Economy system can improve the product cycle and changes the system and mentality for both production and the consumer [10, 28].

In line with these concepts, the principles and actions of circularity have been categorized and classified. With regard to the different categories, the strategies, from lowest to highest level of circularity, have been taken into account [29, 30, 44], where R9 corresponds to the strategy with the lowest level of circularity and R1 pertains to the highest level of circularity. In turn, these strategies are framed in three groups (Table 1).

Research on the Circular Economy has evolved, starting from a technical perspective, where resource efficiency and environmental impact were valued, adding

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Table 1 Classification of R principles. Source: Own compilation based on [44]

Increasing circularity	
Smarter product manufacture and use	
R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
R1 Rethink	Make product use more intensive (e.g., by sharing product)
R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
Extend the lifespan of a product and its parts	
R3 Reuse	Reuse by another consumer of a discarded product, which is still in good condition and fulfills its original function
R4 Repair	Repair and maintenance of defective product so it can be used with its original function
R5 Refurbish	Restore an old product and bring it up to date
R6 Re-manufacture	Use parts of a discarded product in a new product with the same function
R7 Repurpose	Process materials to obtain the same (high grade) or lower (low grade) quality
Useful application of materials	
R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
R9 Recover	Incineration of material with energy recovery

other aspects, such as value chains and business models [24, 31].

In order to know the state of the art, bibliometric techniques have been used, searching for the terms "Circular Economy" and retail * in the Web of Science Core Collection. The search yielded 111 documents.

If the selection is further refined by type of document only to include articles published to the end of the first semester of 2021, we obtain 84 articles in 47 journals.

The main research area in which the articles are framed is Environmental Science Ecology (41), followed by Engineering (39), Science Technology other topics (28), while Business Economics is ranked fourth (23).

There are several common elements among the ten most cited articles (Table 2): All are published in a five-year range. In four of these, the central object studied is food and the use of its surplus in commercial establishments. For example, Borello et al. [5] experimented with evaluating the willingness of consumers to actively participate in closed circuits to reduce food waste through the active participation of all actors in the supply chain. Along the same lines, Mondejar et al. [23] addressed how marketing and sale strategies negatively influence the waste behavior of individuals, emphasizing the critical role retailers play in preventing the generation of food waste.

However, if we look at the 369 keywords that appear in these articles, although, as independent terms, sustainability and model are the most frequent, other keywords that are included in conjunction with others stand out. Examples of these are management, design, supply chain and waste, or a combination of them.

There are very few scientific publications related to such important elements of the Circular Economy in the retail sector, such as Communication, Transportation, Retail Reverse Logistics Operations, or Legislation and Regulation. Thus, there is a lack of a framework explaining how companies willing to become circular adapt their existing business model or create a new one [38].

Methodology

In developing this work, we use a Deep Learning technique to predict the resistance of the businesses located in the commercial premises under study based on their activity, their circularity rating, and the history of opening and closings that the premises have had over the selected periods.

We define the resistance of commercial premises and their associated businesses as the activity's survival in a given year. This survival is conditioned by many factors [35, 47]. However, our purpose is to study whether the activity and circularity information is sufficient to determine its resistance.

To this end, we have divided the prediction of the resistance of the premises into two periods: one related to the Great Depression of 2008, and the other to the post-depression period, from 2014 to 2018.

Obtaining data on the activities of commercial premises and economic activity and changes in them have been obtained from direct exploration through Google Street View®, following a methodology based on the collection of primary data [39]. By using this tool, it has been possible to obtain information from 2008 onwards and verify the actual evolution, in images, until 2018

Table 2 The Ten most cited articles that include the terms "Circular Economy" and "retail"

Title and authors	Year	Source	Citations
Consumers' perspective on Circular Economy strategy for reducing food waste *Borrello M, Caracciolo F, Lombardi A, Pascucci S, Cembalo L*	2017	Sustainability	83
From the table to waste: an exploratory study on behavior towards food waste of Spanish and Italian youths *Mondéjar-Jiménez JA, Ferrari G, Secondi L, Principato L*	2016	Journal of Cleaner Production	82
Food waste accounting along global and European food supply chains: state of the art and outlook *Corrado S, Sala S*	2018	Waste management	70
Developing sustainable business experimentation capability—a case study *Weissbrod I, Bocken NM*	2017	Journal of Cleaner Production	69
Tightening the loop on the Circular Economy: coupled distributed recycling and manufacturing with recyclebot and RepRap 3-D printing *Zhong S, Pearce JM*	2018	Resources Conservation and Recycling	54
On the design of closed-loop networks for product life cycle management: economic, environmental and geography considerations *Accorsi R, Manzini R, Pini C, Penazzi S*	2015	Journal of Transport Geography	37
Environmental sustainability of liquid food packaging: is there a gap between Danish consumers' perception and learnings from life cycle assessment? *Boesen S, Bey N, Niero M*	2019	Journal of Cleaner Production	36
Aligning retail reverse logistics practice with Circular Economy values: an exploratory framework *Bernon M, Tjahjono B, Ripanti EF*	2018	Production Planning and Control	36
Value creation from Circular Economy-led closed-loop supply chains: a case study of fast-moving consumer goods *Mishra JL, Hopkinson PG, Tidridge G*	2018	Production Planning and Control	32
Barriers and challenges to plastics valorization in the context of a Circular Economy: Case studies from Italy *Paletta A, Leal Filho W, Balogun AL, Foschi E, Bonoli A*	2019	Journal of Cleaner Production	26

(Table 3). Commercial areas in cities in the UK and Spain have been analyzed, resulting in a total of 658 data points: London (193), Barcelona (198), Valencia (174), and Almería (93).

This information is structured in a table that presents, for the study carried out in this paper, the format $(a_{yi}c_{yi}o_{yi}...a_{yk}c_{yk}o_{yk})$, where a is the activity of the premises, c is the circularity index, and o the occupation of said premises in the years $y_i...y_k$.

We evaluated the resistance of the commercial premises for the periods 2008 to 2011, in 2012, in 2014, and

Table 3 Detail of the data table, the data corresponding, by columns, to the information on Activity (Axxxx), Circularity Index (Cxxxx), and Occupation (OCxxxx): Open or closed

A2008	C2008	OC2008	A2009	C2009	OC2009	A2010	C2010	OC2010	A2011	C2011	OC2011	A2012	C2011	OC2012
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Service	NP	Open	Service	NP	Open	Service	NP	Open	Service	NP	Open	Service	NP	Open
Industry	R5	Open	Industry	R5	Open	Industry	R5	Open	Industry	R5	Open	Industry	R5	Open
Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Industry	R5	Open	Industry	R5	Open	Industry	R5	Open	Industry	R5	Open	Industry	R5	Open
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed
Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open	Retailing	R2	Open
Education	NP	Open	Education	NP	Open	Education	NP	Open	Education	NP	Open	Education	NP	Open
Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed	Closed	NP	Closed

for the period 2014 to 2017 to predict the survival of activity in 2018.

Deep Learning and its application to prediction

The development of neural networks during the 1980s and 90s significantly boosted the development of artificial intelligence and its applications in scientific and technical fields. The basic neural computation models consolidated their capacities in classification and prediction in problems considered too difficult due to the number, typology, sample characteristics, and quality of the data they worked with [40, 42].

The use of pre-trained neural networks and the appearance of new models has led to a considerable improvement in the classification, recognition, and prediction processes of complex phenomena.

Deep Learning arises from the need to improve recognition processes using pre-trained neural network models for more straightforward tasks [32]

This technique has been widely accepted after displacing other identification, classification, and data analysis tasks in image, video, and text problems. Deep Learning is widely used to analyze symbolic information (non-numerical) and in the processing of text messages [17, 19, 46].

LSTM (Long Short-Term Memory)

Many of the problems that we encounter in the real world are understandable if you consider the evolution of their states over time. Time series are a classic case of this type of problem. A similar problem is encountered when developing systems understand a text or the evolution of a specific market.

One of the main handicaps of neural networks, in their basic architecture, is their inability to deal efficiently with problems in which the state of a phenomenon depends on a succession of states in a previous time [25].

This deficiency has been resolved through recurrent neural networks. A recurrent neural network can be expressed as a function whose output depends on a set of inputs and on the output of that same network at a previous time.

An outline of a recurring network is displayed in Fig. 1.

Internally, the calculation of the output is given by the expression:

$$y(t) = \tanh\left(W \cdot \overline{[x(t), y[t-1]]} + \overline{b}\right),$$

where W is a matrix of weights that confers a weight to each input and output element in the previous instant, and that is subject to modification through training, $\overline{[x(t), y[t-1]]}$. It is the concatenation vector of the inputs and outputs at the previous instant, and $\overline{b}$ is a vector of fit values.

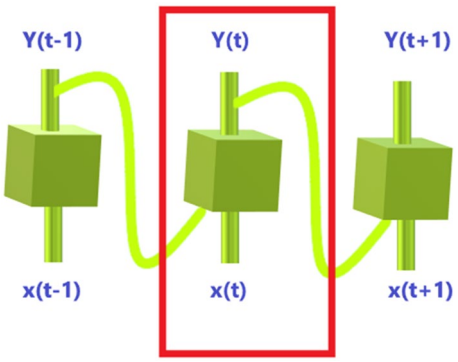

Fig. 1 Outline of a recurrent neural network. The input, x (t), and the output at an earlier time, y (t-1), feed the activation and output function of the neuron to produce the output y (t)

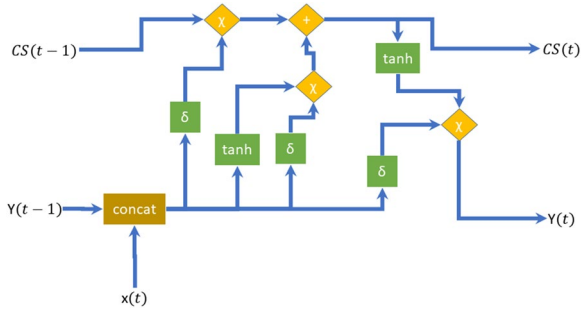

Fig. 2 Detail of one of the levels of an LSTM

One such type of network is LSTM. LSTM provides an answer to the problem of maintaining "long-term dependencies" that other models cannot. Indeed, LSTM solves this problem thanks to its structure. These networks were introduced by Ref. [14], although their redefinition and their applications have been developed in several studies [13, 32, 33].

An LSTM network has a structure like the one shown in Fig. 2:

LSTM has a much more complex internal structure for solving long-term dependencies than the conventional recurring network model. The network is made up of the following:

- *CS (t-1), CS (t)*: The state of the cell at each instant of time. It stores contextual information and long-term dependencies, which are disseminated through the LSTM network with minimal modifications at each instant of time.
- *X (t)*: Data entry at a particular moment.

- *Y (t-1), Y (t)*: Network outputs at given time instants, t-1 and t.
- *Concat*:$\overline{[x(t), y[t-1]]}$ Operation of the concatenation of the inputs with the output at a previous time, forming an input vector to the network at the current time.
- *δ:* Thresholding function of the input data, following a logistic function, to which weights are applied that can be modified by training.
- *Tanh*: Thresholding function between -1 and 1, following a hyperbolic tangent function, to which weights are applied that can be modified by training.
- $+$: Operation of the sum of the components of the input vectors to the function.
- X: Product operation, element by element (bitwise mult.) of the input vectors to the function.

As can be observed, the state of the network is transmitted from one processing unit to another, with local interaction that modifies it slightly. This signal allows us to maintain the long-term dependencies previously mentioned and, if related, connect the status of the premises in previous years with the current status.

LSTM is trained by modifying the weights that appear in the different operations, within each stage, following an iterative process of reducing the error committed at the output, with the validation set taken as a reference.

Results

We carried out an experiment using LSTM to determine if there is a relationship between the resistance of the commercial premises under study, their status in previous periods, the type of activity, and their rating in the Circular Economy plane. This study will describe the commercial premises using a series of labels that, as a phrase, will be interpreted by the classifier as a vector with non-numerical characteristics.

This method of working is novel and, we believe, convenient, for several reasons:

- The numerical encoding of the circularity and activity information is not natural to the problem. It induces false artificial relations of order between the different activities and the circularity classifications. Re-encodings performed on the LSTM network do not produce this effect.
- Traditional statistical techniques do not adequately solve the long-term dependency problems that occur in this problem. We want to determine whether or not that dependence is decisive for the survival of the business.
- The data may be biased from a statistical point of view, making it challenging to use traditional statistical techniques. This issue does not affect neural networks: they can learn from any data set, regardless of its sampling distribution.

Information on each of the premises includes their activity, R index, according to the Circular Economy, and status (open or closed) in each of the years being analyzed.

We use a pre-trained network architecture with an LSTM neural network as the main element, implemented using Matlab, to build a system that "predicts" the status of a commercial premises based on the information available about it in previous years.

As there are two periods, we constructed two predictors, one for each period.

The construction of the predictor requires the partition of each data set from the previous ones into two parts: a training set, in which the LSTM network algorithm will be used to build the predictor, and a data validation set, which will be used to test its accuracy.

The validation set follows the statistical rule of cross-validation, thus eliminating the possible adverse effects of a poor choice of the validation set that invalidates the results obtained.

We have used 70% of the total data set for the predictor construction process and 30% according to the cross-validation criteria to build the validation set, allowing us to test the result obtained.

The idea behind this experiment is that if a predictor can be built with sufficient precision, using the data referenced above, we can deduce that we have a strong dependence between these and the resistance level of a commercial premises over time. This dependence has been studied in the works of Ref. [12, 18, 48].

First experiment. Development of the LSTM predictor during the Great Depression of 2008

This experiment utilized data from 2008 to 2011, following the indicated formatted sequence $(a_{yi}c_{yi}o_{yi}...a_{yk}c_{yk}o_{yk})$, where a is the activity of the premises, c is the circularity index, and o is the occupation of said premises from $y_i...y_k$ from 2008 to 2011. The status of the premises in 2012 and, in a similar procedure, 2014 (open or closed) is used as prediction data. The decision to use a two-year period is important for several reasons:

- It frees up the learning process from the specificity of the year we want to predict (2014 and 2012 are very different years, economically speaking).
- As expected, the precision obtained for 2012 should be higher than for 2014, indicating the strength of the relationship that we want to test.

Using Matlab and the Deep Learning Toolbox, a multi-level neural network architecture with an LSTM level as the main element was trained on an i7 computer with 16 GB of RAM, in which the data had been previously prepared to be used as a training set. The experiment involved the following phases:

– Selection of results to be searched by the predictor (Status of the commercial premises in 2012 (or 2014 in a later experiment)
– Partition of the sample sets (686) into two subsets: the training set (70%) and the validation set (30%). The samples from the latter were not used for the training of the LSTM network. They were taken randomly and followed statistical criteria to cross-validate the result obtained. This last set was used to determine the precision of the predictor.
– Re-coding of the data's text values by numerical values is suitable for the LSTM training system.
– Creation of a Deep Learning level structure with the following structure:
– An initial level of a training data stream
– A level that converted text to vectors for use in training.
– An LSTM level, which is the network that provided the prediction.
– A level of adaptation of the outputs and calculation of the accuracy of the classification.

The operation required relabeling of activities and circularity indices to improve performance in learning processes.

The training of the networks was then carried out. Figures 3 and 4 indicate the following:

- Training accuracy. Accurate classification in real time. The system offers precision data for every five samples entered for learning. This classification accuracy is carried out, during the training process, with the data used for training.
- Smoothed training accuracy. Precision in smoothed classification. Using the moving average of the previous precision values. In our case, it was more beneficial to observe the trend of the training process.
- Validation accuracy. Precision is obtained by the predictor, using the data from the training set exclusively at each moment of the training process.
- Training loss. Mean square error committed during the training process, according to the cross-validation criteria for each group of five introduced learning samples.
- Smoothed training loss. Moving average of the error made using the previous values.
- Loss in the validation set. This is an error made using the set of validation samples for its calculation. It is the most critical error.

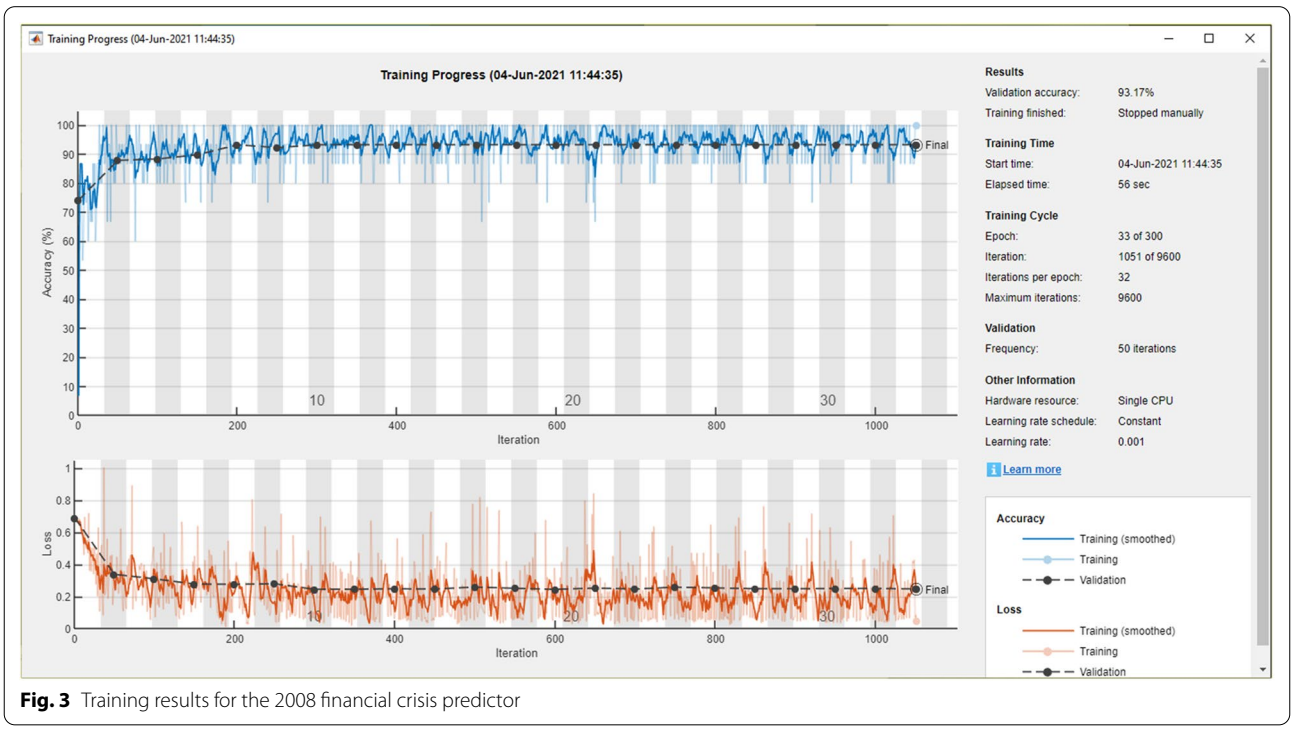

Fig. 3 Training results for the 2008 financial crisis predictor

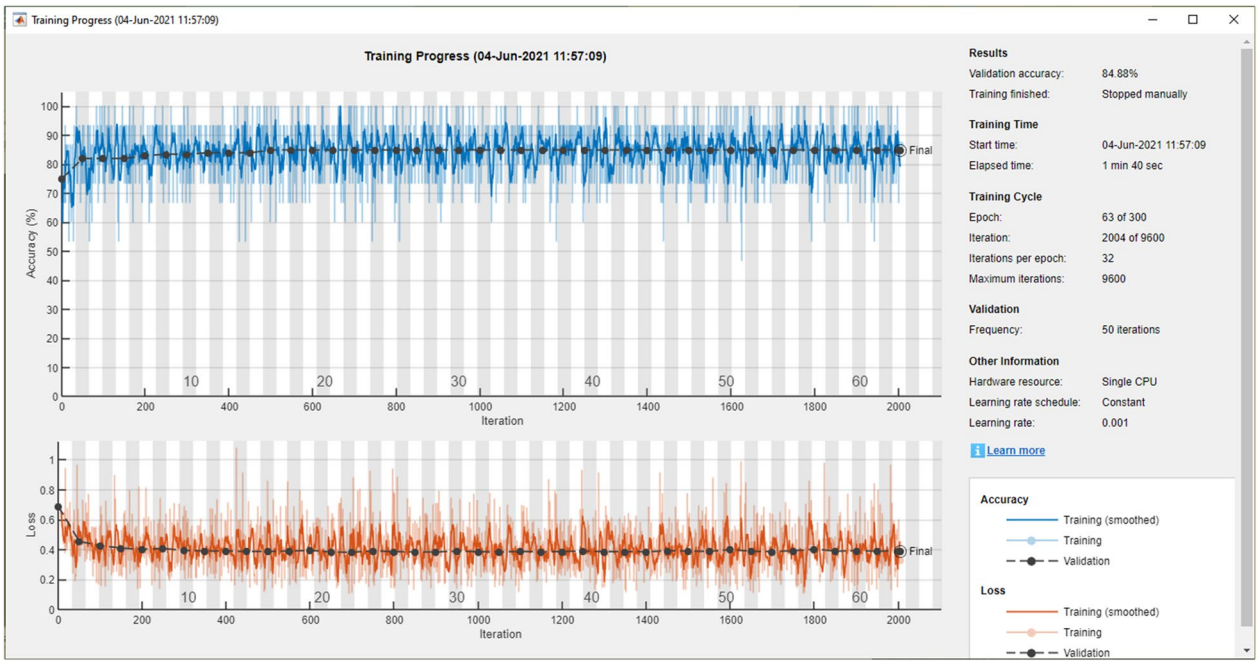

Fig. 4 Training results for 2014

The precision obtained for this predictor is 93.17%. This value means that the system predicts, on the set of tests, with a 93.17% accuracy, the survival of a commercial premises based on the activity and circularity information before 2012.

When repeating the prediction for 2014, the precision obtained dropped to 84.88%, evidence of the strong relationship between the status of the premises in the years of the crisis and its subsequent evolution. This is consistent with the fact that, as time progresses, the survival of the premises is affected by other conditioning factors beyond what the predictor has learned.

Second experiment. Prediction of the status of the commercial premises in the post-financial crisis period

The second experiment uses data regarding the status of the premises and their Circular Economy index in the years after the Great Depression of 2008, in particular, from 2012 to 2017, and links this information to their status in 2018.

The same type of predictor is used and trained under the same conditions as the previous experiments, with data from the post-depression period.

The results of the training also show very significant precision values (Fig. 5), of the order of 94.15%.

These results lead us to think that the relationship between the business's status, activity, and circularity index in a past time interval decisively conditions its survival in subsequent years.

Discussion

"Circularity" has been applied to many subject areas far removed from that of productivity [34]. It has been linked to such disparate areas as urban design [2, 44], digital technologies [6, 37], sports [27, 41], healthcare [36, 45], and retailing. This last sector, retailing, is expected more excellent projection in the coming decades.

An Internet search [9] showed that of the top 25 European retailers, ten publicly addressed the Circular Economy on their websites, indicating their commitment to promoting a transition to a more Circular Economy. "Retailers have a key role to play in sharing the benefits of the Circular Economy as millions of European consumers buy their products in our stores every single day" [11]. Thus, leading retailers must play a leading role in shaping the Circular Economy. However, for the models to be more sustainable, the change in their current business strategies will also need to be accompanied by substantial changes in consumer consumption behavior.

Charter [7] argued that in the "Age of Acceleration," the Circular Economy will be increasingly essential and experiences rapid changes. In the consumer society environment, the retail sector contributes significantly to waste

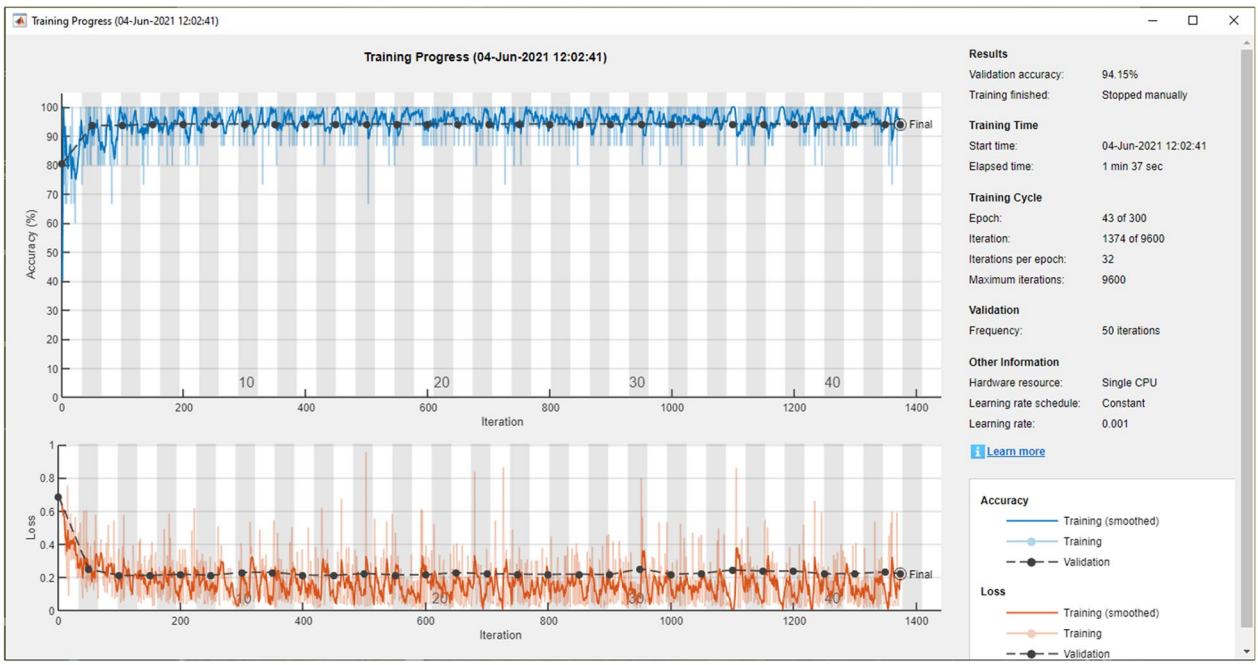

Fig. 5 Training results for 2014

production. For this reason, the Circular Economy has become a significant alternative to the classical economic model in recent years, and the retail sector has started to advance along these lines [20].

Although there is a growing body of literature concerning the Circular Economy, and despite the importance of this issue for the retail sector, academic studies that focus on the Circular Economy and retailing remain scarce. The first publication on this topic did not appear until 2014, with the research of Mirabella et al. [21], which focuses on the use of food waste derived from food manufacturing and the goal of a zero-waste economy in retailing.

In addition to the already mentioned research by Mirabella [21], other outstanding works in this field are as follows: Mondejar-Jimenez et al. [23], which emphasized the critical role of retailers in preventing the generation of food waste through their marketing and sale strategies, Borrello et al. [5], whose results show the potential participation of consumers in closed circuits inspired by the principles of the Circular Economy, Weissbrod and Bocken [43], which showed how a firm pursues innovation activities for economic, social, and environmental value creation in the context of time sensitivity, Zhong and Pearce [49], which concluded that the tightening of the loop of the Circular Economy benefits the environment and sustainability, as well as the economic stability of consumers/prosumers, Corrado and Sala [8], which made a review of existing studies on the generation of food waste on a global and European scale, whose main objective is to describe and compare the different approaches adopted.

The research shows the strong relationship between occupation and activity and the survival of the premises, as well as the relationship between the status, activity, and the circularity index of the business in a past time interval decisively conditions its survival in future.

The current linear production model seems to be the cause of the principal environmental problems, climate change, or plastic accumulation. The Circular Economy represents an alternative to the current linear production, consumption, and waste generation model that is highly unsustainable both at an environmental and economic level.

Conclusions

Predicting commercial and business activity survival is an interesting and complex challenge for public entities (urban planning, purchasing, installing urban furniture, or tax planning). The same is also true for private companies seeking to maximize their investment, choosing locations, and activities resistant to the passage of time.

Over time, and as the commercial fabric of an area consolidates, forecasts become more reliable since the time factor helps understand the market better. However, for commercial activities in the development stage, predictions are more complicated since,

not being able to rely on historical data, forecasters are forced to obtain data from more external agents than those of the business itself, with predictions based on data from web pages, social networks, or internet job postings.

The analysis of the short-term data of our research demonstrates how the survival of a business' activity is linked to its status and circularity strategy in previous years, observing how those places whose activities are related to the Circular Economy survive longer. This conclusion, however, is not categorical because said survival is also linked to specific events in the economic or personal sphere that can permanently distort said activity.

Our analysis also verifies that the status of a business' activity over time can be predicted with a high level of accuracy based on its circularity index, which is very useful for urban development agents and local agents when taking action or making urban planning decisions that strengthen and support local businesses. In addition, the technique can use new characteristics adapted to the urban environment in which the activity takes place to determine if these are also decisive in the survival of the businesses.

Machine learning models that predict business success and the analysis carried out by neural networks conclude that predictions with a high degree of precision can be achieved with the data obtained. However, these prediction levels must be taken with the necessary caution and interpreting that the information obtained is focused and circumscribed to the environment under consideration. We do not know how this technique could work on a global level. While this may seem like a problem, it is not, as the training process can be almost wholly automated once the data for an area has been obtained.

The technique used in this work should be interpreted as an application study. It is not intended to be a commercial advisory service (for now) for business survival as there is not enough data available to train a more generic predictor. Nor is it understood how said predictor would operate in heterogeneous urban environments (neighborhoods of different urban categories, rural areas linked to urban areas, or cities with manifest social conflict).

As a limitation to the study and future lines of research, it would be much more enriching to increase the percentage of success, combine data, and non-formal and qualitative information, and add different data sources to provide the commercial activity with the most information possible on its temporal evolution. In addition, this research has been developed in medium and large-sized cities because GSV is mainly available in urban areas. For future research, it would be interesting to apply these studies in rural areas where available.

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Authors' contributions
JLR-R and JU-T contributed to conceptualization; JATA was involved in methodology; JLR-R, JATA, and JU-T performed validation; JATA and ACGD did formal analysis; JLR-R, JU-T, JATA, and ACGD contributed to writing—original draft preparation; JU-T and JdPV were involved in writing—review and editing; JU-T performed supervision. All authors have read and approved the final manuscript.

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Availability of data and materials
The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no conflict of interest.

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Publisher's Note

4. RESÚMENES Y CONCLUSIONES DE LOS ARTÍCULOS

La creatividad requiere

que la valentía se desprenda de las certezas

(Erich Fromm)

A continuación, se muestran resúmenes y conclusiones de los artículos desarrollados

"How to use Google street view for a time-lapse data collection methodology: potential uses for retailing"

La ubicación ideal para un local comercial es una de las decisiones empresariales más importantes para el pequeño comercio, siendo un factor determinante para el éxito, incluso estando directamente vinculado a la satisfacción del cliente. Las diferentes teorías de la ubicación comercial tradicionalmente ofrecen perspectivas complementarias incluyendo nuevas variables con el paso de los años. Se ha trabajado con tres teorías clásicas, el principio de diferenciación mínima, la teoría de la interacción espacial y la teoría del lugar central, aunque presentan problemas metodológicos ya que son estáticas en el tiempo.

A partir del desarrollo de GSV, surgen nuevas oportunidades metodológicas para la investigación, no solo limitadas a los emprendedores, sino para el análisis y desarrollo de modelos predictivos en diferentes campos mediante una recopilación de datos a través de numerosas imágenes en time-lapse. Los datos relativos a establecimientos comerciales zonales permiten la toma de decisiones sobre elección del lugar óptimo de instalación, estudios de competencia, movimientos de gentrificación comercial o inversiones inmobiliarias entre otras.

Uno de los problemas habituales en el proceso de investigación es la dificultad en la disponibilidad de los datos, así el elevado coste de los mismos en numerosas ocasiones. En esta investigación se presenta una propuesta de metodología para la toma de datos

aplicada a establecimientos comerciales. Nuevos datos analizados en combinación con otras metodologías amplían los horizontes de investigación para futuros estudios.

Una de las ventajas de la metodología aplicada al estudio de locales comerciales es que permite conjugar datos económicos de los establecimientos (precio del suelo, alquileres, facturación...) ya que están perfectamente identificados, junto con otros datos de índole cualitativa (color de la fachada, cercanía a otro establecimiento o amplitud de la vía...).

Además de las líneas de investigación propias relativas al urbanismo y la construcción, las posibilidades que se abren son amplísimas, pudiendo aplicarse en las distintas áreas de conocimiento: en relación a la arqueología, para conocer el deterioro de edificaciones o explotación del patrimonio; en ciencias de la salud, estudios sobre distintas enfermedades y su relación con los barrios o zonas residenciales; sobre despoblamiento y el efectos de la misma en los municipios rurales; análisis de las consecuencias del cambio climático o incluso comparar algunos de los efectos de las pandemias más recientes en determinadas zonas geográficas.

Como factores limitantes de esta herramienta se debe señalar que GSV muestra imágenes de la realidad en un momento determinado, y en ocasiones sería aconsejable tener periodos de tiempo más reducidos de los disponibles actualmente. En otro sentido, la calidad de la imagen puede no ser óptima y en ocasiones aparecen obstáculos que imposibilitan un adecuado registro.

"Local Development and Gentrification Resulting from the Rehabilitation of Singular Buildings: Analysis of Neural Networks"

La rehabilitación y puesta en valor del patrimonio arquitectónico y en concreto de edificaciones singulares es un aspecto clave del desarrollo local. El objetivo de este estudio fue comprender la influencia de estas actuaciones en su entorno transformando negocios adyacentes e iniciando procesos paralelos de gentrificación y desarrollo local. La puesta en valor del patrimonio conlleva no solo aumento de empleo directo por la propia rehabilitación y proyectos asociados, sino que puede ser un generador de

empleo y comercio en las áreas anexas al inmueble. La metodología utilizada se ha basado en mapas autoorganizados de redes neuronales con arquitectura matricial y aprendizaje competitivo. A través del análisis de redes neuronales, se puede identificar relaciones y comportamientos comunes en propiedades comerciales adyacentes a edificios singulares y que comparten patrones y características o atributos comunes. Los edificios singulares analizados se encuentran ubicados a lo largo del litoral mediterráneo español en las ciudades de Almería, Barcelona y Valencia. Los resultados obtenidos se basaron en las siguientes hipótesis: modelo de ocupación y la clasificación basada en la ocupación total, variación total de la ocupación y los usos más comunes de una determinada propiedad comercial en planta baja.

Como conclusiones, destacamos la existencia de locales comerciales que presentan un comportamiento económico anticíclico y la presencia de locales comerciales considerados "desafortunados" o de bajo potencial. La influencia comercial de la zona provoca la apertura durante los años de crisis 2012-2014 de nuevos negocios en locales que no albergaban actividad mercantil en los años precedentes (locales han permanecido cerrados en los trienios 2009-2011 y 2015-2017). Pero que en 2012-2014 han tenido una apertura y cierre de negocio.

Es decir, locales con comportamientos anti cíclicos, cuya puesta en productivo se realiza en el periodo de mayor caída económica. Paradójicamente, esta apertura singular conlleva un cierre casi inmediato, por lo que podríamos deducir que la influencia de la zona actúa como punto de atracción empresarial, los emprendedores piensan que, por la especial ubicación de estos inmuebles, van a conseguir mayor éxito, pero no es suficiente como para salvar los factores externos (inadecuación del inmueble a la actividad, inexperiencia emprendedora, falta de previsión...).

Esta primera premisa se ve refrendada por el comportamiento contrario durante el mismo periodo de tiempo de aquellos locales que, teniendo permanentemente actividad empresarial, cierran para volver a abrir con otra actividad mercantil. Este hecho nos lleva a pensar que existe una tipología de local que independientemente del ciclo económico, son capaces de mantener siempre un nivel óptimo de ocupación empresarial.

Por otro lado, se encuentran locales con un bajo nivel de ocupación, que no suelen responder positivamente cuando comienza una actividad en ellos. La convicción popular de que existen inmuebles gafados, infortunados o donde los negocios que se instalan no perduran podría ser cierta. La activación de una de las neuronas en cuanto a ocupación, variación y uso de los locales nos muestra que aquellos que permanecen cerrados durante un periodo de tiempo elevado suelen tener ocupaciones inferiores al año. Esta conclusión también se ve refrendada por la muestra control.

Este estudio puede ser de especial interés para inversores y empresarios, ya que a partir de este trabajo se abren puertas a líneas de investigación futuras que permitan la eficaz detección de inmuebles con potencial empresarial.

Aunque no se ha podido comprobar directamente la influencia de un inmueble singular sobre el tejido comercial de la zona, sí parece claro que los comportamientos comerciales en cuanto a ocupación y actividad son similares.

"The Circular Economy and Retail: Using Deep Learning to Predict Business Survival"

El sistema de Economía Circular puede mejorar el ciclo del producto y cambiar el sistema y la mentalidad, tanto para la producción como para el consumidor, y se ha convertido en una alternativa significativa al modelo económico clásico. El sector minorista también ha comenzado a avanzar en esta línea. Tras un análisis del estado del arte de la economía circular y el comercio minorista, utilizando técnicas bibliométricas, nuestra investigación se centra en comprender si la relación entre circularidad y comercio minorista puede ayudarnos a determinar la capacidad de supervivencia y resiliencia de una empresa. Para ello, se estudiaron los datos de 658 locales comerciales de cuatro ciudades durante un período de 11 años. Se aplica una técnica de Deep Learning utilizando Long Short Term Memory para determinar si existe relación entre la resistencia de los locales comerciales seleccionados, su estado en periodos de tiempo anteriores, el tipo de actividad empresarial y su clasificación en el plano de la economía circular.

Los resultados muestran que las empresas con actividades relacionadas con la economía circular tienen más probabilidades de sobrevivir durante períodos de tiempo prolongados.

Predecir la supervivencia de una actividad comercial y empresarial es un reto interesante y complejo tanto para entidades públicas (planificación urbanística, la compra e instalación de mobiliario urbano, planificación de la fiscalidad...), como para empresas privadas, que buscarán maximizar su inversión, eligiendo locales y actividades que sean resistentes al paso del tiempo.

Con el transcurso del tiempo y conforme se consolida el tejido comercial de una zona, la predicción se vuelve más fiable, ya que el factor tiempo ayuda a un mejor entendimiento del mercado. No obstante, para las actividades comerciales en etapa de desarrollo, realizar pronósticos se vuelve más complicado ya que al no disponer de datos históricos se está forzando a tomar datos de agentes más externos que propios del propio comercio, con predicciones basadas en datos de webs, redes sociales, empleos por internet, etc.

Con el análisis de los datos a corto plazo de nuestra investigación se puede concluir cómo la supervivencia de la actividad empresarial está ligada a su situación y estrategia de circularidad en años anteriores, observándose cómo aquellos locales cuyas actividades están relacionadas con la economía circular han desarrollado una supervivencia mayor. Esta conclusión, no puede ser tomada de manera categórica porque dicha supervivencia está también ligada a eventos puntuales en el ámbito económico o personal que pueden distorsionar dicha actividad de manera definitiva.

Se puede comprobar, así mismo, que se puede predecir con un alto porcentaje de acierto la situación de una actividad a lo largo de los años en función de su índice de circularidad, lo cual será de gran utilidad para agentes de desarrollo urbanístico y agentes locales para tomar decisiones de actuación y planificación urbana que fortalezcan y apoyen al comercio local. Además, la técnica puede usar nuevas características, adaptadas al entorno urbanístico en el que se desarrolla la actividad, para determinar si estas son también determinantes en la supervivencia de los negocios.

Los modelos de aprendizaje automático para predecir el éxito empresarial al igual que el análisis realizado por redes neuronales, concluyen en el alto grado de predicción que

pueden alcanzar con los datos obtenidos. Estos niveles de predicción, sin embargo, hay que tomarlos con la cautela necesaria e interpretando que la información que se obtiene está focalizada y circunscrita al entorno objeto de estudio. No sabemos cómo esta técnica podría funcionar en un ámbito global. Esto, que pudiera parecer un problema, no lo es tanto habida cuenta que el proceso de entrenamiento, una vez obtenidos los datos de la zona a estudiar, se puede casi automatizar.

La técnica usada en este trabajo debe interpretarse como un estudio de aplicación. No pretende ser un servicio comercial de asesoramiento en supervivencia de negocios porque no se dispone ni de la cantidad de datos suficientes para entrenar un predictor más genérico, ni se conoce cómo dicho predictor operaría frente a entornos urbanísticos heterogéneos (barrios de distinta categoría urbanística, zonas rurales unidas a zonas urbanas, ciudades con conflictividad social manifiesta, etc.).

Como limitación al estudio y futuras líneas de investigación, sería mucho más enriquecedor para aumentar el porcentaje de acierto, combinar datos e informaciones no formales y cualitativas, así como agregar distintas fuentes de datos, con el objetivo de aportar a la actividad comercial la mayor información posible sobre su evolución temporal.

5. PRINCIPALES APORTACIONES Y FUTURAS LÍNEAS DE INVESTIGACIÓN

Los grandes resultados requieren grandes ambiciones

(Heráclito)

A continuación, se presentan las aportaciones más significativas que se extraen de la presente tesis doctoral.

- La aplicación de esta metodología permite conjugar datos económicos de los establecimientos (precio del suelo, alquileres, facturación…), junto con otros datos de índole cualitativa (color de la fachada, cercanía a otro establecimiento o amplitud de la vía…), aportando un valor diferencial frente a otras metodologías.
- Aplicar este estudio para analizar la ubicación ideal para un local comercial sobre todo para el pequeño comercio, puede ser un factor clave para la toma de decisiones conjugándola con otros estudios de geo-posicionamiento.
- En el análisis por redes neuronales de los locales comerciales, se destaca la existencia de locales comerciales que presentan un comportamiento económico anti cíclico, realizando aperturas en épocas donde su entorno cierra y viceversa. Muestra de una ilógica que atiende a una respuesta económica sin análisis previo del sector, entorno o situación global.
- Se puede observar cómo existe el local comercial considerado "desafortunado" o de bajo potencial, ya que o siempre ha estado cerrado o dura muy poco tiempo con actividad económica operativo.
- Existe una tipología de local que independientemente del ciclo económico, son capaces de mantener siempre un nivel óptimo de ocupación empresarial.
- Aunque no se ha podido comprobar directamente la influencia de un inmueble singular sobre el tejido comercial de la zona, sí parece claro que los comportamientos comerciales en cuanto a ocupación y actividad son similares.
- La supervivencia de la actividad empresarial está ligada a su situación y estrategia de circularidad en años anteriores, observándose cómo aquellos locales cuyas

actividades están relacionadas con la economía circular han desarrollado una supervivencia mayor.

- Se puede predecir con un alto porcentaje de acierto la situación de una actividad a lo largo de los años en función de su índice de circularidad.
- El análisis realizado por redes neuronales, así como los modelos de aprendizaje automático para predecir el éxito empresarial concluyen en el alto grado de predicción que pueden alcanzar con los datos obtenidos mediante esta metodología.

Todo trabajo de investigación desarrollado con rigor y con entusiasmo ayuda a responder algunas cuestiones sobre las preguntas iniciales planteadas del tema tratado, y de igual manera, provoca y genera nuevas preguntas, ideas, líneas de investigación y vías de trabajo para futuras investigaciones, tanto a nivel académico como a nivel social, político, administrativo, etc.

A continuación, se presentan algunas futuras líneas de investigación que, de una manera u otra, surgieron en el desarrollo de esta tesis y que pueden ser abordadas en futuros trabajos.

Partiendo de las propias líneas de trabajo relacionadas y vinculadas con el área de urbanismo y la construcción, las posibilidades que se abren con esta metodología son muy variadas, pudiendo aplicarse en las distintas áreas de conocimiento:

- A nivel urbano, poder analizar la evolución de una actuación, como la peatonalización de una vía, la generación de vías verdes y su impacto en el comercio local.
- Vinculado a la arqueología, para determinar la evolución y deterioro con el paso del tiempo del patrimonio.
- Como estudio demográfico, analizando el despoblamiento en zonas residenciales o rurales.
- Análisis de las consecuencias del cambio climático enfocado en zonas urbanas.

- En materia de salud, comparar algunos de los efectos de las pandemias más recientes en determinadas zonas geográficas.
- En relación al parque automovilístico, estudiando el tipo de vehículo y medio de transporte más asociado a determinadas zonas y su evolución con el tiempo.
- A nivel político, estudiando y comprobando si las ayudas de impulso para rehabilitación de fachadas, apoyo al pequeño comercio, etc. Se han puesto en marcha y su evolución temporal.

Este estudio, así mismo, puede ser de especial interés para inversores y empresarios, ya que a partir de este trabajo se abren puertas a líneas de investigación futuras que permitan la eficaz detección de inmuebles con potencial empresarial combinándolo con otras técnicas, permitiendo así obtener una información valiosísima antes de la puesta en marcha de una actividad.

Como limitación al estudio, cabe destacar el acotado temporal inicial fijándose en 2008, año de las primeras imágenes de GSV, así como la falta de información anual de los primeros años ya que no hay imágenes constantes, no obstante, el desarrollo de las TICs permitirá obtener mayor información de años venideros lo que facilitará las futuras líneas de investigación. Como recomendación, sería mucho más enriquecedor para aumentar el porcentaje de acierto, combinar datos e informaciones no formales y cualitativas, así como agregar distintas fuentes de datos, con el objetivo de aportar la mayor información posible sobre la evolución temporal.

6. OTRAS ACTIVIDADES LLEVADAS A CABO POR EL DOCTORANDO

El deseo de conocimiento forma a un hombre

(Patrick Rothfuss)

Uno de los factores clave de toda investigación es la transmisión de los resultados a la sociedad, y compartir el conocimiento.

Por ello, desde el comienzo de esta investigación se pretendido extender los resultados del "laboratorio" y trasladarlos a las aulas, a la sociedad, en definitiva, transmitir el conocimiento de la investigación sobre el comportamiento de los locales comerciales a los principales protagonistas de dicha evolución.

Un ejemplo de difusión en las aulas ha sido la impartición de un módulo de la asignatura "Pueblos y Tradiciones del mundo" en la Universidad de Mayores de la UAL. La evolución de la arquitectura y patrimonio en un paseo virtual en aquellos lugares que era posible a través de GSV. La respuesta del alumnado fue de gran sorpresa al poder "viajar en el tiempo" y poder comprobar la evolución de cada monumento con el paso de los años y analizar su deterioro o puesta en valor en los últimos años. Además, a esta tecnología se incorporó el uso de la Realidad Virtual, permitiendo tener una experiencia más inmersiva, así como aportando grandes ventajas al alumnado:

- Incidiendo en la mejora de la atención, concentración, aprendizaje, lenguaje y memoria a corto plazo.
- Creando una simulación motivadora, mejorando su estado de ánimo.
- Utilizándola como herramienta de evaluación.
- Estimulando la mente, incidiendo de forma positiva en su estado de salud.

Así mismo, en el Master de Desarrollo y Codesarrollo Local Sostenible de la Universidad de Almería, mediante la asignatura experiencias de campo se ha mostrado el proceso de gentrificación y desarrollo local a los estudiantes mediante GSV en diversas zonas urbanas. Analizando su evolución siendo punto de debate el cambio en la última década (Figura 12). Descubrir distintas áreas urbanas y el cambio sufrido en los últimos años ha

permitido a los estudiantes realizar diversos análisis, obteniendo conclusiones muy interesantes como futuros agentes de desarrollo local.

Figura 12. Corredera Alta de San Pablo (Madrid) 2008-2021.

Fuente: Elaboración propia.

En el marco de la noche europea de los investigadores, se desarrolló a través del Grupo almeriense de investigación en Economía Aplicada y como línea de investigación el estudio de la Influencia de los factores patrimoniales sobre el desarrollo local y el turismo el taller "Un paseo por el Paseo: desarrollo económico, arquitectónico y comercial". Actividad para todos los públicos donde se desarrolla a través de un tour por el Paseo de Almería, desde la Puerta de Purchena hasta el Museo Doña Pakyta, mostrando cómo ha evolucionado la arquitectura y la actividad comercial de la que ha sido la principal avenida de la ciudad (Figura 13).

Figura 13. Esquema de la visita realizada.

Fuente: Elaboración propia.

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