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The Circular City and Adaptive Reuse of Cultural Heritage Index: Measuring the investment opportunity in Europe

Gillian Foster [a,*], Ruba Saleh [b]

[a] *Institute for Ecological Economics, Vienna University of Economics and Business, Austria*
[b] *ICHEC Brussels Management School Boulevard Brand Whitlock 4, 1150 Woluwe-Saint-Pierre, Belgium*

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ABSTRACT

The long-lived, culturally relevant, and unique buildings of Europe's urban landscapes embody the values of the circular economy (CE) and sustainability. They are central to urban identities, generation after generation. Furthermore, adaptive reuse of cultural heritage buildings (ARCH) contributes to slowing down the extraction of natural resources, reducing energy for new buildings, and reducing construction and demolition waste and greenhouse gas emissions. ARCH's inherent characteristics distinctly express the 2019 European Green Deal's CE objectives and the 2020 building Renovation Wave Strategy. In this context, European city managers, heritage conservationists, and other stakeholders need a systematic method to characterize the investment opportunity for ARCH, considering CE. To fill this methodological gap, this study introduces a new composite indicator called the Circular City Adaptive Reuse of Cultural Heritage Index.

1. Introduction

Many European city managers are keenly interested in the circular economy (CE) rehabilitation of existing buildings promised by the 2020 European Union (EU) Renovation Wave Strategy. The Renovation Wave is the latest of the rapidly expanding CE policies that affect cities since the European Commission adopted the Circular Economy Action Plan in 2015. The topic of this article, the adaptive reuse of cultural heritage buildings (ARCH) in Europe's cities, is a ubiquitous yet poorly understood segment of existing building rehabilitation. To date, there is no systematic way of characterizing and measuring the investment opportunity at the city or regional level for ARCH. Without an objective methodology, how can city managers and other stakeholders assess the opportunity to allocate legislative time, budget, human resources, and political capital to ARCH? How can researchers and the EU know which conditions drive investment in ARCH across Europe and in specific cities? The purpose of this article is to propose a solution to this methodological gap and answer these complex questions by developing a novel dataset and aggregate index for identifying which European cities present the best investment opportunities for ARCH. The proposed solution is a new composite indicator-based tool called the "Circular City Adaptive Reuse of Cultural Heritage Index" (Index).

The Index applies 15 indicators in three dimensions, Cultural Stock,

Environmental Stewardship, and Socioeconomic Factors to create the composite indicator and evaluate 190 European cities. The cities are chosen based on their inclusion in the 2019 European Cultural and Creative Cities Monitor. To introduce the Index, this article defines the motivation for this research while explaining ARCH's role in circular and sustainable city development. The central concepts, components, and uses of the Index are presented. This discussion explains and justifies the inclusion of each of the indicators that comprise each dimension of the Index. Finally, the article presents and discusses the results of the descriptive analysis of European cities conducted with the Index.

1.1. Why is the CE adaptive reuse of cultural heritage buildings important for Europe's cities?

ARCH refers to building renovations and expansions that maintain as much of the existing building and its cultural heritage features as possible while changing the building's use for contemporary needs. Cultural heritage features may be architectural, or the presence of the building and site commemorate the people and uses of the past. Urban factories, warehouses, and palaces converted to mixed-use residential/retail/performance spaces are an example of ARCH. CE aims to: reduce waste, increase resource efficiency use at all stages of the product value chain, preserve natural capital, lessen the environmental impacts of

production and consumption, and increase (or not diminish) people's well-being. CE intends to be regenerative, replacing a linear end-of-life disposal concept with new circular flows that retain and reuse materials to the extent possible. The key contributions of ARCH to sustainable and circular cities are well established in the literature and are condensed here in four points.

- ARCH contributes to extending the dynamic lifespan of heritage and slowing the extraction of natural resources and energy for new buildings (Dewiyana et al., 2016; Gravagnuolo et al., 2017; Plevoets and Van Cleempoel, 2019; Thornton, 2011). This element is of interest to cities and regions focusing on municipal waste reductions, in particular the reduction of construction and demolition (C&D) wastes from the building sector.
- ARCH projects can anchor social and economic hubs in cities and actively revitalize them by capitalizing on their local authenticity (Acri et al., 2019; Bullen and Love, 2011; Kee, 2019; Strumiłło, 2016). As Europe's demographics change over time and cities continue to grow, city managers consider using built heritage for housing and other uses to accommodate future generations.
- ARCH buildings "preserve social, cultural and emotional values" (Abastante et al., 2020), an argument also made in the Cultural Heritage Counts for Europe Report (CHCfE, 2015). Quality of life, social cohesion, and social sustainability are entwined with the built environment (Dempsey et al., 2011; Roszczynska-Kurasinska et al., 2021).
- Refurbishing urban ARCH buildings (which may have energy efficiency and thermal comfort challenges) is a critical path towards climate change mitigation and adaptation (Foster, 2019; Napoli et al., 2020; Potts, 2021). The European Union's (EU) ambitions regarding climate change and energy efficiency targets will be difficult to reach without urban ARCH buildings. The current EU targets for 2030 are:
  - "At least 40% cuts in greenhouse gas emissions (from 1990 levels)
  - At least 32% share for renewable energy
  - At least 32.5% improvement in energy efficiency."[1]

In summary, ARCH actualizes CE. ARCH is essential for cities' social and economic health while mitigating greenhouse gas emissions and C&D waste. Furthermore, ARCH serves as an "an expression of cultural diversity and history" (EC, 2020). Therefore, the understanding that investment in ARCH is vital for European cities' sustainable future motivates the current research.

1.2. Article outline

The above introduction defines the European context for CE and ARCH and describes the methodological motivation for this research. With this foundation, the following sections introduce the composite indicator-based tool (the Index) in detail. Section 2 focuses on the research methods applied to create the Index and conduct the analysis. Section 3 clarifies the conceptual framework and the data that produce the Index, including their novelty in comparison to existing literature. Section 4 presents the research results. Section 5 summarizes the policy implications of the findings and offers concluding remarks.

2. Research methods and analysis

This section communicates the research methods used to design the Index (2.1) and the descriptive statistical analysis performed with the Index (2.2). The Index is a new composite indicator that brings together data from a number of sources that together describe "complex phenomena that are not directly measurable and not uniquely defined for evaluation and comparison" (Becker et al., 2017). Therefore, composite indicators are useful for measuring complex multidimensional issues such as circular economy and ARCH. In addition, the Index allows for descriptive statistics.

2.1. Why is the COIN tool the selected research method?

To achieve a methodologically robust and transparent composite indicator, the authors apply the research method of the Composite Indicators and Scoreboards (COIN) Tool developed by the European Commission Joint Research center (EC, 2008).[2] The study uses the COIN Tool Lite Version 1.0 (2019) because it is a well-known method of developing and managing large data sets of multi-dimensional indicators. In general, the analysis applies the guidance of the EC Joint Research center (Becker et al., 2019) and the Ten Step Guide (https://composite-indicators.jrc.ec.europa.eu/?q=10-step-guide). There is one important exception. The authors have relied on an academic literature review and feedback from the draft of this publication for guidance on which indicators to include and how to weight them instead of a stakeholder consultation. A comprehensive consultation is not feasible due to the large number of cities and stakeholders.

COIN enhances the transparency of the authors' methodological choices, for example, the weighting of the indicators. In keeping with the COIN Tool guidance, several key methodological decisions in the development of the INDEX are summarized here:

- A framework with two arithmetic aggregation levels with three dimensions is selected as described below.
- Fifteen indicators are included and assigned to one of the three dimensions.
- All indicators are represented numerically.
- Data were selected at the city level, or when not available, at the national level.
- National-level data are assumed to reflect the city-level accurately. For example, the Eurobarometer citizens' survey data for Germany are assumed to reflect the views of citizens of Stuttgart, Munich, and Berlin.
- The min-max normalization approach that rescales indicators onto an identical range (0–100) is selected.
- All indicators are statistically equally weighted.
- The direction of all indicators is treated the same. Higher values indicate higher positive achievement of the indicator.

The overall structure of the dataset is assessed, using the model output, to make sure that no indicator is dominating the framework or is under-represented. The COIN Tool highlighted the outliers for three of the 15 indicators. Although composite indexes are sensitive to outliers, it is not always necessary to treat these. "An outlier may be due to an error, but it may be also simply due to a skewed indicator distribution. To deal with outliers, one must first detect their presence, and then decide whether they should be treated or not" (Becker et al., 2019). The three indicators with outliers highlighted in the dataset are due to actual distribution of indicator data. The three indicators are: cultural heritage within the circular plan (yes or no); number of sites and landmarks; and population. The authors chose to eschew rebalancing the outliers through Winsorization because these indicators are real world data covering cities of various sizes with differing characteristics, for example, Paris is bigger than Vienna. Likewise, missing data and zeros were not imputed, and the original data were analyzed to create the Index.

The COIN Tool calculates and illustrates Pearson correlation coefficients between the indicators. The authors paid attention to highly collinear indicators, and negative correlations within the dimensions.

The effect of each indicator in the Index is dependent not only on its weight, but on its correlation with other indicators, and their weights. The Index includes negative correlations between some indicators. However, the negative correlations were accepted as a feature of the data because, they show "trade-offs between indicators" (Becker et al., 2019). The function of the COIN Tool is to calculate scores for each indicator and dimension and calculate an aggregate score for each city.

In the authors' view, the dataset's composition and the resulting descriptive analysis of cities is valid because real-world data reflect the differences among the cities. The data are not being used to establish statistical causality of the underlying indicators, for example, indicator X causes indicator Y. The results are not interpretable in this way. Further, the authors concur with Van Puyenbroeck, et al. (2020) that "comparing cities' multi-dimensional performance through the lens of a fixed and common set of weights may even be counterproductive in that it prevents acceptance of such a benchmarking tool" (Van Puyenbroeck et al., 2021). The data collected between June and December 2020 for the indicators of the Index highlight rather than mask differences among cities in order to provide real-world, policy-relevant information.

2.2. Exploratory statistical analysis

Following the creation of the Index dataset with the COIN Tool, the tabulated scores of the indicators and dimensions of the 190 cities of the Monitor were analyzed using descriptive statistics in Microsoft Excel. The descriptive statistical analysis herein is exploratory. It measures central tendencies, frequencies, rankings, and variances within the data. In addition, crosstabulation between variables and geographic distribution of the cities generate new policy-relevant patterns among the cities in the dataset.

3. The conceptual framework and data selection of the Index

This section defines the conceptual framework and data selected for the Index. The key concept of "investment opportunity set" (IOS) is defined and how the authors apply it to ARCH is explained. The criteria for data selection established by the authors and the methodological justification for the selected indicators and dimensions in the scientific literature are presented.

3.1. What is an investment opportunity set for ARCH?

In general, an IOS in economics and finance refers to a descriptor or proxy for value decisions (investments), taking risk into consideration (Myers, 1977). The current work applies the concept as described by Kallapur, et al. (1999). Instead of limiting the concept to firms, this work extends the concept of IOS to ARCH buildings in the context of CE for cities (Kallapur and Trombley, 1999).

> Myers (1977) introduced the term "investment opportunity set" (IOS) to refer to **the extent to which firm value depends on future discretionary expenditures by the firm.** Thus, IOS refers not only to traditional investment opportunities such as the right to explore for minerals, but also to other discretionary expenditures such as the extent of brand advertising required in the future to ensure the success of the firm. **In general, the firm's investment opportunity set will depend on firm-specific factors such as physical and human capital in place, as well as on industry-specific and macro-economic factors**. (Kallapur, et al. 1999) (emphasis added).

The authors pose a link between the Kallapur et al. (1999) concept that the future value of the firm depends on discretionary spending and the concept that the value of the city depends upon discretionary spending on ARCH as follows. ARCH investments are capital and non-capital discretionary expenditures. In particular, cities' ownership,

maintenance and rehabilitation of cultural heritage buildings is discretionary. Cultural heritage buildings often decay given municipal budget constraints. The authors maintain that the future value of areas where historic buildings are located, even the entire city, depends on the degree of ARCH. This concept corresponds to the theories of several leading authors in the field (Fusco Girard, 2014; Galdini, 2019; Zancheti and Jokilehto, 1997). Galdini (2019) describes the opportunity for future value (re)creation that ARCH represents when utilized. She explains, "Reusing old buildings and recycling open spaces that have lost their functions have long been effective strategies to preserve and restore facilities and revitalize neighbourhoods, providing environmental, economic, and social benefits. As many cases in Europe demonstrate, reuse practices can give a second life to urban voids: by reinventing their function and re-thinking their meaning, such practices succeed in promoting urban regeneration processes" (Galdini, 2019). Conceptually, just as a firm's discretionary expenditures ensure the future success of the firm, a city's discretionary expenditures in ARCH ensure the future success of the city. With the Index, the authors mirror the concept and proxy measurement of an IOS for the firm by posing a corresponding concept and proxy measure of an IOS for ARCH at the city level.

3.2. How are indicators selected?

Given the conceptual framework above, the authors chose indicator datasets subjectively "based on the analytical soundness, measurability, country coverage, and relevance of the indicators to the phenomenon being measured and relationship to each other" (EC, 2008). Analytical soundness of each indicator is informed by the literature review. The boundary of the Index data is the 190 cities of the 2019 Monitor because the phenomenon measured is inherently cultural (Montalto et al., 2019). The following criteria are met for each indicator dataset included in the Index.

- Selection is guided by the literature review (see Section 3.2.1 and Table 1);
- Relevant to the Index's conceptual framework;
- Data availability (publicly accessible and free of charge);
- Credibility (only statistical data from established sources such as the Eurostat, EC or UNESCO were included); and
- Contemporary focus (all published datasets are from 2016 to 2020; the data and results are state of the art).

The indicator selection criteria reflect common practice in cultural heritage economics, "The choice of selected heritage indicator in each category of the stream of value is based on available data, expert opinion surveys, or subjective assessment" (Ost, 2012b).

3.2.1. Literature review for indicator selection and research innovation

Over the last two decades, scholars have argued that there is a link between cultural heritage, adaptive reuse, sustainability, and more recently CE. A recent literature review of existing research frameworks, methodologies, and assessment methods for assessing cultural heritage adaptive reuse noted that the terms "sustainable development", "sustainability", and "adaptive reuse" are prevalent, hot spots in the literature (Li et al., 2021). They find that "methodology and assessment methods are indispensable for holistic adaptive reuse decision-making" (Li et al., 2021). Consequently, research for decision making in the cultural heritage field (and now from a sustainability/CE perspective) attempts to capture complex use and non-use (unpriced) values (Ferretti and Comino, 2015; Fusco Girard and Vecco, 2021). Further, at the micro-level, the decision to leave a heritage asset as is, reuse it, or demolish it for development derives from the concept of opportunity cost in heritage economics, (Throsby, 2002). An account of the literature on all evaluation methods is beyond the scope of the present work; therefore, the focus is on indicator methods.

Table 1

Circular City ARCH Index overview of indicators.

Dimension	Indicators	= Example references in indicators literature (New indicators in the context of ARCH are noted with an asterisk.)	Data source for the index	Multi-level governance scale	Year
Cultural stock	The Cultural and Creative Cities Monitor index score	New indicator in the context of ARCH.*	Monitor	City	2019
Cultural stock	Cultural heritage within the circular plan (yes or no)	New indicator in the context of ARCH* (Foster and Saleh 2021)	(Foster and Saleh, 2021)	City / Regional / National	Various
Cultural stock	Number of sites and landmarks	(CHCfE, 2015; Eurostat, 2019; Fusco Girard et al., 2015; Montalto et al., 2019)	Monitor	City	2019
Cultural stock	Presence of at least one UNESCO World Heritage Site (WHS)	(CHCfE, 2015; Eurostat, 2019; Petti et al., 2020)	UNESCO World Heritage Center[4]	City	2019
Cultural stock	European Capital of Culture (yes or no)	(CHCfE, 2015; Eurostat, 2019)	Creative Europe program[5]	City	2020
Cultural stock	Share of general government expenditure for cultural services 2018 (Eurostat) National level 2018	(CHCfE, 2015; Eurostat 2019; Petti et al., 2020)	Eurostat (Eurostat, 2020a)[6]	National	2018
Cultural stock	Citizens attribute high importance to cultural heritage (Special Eurobarometer 466 very important)	Citizens' perception of cultural heritage value (Eurostat, 2019; Nocca and Girard, 2018; Saleh and Ost, 2020)	Special Eurobarometer 466 (Eurostat, 2017)[7]	National	2017
Environmental stewardship	Circular plan / road map / initiative / strategy/ other score	New indicator in the context of ARCH.* (Foster and Saleh, 2021; Prendeville et al., 2018)	(Foster and Saleh, 2021)	City/Regional/ National	Various
Environmental stewardship	Climate neutral city plan / initiative / strategy (yes or no)	(Potts et al., 2021)	Three initiatives were reviewed namely: Climate Alliance; Convent of Mayors for Climate and Energy Europe; and European Green Capital	City	2020
Environmental stewardship	Citizens attribute high importance to the protection of the environment (Special Eurobarometer 501 very important)	New indicator in the context of ARCH.* (Eurostat, 2020b)	Special Eurobarometer 501[8]	National	2020
Environmental stewardship	C&D waste percentage share of total waste	(Bosone et al., 2021; EEA, 2020; Mahpour, 2018)	Eurostat[9]	National	2018
Environmental stewardship	Built environment within the circular plan (yes or no)	(Foster and Saleh, 2021; Giacomo Salvatori, 2019)	(Foster and Saleh, 2021)	City/regional/ national	Various
Socioeconomic/ demo-graphics	Population (Cultural and Creative Cities Monitor 2019) / (Eurostat) last update 14/05/2020 NUTS 3	(CHCfE, 2015; Monitor, 2019)	Monitor	City	2019
Socioeconomic/ demographics	GDP - Gross Domestic Product at market prices / Million Euro	(CHCfE, 2015; Monitor, 2019)	Eurostat[10]	National	2018
Socioeconomic/ demographics	European innovation scoreboard	New indicator in the context of ARCH.* (OECD, 2018)	European Commission[11]	National	2019

Indicator datasets that evaluate complex values, for example in multi-criteria analysis, are frequently examined in the literature. For example:

- Cultural impacts (ICOMOS, 2011);
- Social impacts (Roszczynska-Kurasinska et al., 2021);
- Economic impacts (Ost, 2012a, b; Throsby, 2016)
- Environmental impacts (Foster and Kreinin, 2020; Foster et al., 2020)
- socioeconomic impacts (Labadi, 2011); and
- General sustainable/circular urban development/metabolism and heritage theme (Berthold et al., 2015; Bosone et al., 2021; Della Spina, 2021; Gravagnuolo et al., 2017; Guzmán et al., 2017; Petti et al., 2020)

Nevertheless, methods that evaluate the complex case of adaptive reuse from a sustainability and/or CE perspective at the city and regional level are lacking (Bosone et al., 2021). A notable exception is Phillips and Stein (2013) who developed a conceptual community-level indicator framework integrating "historic cultural and built resources" with economic development and sustainability (Phillips and Stein, 2013). As with the present work, Phillips and Stein (2013) highlight broad policy and investment applications, saying, "An indicators framework can help with gaging if progress is made towards goals and if

policy, actions, investments, and other activities are on track or not" (Phillips and Stein, 2013). In contrast to the current work, this conceptual article does not propose a composite index method, apply an IOS approach, or analyze data for their chosen indicators at the city/regional level. In conclusion, the literature review provides the methodological basis for selecting individual indicators selection and confirms the research innovation of the Index.

3.3. Which indicator datasets are included in the index?

Corresponding to the IOS for a firm, the authors interpret that an IOS in the case of ARCH and CE must capture city-specific factors for the existence of cultural heritage buildings (physical capital), sentiment of the population (as in human capital), and socioeconomics / demographic data (macro-economic factors). In keeping with the IOS concept and the ARCH literature, the Index includes 15 indicators clustered in three dimensions, Cultural "Stock" (including indicators for physical and human capital), Environmental Stewardship (including indicators for physical and human capital), and Socioeconomics / Demographics (indicators for macro-economic factors) as shown in Fig. 1. This section explains the rationale for each indicator and dimension. In addition, Table 1 provides an overview of the indicator datasets and examples of the literature that support the inclusion of each indicator.
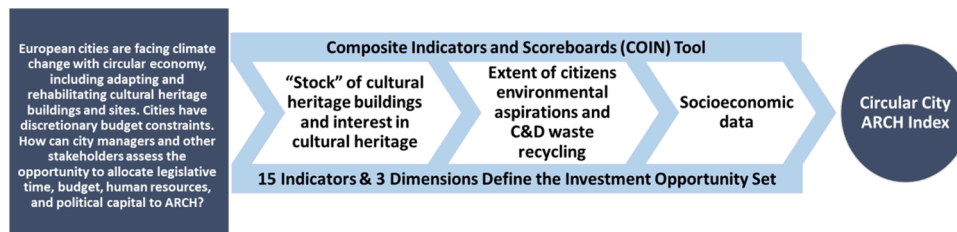
Fig. 1. Graphical representation of the Index's conceptual framework.

3.3.1. Description of the index dimensions

The Cultural "Stock" Dimension measures the extent of cultural heritage buildings and interest in cultural heritage in the city. The indicators that comprise the Cultural Stock Dimension include the presence of World Heritage Sites, the number of cultural heritage sites and landmarks, and the Monitor score. These indicators measure the relative wealth of cultural heritage buildings in the city. Citizens' attitudes towards cultural heritage ascertained in the latest Eurobarometer Survey 466 are considered. In this study, the percentage of citizens that perceive cultural heritage as "very important," the highest level, signals interest in preserving cultural stock and safeguarding it for future generations. Also, whether the city is a European Capital of Culture is an indicator of the municipalities' motivation to utilize and build on the city's cultural capital. The reason is that the city must dedicate significant resources to the European Capital of Culture initiative. "Six years before the [European Capital of Culture] title-year the selected host member states publish a call for applications, usually through their Ministry for Culture. Cities interested in participating in the competition must submit a proposal for consideration."[3] Collectively, these indicators gage if ARCH is a major concern for the city or not.

The Environmental Stewardship Dimension measures cities' aspirations towards environmental sustainability. This dimension includes the importance that citizens attach to environmental protection as shown by the most recent Eurobarometer Survey 501. The survey asked, "How important is protecting the environment to you personally?" Answers were scaled as follows: "very important," "fairly important," "not very important," "not at all important," and "don't know." In this study, the percentage of citizens that perceive the environment as "very important," the highest level signals interest in implementing environmental policies such, as CE. Another indicator in this dimension is C&D waste as a percentage of total waste. This indicator measures the challenge that cities have with managing general construction (and presumably ARCH) waste. This indicator is relevant because reducing C&D waste through recycling and reuse is frequently highlighted in the CE and ARCH literature (Baker et al., 2017; Ghisellini et al., 2017; Hobbs and Adams, 2017; Iacovidou et al., 2018; Sfakianaki and Moutsatsou, 2015). Finally, membership in an organization with specific sustainability commitments, such as a climate neutrality pledge, validates environmental stewardship. Therefore, a city's membership in any of the following three initiatives was chosen as an indicator in the Index: Climate Alliance; Convent of Mayors for Climate and Energy Europe; and European Green Capital. The Environmental Dimension indicates how strongly a city is committed to implementing sustainability policies.

Socioeconomics/Demographics Dimension – Relevant socioeconomic data, such as the size of the population, and GDP are proxy measures for economic activity and financial flows. Further, this dimension includes the national ranking in the 2019 European Innovation Scoreboard. The Scoreboard is a national measure of innovation performance. In the Index, it is an indicator of the local actors' openness to novel concepts and the ability of the economy to adopt them, such as CE.

In summary, the 15 indicators of the Index are multi-dimensional and include disparate yet equally valid indicators that are methodologically supported by the literature. Five of the indicators are applied as indicators in the context of ARCH for the first time. These are noted in the third column of Table 1. The Index and its three sub-dimensions define a new concept, the Circular City ARCH Investment Opportunity.[4567891011]

4. Discussion of results

This section presents the results of the exploratory analysis that answer the studies' main research questions and puts forth the authors' interpretations and policy recommendations. The discussion focuses on 20 top ranked cities of the Index for the sake of brevity; however, scores are available for the full 190 cities analyzed (https://data.mendeley.com/datasets/8jzr4f5khr/draft?a=24a1a005-f7f7-43c5-8c42-7db78f472b40). The underlying data are available as supplementary materials upon request.

4.1. What can we learn from the index's rankings?

Primarily, the Index ranking answers the research question, "How can city managers and other stakeholders assess the opportunity to allocate legislative time, budget, human resources, and political capital to ARCH?" As shown in Table 2, the ranking demonstrates that certain cities have a greater opportunity to invest in ARCH and CE than other cities. For example, of the top 20 Index cities, only nine (45%) have developed their own local CCPs (Paris, London, Liverpool, Madrid, Amsterdam, Stockholm, Bradford, Rotterdam, and Barcelona). With the information provided by the Index, each city has a method to assess if discretionary spending on ARCH and CE is important to its future. The findings lead to several policy recommendations for high-ranked cities:

- The 11 cities in the top 20 without CCPs should consider implementing their own local CCPs, if the city is not already participating in a regional CCP.
- All 20 cities should review their policies, particularly building procurement, energy efficiency, regulation, and C&D waste management, for positive and negative effects for ARCH.
- The potential contribution of ARCH to the CE goals of the top 20 cities needs to be researched.
- High-ranking cities should review their masterplans and provisions for historic preservation to ensure they meet today's needs.

- High-ranking cities should consider if the necessary skills, capabilities, and processes that support ARCH are available in the local real estate and construction industry. For example, are systems in place to recover, repair, and reuse building elements?
- High-ranking cities should consider incentives for investments in ARCH.

Table 2

The comparison of top 20 cities of the Monitor and the Index (Bold and underlined text notes cities that appear on both lists.).

Ranking	Top 20 cities, Cultural and Creative Cities Monitor	Top 20 cities, Circular City ARCH Index
1	**Paris (FR)**	**Paris (FR)**
2	Zurich (CH)	**London (UK)**
3	Bern (CH)	Berlin (DE)
4	Copenhagen (DK)	Liverpool (UK)
5	Lisbon (PT)	Madrid (ES)
6	Basel (CH)	Lille (FR)
7	**Stockholm (SE)**	**Stockholm (SE)**
8	**Luxembourg (LU)**	**Luxembourg (LU)**
9	Munich (DE)	**Amsterdam (NL)**
10	Dublin (IE)	Essen (DE)
11	Geneva (CH)	Edinburgh (UK)
12	Stuttgart (DE)	Bradford (UK)
13	**Amsterdam (NL)**	Rotterdam (NL)
14	Lund (SE)	Nottingham (UK)
15	Weimar (DE)	Lyon (FR)
16	Florence (IT)	Hamburg (DE)
17	Heidelberg (DE)	Barcelona (ES)
18	Glasgow (UK)	Toulouse (FR)
19	**London (UK)**	Bristol (UK)
20	Dresden (DE)	Bordeaux (FR)

Table 2 presents the results of the Circular City ARCH Index in comparison to the Cultural and Creative Cities Monitor rankings. The two composite indexes are related but certainly not the same. For example, only 25% of the European cities on the Monitor's top 20 are also in the top 20 of the Index. These are Paris, London, Luxembourg, Amsterdam, and Stockholm. In contrast and complimentary to the Monitor, a top 20 ranking on the Index means, that a city scores highly relative to others based on its tangible and intangible cultural heritage (Cultural Stock) with aspirations toward environmental sustainability and market conditions conducive to CE and ARCH (Socioeconomic/ Demographics). These results demonstrate that the Index is substantially different from the Monitor. The Index is a new contribution to the literature.

4.2. Patterns among the top ranked cities of the Index

The authors conducted exploratory descriptive statistics to observe patterns among the cities of the Index. The findings answer the question, "How can researchers, and the EU know which conditions drive investment in ARCH across Europe and in specific cities?" The most significant observed patterns are the prevalence of national capitals and the geographic variation of highly ranking cities. In addition, patterns are observed within each dimension as discussed in Section 4.3.

Where are the highest ranked cities located? A significant number of the Index's highest ranked cities are European capitals. This finding corresponds to other research that confirms that "capitals tend to be the best performing cities on culture and creativity" (Montalto et al., 2018). Seven (35%) of the top 20 cities of the index are capital cities. The authors venture that capital cities are magnets for creativity and have historically been centers of wealth. Therefore, a significant portion of
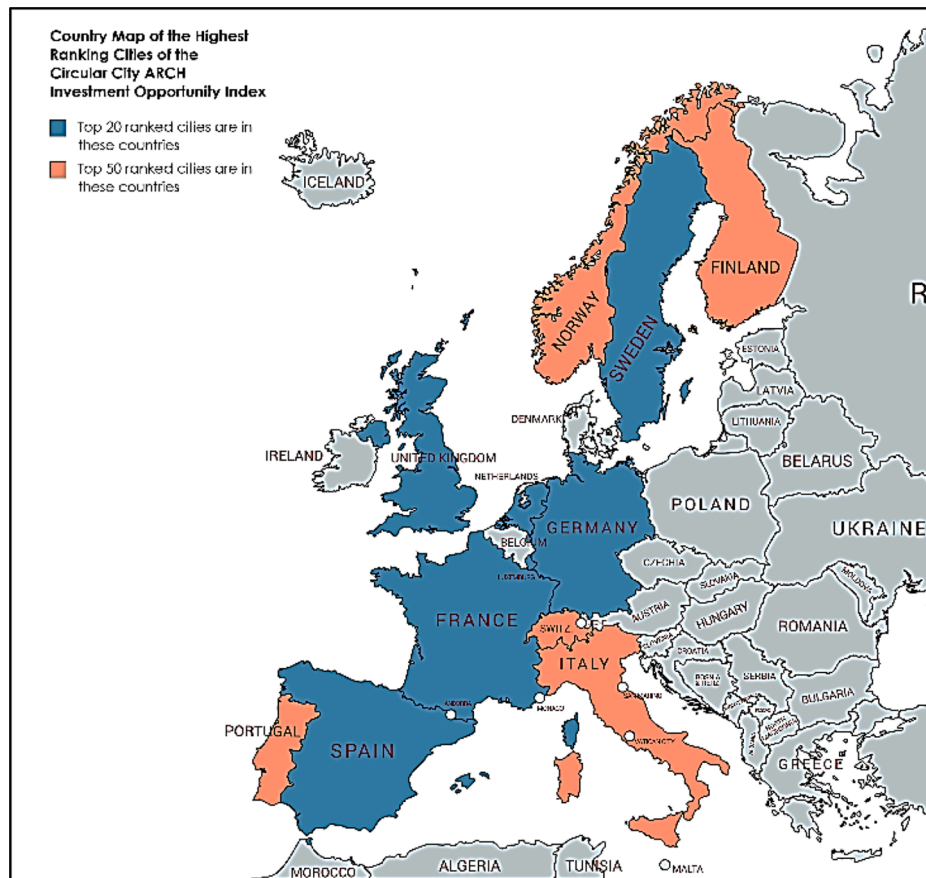

Fig. 2. Country map of the highest-ranking cities of the Circular City ARCH Index (Source: https://mapchart.net; accessed February 3, 2021). Orange denotes the counties of the 20 top ranked Index cities. Blue denotes the countries of the 50 top ranked Index cities.

Table 3
Cultural stock dimension results.

Rank	Cities
1	Paris (FR)
2	Luxembourg (LU)
3	Lisbon (PT)
4	Porto (PT)
5	Valletta (MT)
6	Guimaraes (PT)
7	Tallinn (EE)
8	Prague (CZ)
9	Athens (EL)
10	Stockholm (SE)
11	Vilnius (LT)
12	Bradford (UK)
13	Krakow (PL)
14	Madrid (ES)
15	Florence (IT)
16	Berlin (DE)
17	Riga (LT)
18	Avignon (FR)
19	Amsterdam (NL)
20	Thessaloniki (EL)

built heritage we see today from earlier periods is in centers of wealth or industry, which coincides with capital cities.

Few countries are represented in the top 20. The seven countries are France, Germany, Spain, Luxembourg, the Netherlands, Sweden and the United Kingdom. Although the countries are located in the North and South of Europe, all are "Western European." This is significant because

the Monitor cities that bound this study include 30 countries with a broader geographic distribution. Only 35% of the countries analyzed have at least one city in the top 20. The top 20 cities lack geographic diversity.

The geographical variance of the top 50 cities of the Index is likewise skewed toward the west. There are only 12 countries represented in the top 50. The five countries in addition to those listed above are Italy, Norway, Switzerland, Finland, and Portugal. In addition, the top 50 cities include Finland and Portugal, both CE forerunners. Fig. 2 portrays the top 20 and top 50 highest ranked countries. Western European countries are the majority of highly ranked countries on the Index.

4.3. Results of the Index dimensions

The analysis of each dimension (Cultural Stock, Environmental Stewardship, and, Socioeconomics / Demographics) highlights diverse elements and notable commonalities. The findings demonstrate conditions that contribute to a strong IOS through their frequency / prevalence among top-ranked cities.

Cultural "Stock" Dimension – A different pattern emerges from the results of the Capital Stock Dimension. The countries included in the top 20 and top 50 are more geographically diverse. Table 3 displays the top 20 ranked cities for the Cultural Stock dimension. The countries included on this list are France, Sweden, Luxembourg, Portugal, Malta, Estonia, the Czech Republic, Greece, Lithuania, the United Kingdom, Poland, Spain, Italy, Germany, and the Netherlands. Fig. 3 portrays the most-highly ranked 20 countries for the cultural stock dimension. The 15 countries represent half (50%) of the countries within the dataset. As
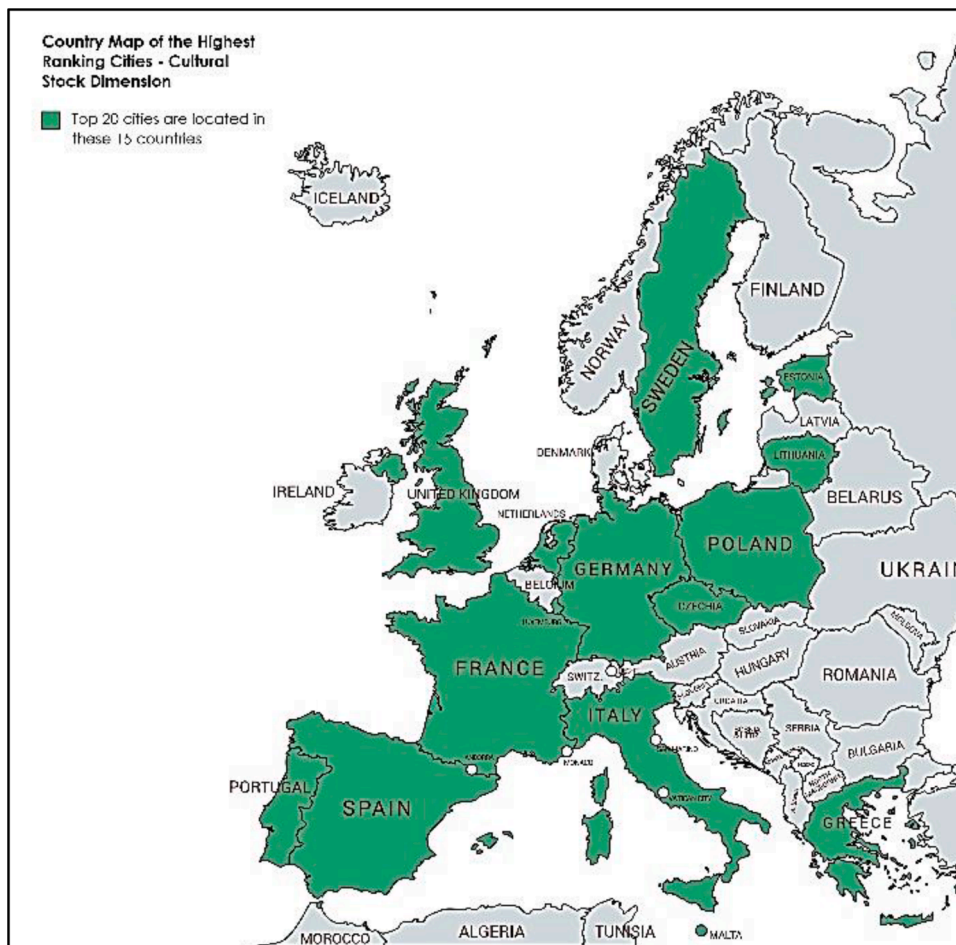

Fig. 3. Country map of the highest-ranking cities of the Circular City ARCH Index's Cultural Stock Dimension (Source: https://mapchart.net; accessed February 3, 2021). Green denotes the 15 countries of the 20 top ranked cities.

Table 4

Environmental stewardship dimension results.

Rank	Cities
1	Paris (FR)
2	Oslo (NO)
3	Liverpool (UK)
3	London (UK)
5	Amsterdam (NL)
5	Rotterdam (NL)
7	Copenhagen (DK)
8	Stockholm (SE)
8	Gothenburg (SE)
10	Edinburgh (UK)
10	Nottingham (UK)
10	Leeds (UK)
10	Birmingham (UK)
14	Lille (FR)
14	Toulouse (FR)
14	Lyon (FR)
14	Bordeaux (FR)
14	Nantes (FR)
14	Saint-Étienne (FR)
20	Madrid (ES)
20	Barcelona (ES)

the map shows, culturally significant countries / cities such as Rome, are not on the list. This is likely because these cities do not have official circular economy strategies in place yet. Therefore, they do not score as highly on the Index as cities that are implementing CE and include buildings and cultural heritage.

Highlights of the data within the Cultural Stock Dimension:

Presence of at least one UNESCO World Heritage Site (WHS) – Nearly all (90%) of the top 20 Index cities have at least one World Heritage Site. Only Nottingham and Bristol in the United Kingdom do not have a World Heritage Site. Among the top 20 cities of the Monitor, nearly all (90%) have at least one World Heritage Site. Contrastingly, 61 (32%) of the 190 cities of the Monitor host at least one World Heritage site. The conclusion is that the presence of a World Heritage Site influences a high ranking.

European Capital of Culture – Ten of the Index's first 20 cities and 22 of the first 50 cities benefited from the ECOC program and title. Only 38% of all the cities in the dataset have ever held an ECOC title. The conclusion is that cities that activate their cultural stock as a catalyst for economic and social development score higher than other cities.

General government expenditure on cultural services as a share of total government expenditure – The percentage of government spending is a clear measure of the priority that any issue has in public policy. The first 20 cities of the Monitor average 0.91% of government spending for cultural services. The minimum percentage of government spending is 0.6% (United Kingdom, Italy, and Portugal). Their maximum percentage is 1.3% for Luxembourg. In comparison, the average for the remaining 170 cities of the Monitor is 1.1%, the minimum is 0.1%, and the maximum is 2.8%. The range and variation in the share of general government expenditure on cultural services at the national level is greatest and highest for cities that do not rank at the top; hence, budget is not a determining factor in the ranking.

Citizens attribute high importance to cultural heritage according to the Special Eurobarometer 466 – The survey was conducted in EU Member States only. At the national level, more than a quarter of the population believes that cultural heritage is highly important (the lowest value is 28% in Hungary and the highest is 67% in Cyprus). The average of the EU28 Member State countries is 42%.

Environmental Stewardship Dimension – This dimension measures the relative appetite for CE at the city level by pooling data on governmental and citizens' views on the importance of environmental protection actions. The authors interpret that the Index cities shown in Table 4 are particularly open to CE and ARCH because they are in line with the perspectives of the city government and citizens. However,

their top 20 status could be misleading because these cities represent only seven countries. As the individual indicators that are part of this dimension indicate, most city governments and citizens in the sample value environmental stewardship.

Highlights of the data within the Environmental Stewardship Dimension:

Citizens attribute high importance to the protection of the environment according to the Special Eurobarometer 501 – For all cities in the dataset, more than a third of the population believe that the environment is highly important, lowest (36%) in Latvia and Estonia and highest (81%) in Sweden. The average is 53%. Contrastingly and higher, an average of 61% of citizens in the top 20 Index cities rate the importance of the environment as very high.

C&D waste (percentage share of total waste) - The data for C&D waste show that the percentage of recycling of the mineral part of C&D waste per country oscillates for the first 20 cities of the Index. It is approximately 81% in Luxembourg City (Luxembourg) and only 9% in Stockholm (Sweden). The data show that Luxembourg is aware of the high percentage of C&D waste. It also shows that although Sweden has a low percentage of C&D waste, Sweden makes an important effort to boost the material bank from building renovations. This indicator highlights the links between environmental stewardship and cultural stock dimensions as well. Portugal, a country in the top 20 for the cultural dimension, also has 9% C&D waste as a share of total waste. Portugal has a pilot project supported by the national plan and implemented by the Portuguese Association for Urban Rehabilitation and Heritage Protection (APRUPP), which promotes and disseminates the concept of urban rehabilitation.

Three countries stand out for their high level of C&D waste at the national level and lack of strong CE strategies at the city level: Austria at 74.4%, Malta at 79.3%, and, Luxembourg at 81.2%. A strong CCP, as defined in (Foster and Saleh, 2021), should be adopted by the cities Vienna, Graz, Valletta and Luxembourg City. The data illustrate a clear Circular City and ARCH investment opportunity for these cities.

Climate neutral city plan / initiative / strategy – Cities in the dataset with membership in a climate neutral city plan/initiative/ strategy are determined by membership in the Climate Alliance[12] and Covenant of Mayors for Climate and Energy Europe.[13] In addition, the authors noted the cities that had an action plan for reaching 2020 or 2030 climate change targets. The cities that are part of the Mayors Adapt
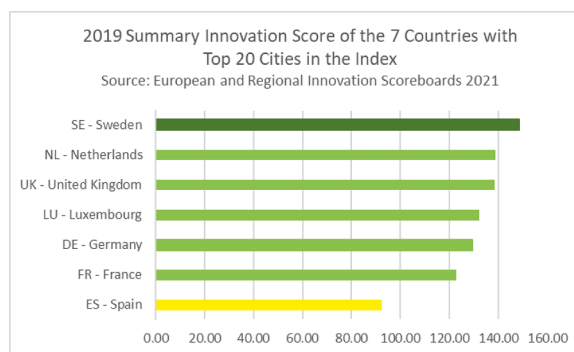

Fig. 4. The 2019 European Innovation scores of the seven countries with top ranked Index cities. Dark green denotes an innovation leader, light green is for strong innovators, and yellow represents a moderate innovator. (Source: htt ps://interactivetool.eu/EIS/EIS_2.html; accessed June 28, 2021.). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

[12] https://www.climatealliance.org/municipalities
[13] https://www.covenantofmayors.eu/plans-and-actions/action-plans.html

Table 5
Correlation matrix of the dimensions.

Cultural "Stock"	1		
Environmental stewardship	0.14	1	
Socioeconomic/ demographics	0.05	0.70	1
	Cultural "Stock"	Environmental stewardship	Socioeconomic / demographics

program of the EC to engage cities to act on climate change adaptation are also noted. Finally, the authors checked which cities obtained the European Green Capital award.[14]

The data demonstrate that city governments in the sample have prioritized climate change and greenhouse gas reductions. Out of the 190 cities, only 43 are not members of the Climate Alliance or Mayors Adapt. These 43 have not adopted the climate change action plans. Of the Index's top 50 cities, only two are not a member of one or more of the initiatives researched. ARCH is useful for climate mitigation and adaptation, retaining embodied carbon to reduce new greenhouse gas emissions (Foster, 2019). A policy recommendation deriving from the results of this analysis is that the EC should work with the Covenant of Mayors to disseminate CE and ARCH policy rationales and strategies as part of the Renovation Wave Strategy.

Socioeconomics / Demographics Dimension – This dimension holds few surprises, as it employs GDP and population statistics. The innovation indicator combined with GDP and population contextualizes the IOS. CE and ARCH are innovations relative to current governance and business. They require adopting new ideas and methods.

The European Innovation Scoreboard – The data include the European Innovation Scoreboard 2019 for the 30 countries in the study. As shown in Fig. 4, the majority of the seven countries representing the top 20 cities of the Index are strong innovators. One country, Sweden, is an innovation, leader and one country, Spain, is a moderate innovator. The analysis confirms that innovation, CE, and ARCH coincide in many European cities that rank high on the Index.

Correlation of the Dimensions: Table 5 presents a correlation matrix of the three dimensions. The correlation analysis highlights that the dimensions are positively correlated; however, only the Environmental Stewardship and Socioeconomic / Demographic Dimensions are moderately positively correlated. This could be interpreted as cities with high population and GDP also have high environmental concerns.

5. Conclusion

The Circular City Adaptive Reuse of Cultural Heritage Index is a composite indicator that estimates the investment opportunity set for CE and ARCH in cities across Europe. This previously unavailable tool is empirical and informative. The motivation for creating a composite indicator is to provide a new methodology to support decision-making, primarily in municipal government.

City managers across Europe can use the Index to benchmark their cities' progress in comparison to others and determine whether ARCH should be a key element of their CCPs, budgets, and policies. The Index is also useful for funders, investment committees, and firms interested in implementing CE-driven rehabilitation, renovation, and reuse of existing cultural heritage buildings in European cities in line with the Renovation Wave Strategy.

From a European policy perspective, the Index provides a new look at where the Green Deal's Renovation Wave can be implemented across Europe to improve environmental outcomes while reaping the socioeconomic benefits of cultural heritage. The major policy implications

derived from the Index findings are action-oriented for the EC and for the high-ranked cities.

European Commission

- The top 50 cities are all in Western and Central Europe; therefore, more emphasis on CE and ARCH for more diverse countries is needed. The authors recommend that the EC work with the Covenant of Mayors for Climate and Energy's Eastern Partnership to disseminate CE and ARCH policy rationales and strategies as part of the Renovation Wave.
- Most of the top-ranking city governments are prioritizing climate change and greenhouse gas reductions through formal city networks and climate action pledges. The EC should seek to increase municipalities' awareness and capabilities about the climate change benefits of ARCH and CE through greater cooperation with city networks.

Highly Ranked Index Cities

- Eleven of the top 20 ranked cities should consider implementing their own local CCP, if the city is not already participating in a regional CCP.
- All highly ranked cities should review the current protocols for building procurement, energy efficiency, and C&D waste management in light of ARCH.

The top 10 ranked cities are Paris, London, Berlin, Liverpool, Madrid, Lille, Stockholm, Luxembourg, Amsterdam, and Essen. The study spotlights cities like Bristol, Barcelona and Rotterdam that are not capital cities and make a strong case for implementing CE with ARCH. According to the Index, these cities are currently at the vanguard of CE and ARCH. The research community can investigate ARCH's ability to address CE goals (i.e., greenhouse gas and waste reduction) in these cities to provide a stronger empirical basis for EU and urban policies. Further, these cities have tested strategies that others may replicate to maintain the value of ARCH for the city's future success.

Data statement

The Circular City Adaptive Reuse of Cultural Heritage Index ranking of the full 190 cities analyzed are available here (https://data.mendeley.com/datasets/8jzr4f5khr/draft?a=24a1a005-f7f7-43c5-8c42-7db78f472b40). The underlying data are available as supplementary materials upon request.

CRediT authorship contribution statement

Gillian Foster: Conceptualization, Methodology, Investigation, Formal analysis, Writing – review & editing. **Ruba Saleh:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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[14] https://ec.europa.eu/environment/europeangreencapital/

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