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www.drarch.org
info@drarch.org editor@drarch.org

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Editorial

Mehmet Topçu (Editor in-Chief)

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As DRArch team, we came again with good news on this issue. DRArch also managed to take place in the following abstracting, databases & indexing; DOAJ (Directory of Open Access Journals), TRDizin - TR Index (Tubitak, Ulakbim Türkiye), EBSCO, these developments raise our hopes that our path is correct.

DRArch has published Volume 4, issue 1, with articles of high scientific quality. The article "Resilience in the shadow of systemic risks" by Seda Kundak provides a broader perspective and a systematic review focusing on the commons of resilience and systemic risks in the frame of risk mitigation. Considering the earthquake that took place in Turkey on February 6, 2023, the importance of this article increases. Drarch plans to issue a special issue.

The second paper is titled "Agglomeration of population and employment in the urbanization - industrialization interaction: The case of İzmir," comes from Emine Yetişkul and Fahrettin Kul. The article focuses on recent agglomeration and dispersion processes in the settlement pattern from the relationship between urbanization and economic growth. They investigate spatial agglomeration in the İzmir city region and metropolitan area by using population and employment data from 2009 and 2019. Based on empirical results, they discuss new sub-regions, urban centers, and clustering that emerged due to economies of scale and positive and negative externalities of agglomeration. The article "Citizen science projects in the context of participatory approaches: Case of Izmir" by Pelin Özden and Koray Velibeyoğlu again focused on İzmir. This article will contribute to better manage natural resources, monitor endangered species, and maintain protected areas, decision-makers, and non-governmental organizations.

The fascinating piece of work comes from Hasan Mutlu, Başak Billur Mutlu and Vedia Dökmeci with the article titled "Comparison of spatial distribution of pharmacies in Istanbul between 1997-2022". In this study, the spatial distribution of pharmacies is investigated in Istanbul by taking into consideration their important role for the health care delivery system. Suggestions has been made for more balanced distribution of pharmacies in order to prevent bankruptcies while sufficient accessibility provided for the customers, and for future research.

The authors, Elif Vurucular Kesimci and Ayşen Ciravoğlu aim to investigate the impact of urban public space on the consciousness, interaction and gathering of city dwellers and urban movements. This research has investigated the impact of urban public space on the consciousness, interaction and gathering of city dwellers as well as urban movements. Within the scope of the research, eight "rebel cities-Tunis, Cairo, Barcelona, London, New York, Dublin, Paris, and Hamburg-" had been analyzed. The places where urban movements were visible in urban space and their surroundings have been analyzed using the Space Syntax method, and the gathering/unification/integration potential of public space has been spatially investigated by determining the characteristics of urban patterns.

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In Celal Erdoğdu's study titled “Beyond luck: The key to profitable residential real estate investments for individual investors in Turkey,” does the individual housing investor see all the opportunities in the housing market? What types of buyers are taking advantage of these opportunities? It started with two basic questions.

This study aims to create tools to help individual residential investors identify opportunity periods in the market, analyze such opportunities retrospectively and test consumer behaviors in response to these opportunities.

Since the advent and usage of artificial intelligence approaches in architecture, a significant number of studies have focused on integrating technological solutions to architectural issues. Buse Bölek, Osman Tutal and Hakan Özbaşaran focused on this current issue in their study titled "A Systematic Review on Artificial Intelligence Applications in Architecture."

Zahra Zamani aims to fill the void of knowledge through an objective comparison of three science and research buildings' architectural, casework, and module properties in her article titled as " Analyzing design and planning trends in medical research laboratories and workplace environments: A benchmarking study" The focus was to retrieve and compare laboratory workspace metrics trends essential for planning decisions.

Hakan Ünalan and Emrah Gökaltun's article titled " Alternative window wall ratio of glasses with different solar heat gain coefficient and solar transmittance and their effect on total energy consumption in alternative directions" in which they focused on the energy simulation model of the building, heating energy, indoor-outdoor environment and climate data were defined, energy consumption verification was carried out and a realistic model was achieved.

The last article of the issue written by Nilay Özsavaş Uluçay has the titled “Basic design course through art-based research in interior architecture education”. This article presents the basic design course applications based on the design education of first-year interior architecture students. This study aims to emphasize the importance of education in the design-oriented thinking process with practice through the content of the basic design course. Within the scope of the study, art-based research in interior architecture education was carried out, and the intersections of its results are described. In the studio, basic design elements and principles were conveyed with the techniques commonly taught in schools, and architectural movements were given to students as term papers for research. The study directs the student to create 2D and 3D compositions by combining the studies he/she has done during the term and the research assignment. The findings show that students can reflect on their research on architectural movements to new three-dimensional abstract spaces by combining them with basic design education.

As the editor in-chief of 4th volume, first issue DRArch, I would like to extend my deepest gratitude to all participants and to all our readers for the support they provide to the Journal. And I would like to a special thanks to the referees. We look forward to your comments, contributions, suggestions, and criticisms.

Best regards…

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Following names that provided valuable contribution as referees of articles in this issue are:

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DRArch's objectives are:

- to question how future building technologies are revolutionizing architectural design, city planning, urban design, landscape design, industrial design, interior design and education,

- to catalyze the processes that lean on interdisciplinary and collaborative design thinking, creating a resilient thinking culture,

- to improve the quality of built environment through encouraging greater sharing of academicians, analysts and specialists to share their experience and answer for issues in various areas, which distributes top-level work,

- to discover role of the designers and design disciplines -architecture, city planning, urban design, landscape design, industrial design, interior design, education and art in creating building and urban resilience,

- to retrofit the existing urban fabric to produce resilience appears and to support making and using technology within the building arts,

- to discuss academic issue about the digital life and its built-up environments, internet of space, digital in architecture, digital data in design, digital fabrication, software development in architecture, photogrammetry software, information technology in architecture, Archi-Walks, virtual design, cyber space, experiences through simulations, 3D technology in design, robotic construction, digital fabrication, parametric design and architecture, Building Information Management (BIM), extraterrestrial architecture, , artificial intelligence (AI) systems, Energy efficiency in buildings, digitization of human, the digitization of the construction, manufacturing, collaborative design, design integration, the accessibility of mobile devices and sensors, augmented reality apps, and GPS, emerging materials, new constructions techniques,

-to express new technology in architecture and planning for parametric urban design, real estate development and design, parametric smart planning (PSP), more human-centered products, sustainable development, sustainable cities, smart cities, vertical cities, urban morphology, urban aesthetics and townscape, urban structure and form, urban transformation, local and regional identity, design control and guidance, property development, practice and implementation.

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Editorial Team

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Research Article
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Resilience in the shadow of systemic risks

Seda Kundak*

Abstract

Systemic risks possess a high level of complexity and uncertainty that can be latent behind the veil of initial stress of possible disasters. They refer to, on the one hand, the functionality of interconnected systems and, on the other hand, the probability of indirect losses which can propagate through larger territories. Once considering the solid definition of resilience by the United Nations, the emphasis tends on systems' ability to different facets of disturbance rather than the performance of the sum of each singular entity confronting the main shock. This paper aims to provide a broader perspective and a systematic review focusing on the commons of resilience and systemic risks in the frame of risk mitigation. The outcomes highlight the urgency of multidisciplinary actions, which have not been achieved yet since the 1999s earthquakes.

Keywords: systemic risks, resilience, Kahramanmaraş Earthquakes

1. Introduction

The concept of resilience is described from two prevailing perspectives: engineering resilience and ecological resilience. Engineering resilience is bouncing back to the initial state after a disturbance. Consequently, this denotation displays the static features of the affected items. Therefore, the definition of engineering resilience seems incomplete once considering the broader definition of ecological resilience on which social resilience is also based. However, engineering resilience refers efficiency of function, whereas ecological resilience is related to the existence of function (Holling & Gunderson, 2002). By definition, engineering resilience represents the controllability of systems, while ecological resilience emphasizes the equilibrium of systems within their new features after external disturbance. Even though these two perspectives are considered flip-side, they provide a complementary approach to better understanding systemic risks.

Systemic risk refers to functional deformation or overwhelming of systems of which the negative impacts propagate through other systems and larger territories. Economic crises, breaks in the supply chains and indirect losses of disasters represent some specific examples of systemic risks. The rise of systemic risks can also be related to a high level of globalization. Today, instead of hosting the production of all local needs in place, the production process is dispersed worldwide to take advantage of location, labor force, sources and legal frame. Furthermore, this increasing connectivity boosts new collaborations of local actors to build a coherent network system to enhance innovation at all levels. A low frictional environment accommodated by these networks makes long distances closer with a high volume of exchange and mobility. As expected, these complex systems also provide a convenient milieu for the propagation of adverse conditions. Here, systemic risks take to the stage as unpredictable, less controllable and sophisticated actors.

This paper aims to provide a broader perspective and a systematic review focusing on the commons of resilience and systemic risks in the frame of risk mitigation. In the first section, the review of systemic risks is presented. In the next section, components of resilience are evaluated in the frame of urban systems. The following section is devoted to the systemic impacts of

*Seda Kundak, Istanbul Technical University, Türkiye, kundak@itu.edu.tr
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earthquake disasters in Türkiye, emphasizing the 2023 Kahramanmaraş earthquakes. In the final part, the concluding remarks are drawn.

2. Review of Systemic Risks

Risk, as a notion, holds uncertainty and probability, which discuss estimations of conditions and consequences for an undefined time slot in the future. From the broader perspective of the definition, risk-taking behavior may have resulted either positively or negatively. However, confronting natural or technological hazards, there would not be any winner among risk-takers. The classical risk analysis approach covers the probability of a threat and vulnerability of exposed objects. In several cases, the value of assets is also included in the equation. In recent decades, the tendency to improve innovative approaches in the risk analysis field has arisen due to the compounding and cascading impacts of disasters. The prospective methods have been expected to enfold dynamic features and propagation of risks which can be delineated according to the root causes of disasters. Systemic risks, from this viewpoint, are located on the main focus of risk challenges.

To move forward on systemic risks, a brief look through system theory (system approach) would enable us to highlight the general approach to the systems. The systems theory is based on studies in different fields by different disciplines (Mingers & White, 2010). In Bertalanffy's general systems theory (1969), each system and its sub-systems are considered a unified structure formed by the interdependent parts within itself and their interaction with each other and with their environment, as they are open systems. A continuous development/evolution with new features acquired as a result of continuous interactions between parts and the self-organization of this open system through feedback are among the defining features of this system (Bertalanffy, 1969; Skyttner, 2005). This theory has experienced rich interaction with fields such as complexity, system dynamics and cybernetics and also had a significant impact on Luhmann's theory of social systems (Montuori, 2011; Luhmann, 1995). Forrester (1970), who gave valuable contributions to the development of system dynamics, was interested in modeling dynamic system behaviors such as the industrial supply chain and the movements of the population in the city with the current flow, information, feedback and delay relationships (Mingers & White, 2010). In his studies, Forrester used system analysis as a tool in urban planning in which he considered cities complex systems (Forrester, 1970). He analyzed critical factors in the development of the cities and promoted the urban dynamics model to estimate the future of urban areas (Forrester, 1969). Another model in the discipline of urban and regional planning with the systems approach was launched by McLoughlin (1969). He developed cybernetic models to understand better and estimate the interaction between human and their physical environment and, consequently, their impacts on changes. System theory studies where cities are considered complex systems enriched risk management and sustainability research (Bach et al., 2020). For instance, as one of the most notable contributions to the concept of resilience, Holling (1973) based his study on system theory on delineating ecological systems' resilience which provides a novel approach to the field of risk reduction (Alexander, 2013).

The fundamental theories on risk assessment have created more inclusive and integrated frameworks by transforming the approaches in different disciplines at every stage of society's transition from the industrial revolution to modernization and today to digitalization. Ulrich Beck's 1986 Risk Society and Antony Giddens' 1990 Consequences of Modernity pioneered the discussion of the relations between risk and society in the scientific world. Beck (1986) drew attention to the new risks produced by modern society by revealing the relationships between socia l and spatial differences and risk formations. Giddens (1990) defines modernity as risk culture. He states that in this culture, an advanced specialization and focus are required to identify risks, but this may cause the problem of needing to be able to connect with the whole. In both works, it has been emphasized that as a result of globalization and increased interaction between systems, both the distribution and spread of risks and the size of their impact have grown. Luhmann (1986) and Habermas (1987) examined risks through the systems approach. Luhmann (1986) describes the environmental and

social systems of modern society as a production system. He states that the interaction and communication between systems should also be considered in the context of risks since the output of one system is the input of another. Although Habermas (1987) has a similar approach, he argues that interactions and communications between systems should be examined at the public sphere level, including social, cultural and economic components. Even though the referred studies of these four distinguished scholars did not put systemic risks in words, it is clear that they warned the scientific community about such complex disruptions. In the OECD's report, dated back to 2003, systemic risks are included in the assessment of new risks for the 21st century. In the report, critical topics within the scope of the development and impacts of systemic risks due to natural and anthropogenic threats are defined as follows:

- Increasing mobility and complex inter-system structuring: In addition to human mobility, spatial mobility of products and production processes are expressed in this chapter. Problems in the natural environment and quality of life caused by human activities and production systems have begun to show their medium and long-term effects (e.g., climate change), revealing the necessity of evaluating systemic risks at regional and international levels.

- Increasing density of settlements and human activities: Urbanization and rapid population growth cause increased risks in hazard-prone areas. In addition, excessive loads on the infrastructure and social and economic systems of high-density settlements make these systems vulnerable and consequently increase systemic risks.

- Increasing risks and uncertainties: It has been observed that the collateral and the systemic impacts of disasters have tended to increase in recent years. This situation causes uncertainties to augment and traditional methods to be insufficient in risk assessment.

- Exchange of responsibilities between stakeholder groups or actors: Risk management approaches that are centralized and structured on a command system are likely to be inadequate in the future. Therefore, it is necessary to increase risk awareness, ensure cooperation, produce a coherent and applicable legal framework, and develop international instruments when necessary.

- Social change and perception of risks: With modernization, society's perspective, perception and reactions to old risks (such as earthquakes) and new risks (such as technological) differ.

In the systemic risk literature, the features on the spatial, social, economic and cultural environments align with the 2003 report of the OECD. In addition to the increase in population and population density (Rosa et al., 2014), construction on sensitive and hazardous areas (Rundle et al., 1996) and the threats posed by increased consumption on the resource system (Rosa et al., 2004) are listed as the main factors of systemic risks. Moreover, the presence of multiple and non-linear interactions and reflections (Klinke & Renn, 2000) due to the interdependence (dependence) between technical (technological), social and cultural systems affect systemic risks. Systemic risks refer to the probability of deterioration in the system's functioning rather than the deterioration of individual structures or components in any system (Kaufman & Scott, 2003). Systemic risks are also defined as risks that can cross borders. Here, the definition of cross-border is expressed as beyond the natural and administrative borders (Hannigan, 2012). This propagation which may occur in sub-systems and is likely to affect the upper systems, cannot be explained by fragmented approaches in the assessment and management of systemic risks based on subjected areas or geographical units (Lidskog et al., 2010). Rosa et al. (2014) produced a list of what systemic risks are not instead of defining what systemic risks are. If the risk is at an acceptable level and can be simplified, if the uncertainties regarding its occurrence or impacts can be eliminated, and if the entire society is safe by keeping the risk under control, the presence of systemic risk cannot be mentioned.

The critiques on the cities in the post-industrial era (Anthropocene) have been focused on diversity, connections and complexity (Rocha et al., 2015; Zinn, 2016; Cutter, 2021). Since the diversity of consumption-based products in urban areas is provided as a result of the commercial networks developed by the settlement rather than its production, this system of relations is complicated by numerous intermediary structures. While the entire system offers advantages in

meeting the needs and development of settlements, any problem that may develop at any point in the system can spread through established networks. In this context, it is suggested that cities should create a controlled network system and transform it into a more autonomous structure to ensure diversity within their borders (Keys et al., 2019; Elmqvist et al., 2021). As a result of rapid urbanization and migration, the inadequacy of urban infrastructure and social services in the face of concentration in urban areas increases systemic risks (Chen et al., 2019). Furthermore, in the urban economic system, while single product-oriented developments create obstacles to economic diversity and decrease job opportunities, they may also cause favorable conditions for systemic risks (Ma, 2020).

The debate on delineating systemic risks has been limited to more than just the scientific milieu. Following the spark generated by the OECD report in 2003, in preparing the Sustainable Development Goals, systemic risks have also been considered as a new lens to achieve risk-informed sustainable development (Figure 1) (UNDRR, 2019). Four main framework channels on risk reduction, sustainability, climate change and human settlements have been associated with ensuring focus on systems' interconnectivity to be prepared to deal with future risks. Furthermore, as indicated in Figure 1, a notable shift from the hazard-based approach to the social dimension of risks included several disciplines for risk reduction. Today, state-of-the-art on risk issues implies a holistic perspective on impact chains and systemic risks.

It is worth noting that systemic risks are crucial problems of the modern world due to their great potential to cause new Black Swans that have been named and described by Taleb (2007). Even though the re-occurrence of natural hazards is considered probable, the impact chains may cause "highly improbable" systemic failures. Therefore, novel approaches for analyzing systemic risks introduce a critical research area in evaluating impact chains of disasters (Centeno et al., 2015). Furthermore, these new approaches are expected to be integrated with risk management systems (Renn & Klinke, 2004; Schweizer & Renn, 2019; Renn et al., 2020; Schweizer, 2021; UNDRR, 2022; Trump et al., 2017).

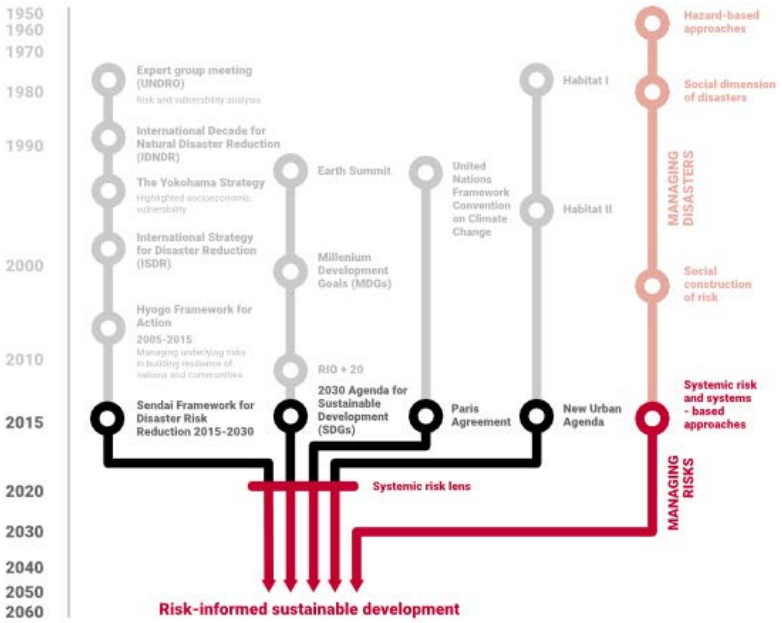

Figure 1 Risk reduction – a journey through time and space (UNDRR, 2019; pp:25)

3. Resilience of systems

According to the UNISDR (2009), resilience is defined as: "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.". This long and comprehensive definition covers different components of resilience. The first segment (system, community, society) refers to the dynamic features and complexity; the second one (resist, absorb, accommodate to, recover) points out the adaptive capacity confronting disturbance; the third one (timely, efficient) is about the governance; and the last part (essential basic structures, functions) presents the integrity and performance against external shocks (Kundak, 2017). In the long journey of the concept of resilience since the 1970s, many prominent definitions have been presented in the various scientific fields to understand its components better and improve its implementation methods. Within the acknowledgment of broad literature on resilience, the systemic perspective of the resilience debate has been focused on here.

As a simplified presentation of a typical system, a set of related entities and sub-systems forms integrity to ensure their existence and functioning (Figure 2). The urban system (S in Figure 2) can be taken as an example to study the systems' dynamics. It covers sub-systems (S1) of production, services, transportation and infrastructure. Likewise, each sub-system includes entities (or sub-sub-systems) such as infrastructural systems consisting of water, sewerage, electricity, natural gas and communication (S2). All the components of the systems interact with each other at certain levels. For instance, the electric system (S2), a part of the infrastructural system, has a more significant impact than the other entities on the functioning of the sub-systems (S1). Similarly, some sub-systems may directly affect the entities of the other sub-system rather than affecting the entire sub-system. For example, the degradation of ecological systems and climate change may cause bottlenecks in water supply and consequently affect the urban water system. On the other hand, it is worth noting that all systems (e.g., cities) establish linkages with other systems (e.g., cities) to enhance interactions and exchanges among them.

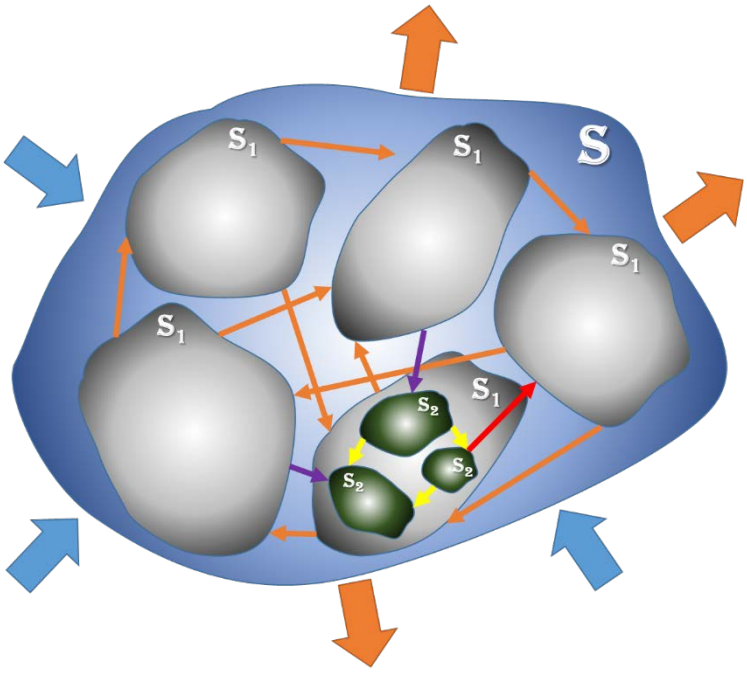

Figure 2 System, sub-systems and entities

The large systems (e.g., large cities) are so big that it is not possible to turn them upside down completely (Gunderson et al., 2002). In other words, these systems are not affected by short-term or relatively small disturbances due to their size. Their resilience mostly depends on redundancy (Folke et al., 2002; Godshalk, 2003; Adger et al., 2005; McDaniels et al., 2008; Xu et al., 2021) in the form of multi-nucleus structures and alternatives. Furthermore, the diversity of the systems is evaluated as a significant attribute that generates redundancy to build resilience in complex systems (Folke et al., 2002; Fiksel, 2003; Godshalk, 2003; Adger et al., 2005; Chuvarajan, 2006; Berkes et al., 2002; Marcus & Colding, 2014). Even though the complexity increases uncertainties, it allows the systems to persist. What has been described so far shows that large systems are not unbreakable but hard to break. Once the large systems confront an intense disturbance that they cannot cope with, it leads to internal functional failures and adverse impacts on neighboring systems (Holling & Gunderson, 2002). This violent scene is where systemic risks show up. For example, large cities perform the role of primacy in the hierarchical structure of their geography and high centrality in the global network. This positioning allows large cities to establish numerous connections not only in exchanging goods and services but also socially and culturally. As mentioned in the previous part, these connections are also convenient for systemic risks to travel and propagate. Furthermore, the real challenge comes with systems that correspond to different scales, cross-scales and dynamic structures, where the focus on one scale misleads the evaluation of the probable impacts (Pritchard, L. Jr. & Sanderson, 2002; Pritchard, 2000; Chuvarajan, 2006). Another most mentioned attribute of resilience is robustness which can be relied on the resistance and stability of any system against inevitable shocks (Folke et al., 2002; Godshalk, 2003; Bruneau et al., 2003; Adger et al., 2005; Van der Veen & Logtmeijer, 2005; Chuvarajan, 2006; UNESCAP, 2008; XU et al., 2021). On the one hand, robustness defines how the systems are strong enough to stay steady; on the other hand, due to a rigid structure can cause obstacles to flexibility. From this viewpoint, Holling and Gunderson (2002) question resilience to develop a social and ecological perspective based on dynamic attributes. Considering resilience as resistance, “it is not an ideal in itself” and “it can be the enemy of adaptive change” (Holling & Gunderson, 2002, pp31-32). Therefore, the systems need creative destruction (Schumpeter, 1950) to move forward by developing innovation and entrepreneurial activities such as startups and unicorns of our era. It is worth noting that systems without precession, transformation and improvement perish.

To delineate resilience through the lens of systemic risks, time and spatial parameters play a crucial role. Temporal parameters cover the historical background of current conditions and consequences, as well as the response, recovery and mitigation phases of risk management activities. Spatial parameters refer to directly affected areas by the calamity and indirectly affected geography by the losses. In Figure 3, three different notations have been combined to reveal processes related to resilience and systemic risks. Blaikie et al. (1994) produced a comprehensive diagram to show the root causes and progression of vulnerability. At the starting point, limited access to critical resources and ideological approaches create a susceptible environment that would subsequently develop vulnerabilities. Next, the lack of institutional and administrative cohesion and macro scale dynamics increase and propagate vulnerabilities in the systems' functioning. Finally, after a long journey, accumulating all inconvenient decisions and implementation leads to unsafe conditions.

The second part of Figure 3 emphasizes the impact chain of disasters on a small piece of an urban system (Kundak, 2023). Once considering the given hazard as an earthquake, the initial impacts of an earthquake are shown with black arrows. At first, buildings, roads, infrastructure systems and industrial facilities receive damage. The red arrows indicate the first-level impacts that the initial damages can cause. Damage to buildings causes loss of life and injuries and leads to road closures and failures in infrastructure. Fires, explosions and leaks can follow damage to industrial facilities. Damage to roads slows search and rescue operations down, while damage to infrastructure (natural gas, electrical systems) increases the number of casualties. Yellow arrows correspond to the second level of the impact chain. Explosions and fires at industrial facilities may cause damage to buildings nearby, as well as probable leakages, which can increase the number of

casualties. In addition, depending on their location, these facilities are likely to affect search and rescue and evacuation operations. Therefore, these disruptions make it difficult to respond to disaster victims on time.

The last part of Figure 3 focuses on the systemic impacts of a disaster. Past disasters have shown that indirect impacts are not limited to the most affected areas; contrary, direct losses have impacts on functioning and production activities which can be considered a wide range of systemic impacts. In the aftermath of disasters, the length of the recovery process depends on preparedness for this process. In a typical risk or disaster management procedure, even though there is a strong emphasis on the response phase, the recovery process is mainly evaluated as a reconstruction business. Furthermore, in the lack of recovery plans, fragmented implementations would present potential problems regarding urbanization and future development. The long recovery process causes a decrease in the quality of life of not only survivors but also all inhabitants of the affected area. This may cause obstacles in social inclusion and disruption in social capital. At the individual level, a long recovery process does not help to ease the impacts of post-traumatic syndrome. At the community level, the label "disaster survivor" turns from a deep empathy into an exclusion. The polarization in the community leads to erosion in trust which creates a handicap in social cohesion. Migration is another expected consequence of large-scale disasters, which transfer disaster impacts to other settlements that are unprepared for a sudden and mass population flow. Besides physical damages to business units, including industry, services and commerce, the losses in the community result in business disruption and a reduction in production. There are two facets of this scene. First, it causes challenges in access to basic needs and services for those living in the disaster area. Second, the pause in businesses affects the production sphere either at a regional or national scale because of the breaks in the supply chain. The overall losses of disasters are counted by their representation in the GDP rather than absolute values. Greater losses indicate the long and drastic economic recovery process, which would result in inflation and poverty nationwide.

4. Discussion: Kahramanmaraş Earthquakes

Until February 2023, the earthquakes of Erzincan (1939) and Kocaeli (1999) were the most devastating disasters in the history of the Republic of Türkiye. On December 27th, 1939, at 01:57, an earthquake with Mw 7.9 occurred in Erzincan, which also affected a large territory including Tokat, Ordu and Samsun (KRDAE, 2023). Because of the limited communication technologies of the time and the vast damage in the affected geography, the government informed the earthquake in the early morning. Before the major earthquake, on November 21st, 1939, Erzincan had been hit with a Mw 5.9 earthquake where many buildings received severe damage and 43 inhabitants lost their lives (KRDAE, 2023). Accordingly, it can be assumed that the buildings damaged in the previous earthquake were destroyed in the earthquake on December 27th. The Erzincan earthquake caused 116.720 buildings to collapse and killed 32.968 people (KRDAE, 2023). Due to the harsh winter and railroads deformed by the earthquake, it took a while to reach the affected areas. The most iconic decision on disaster response and recovery took place after the Erzincan earthquake. The prisons in the disaster area collapsed or suffered severe damage and were uninhabitable. Fethi Okyar, the Minister of Justice, proposed to employ prisoners and detainees to support disaster response and recovery activities and suspend their execution (Haçin, 2014). After the decision taken in January, in April 1939, prisoners and detainees were released due to a new amnesty law. In the post-disaster period, many survivors were guided to move to other cities such as Istanbul, Ankara, İzmir, Adana, Bursa and Giresun. Until the summer of 1940, some turned back to Erzincan and some established a new life in the cities where they had moved after the earthquake (Haçin, 2014).

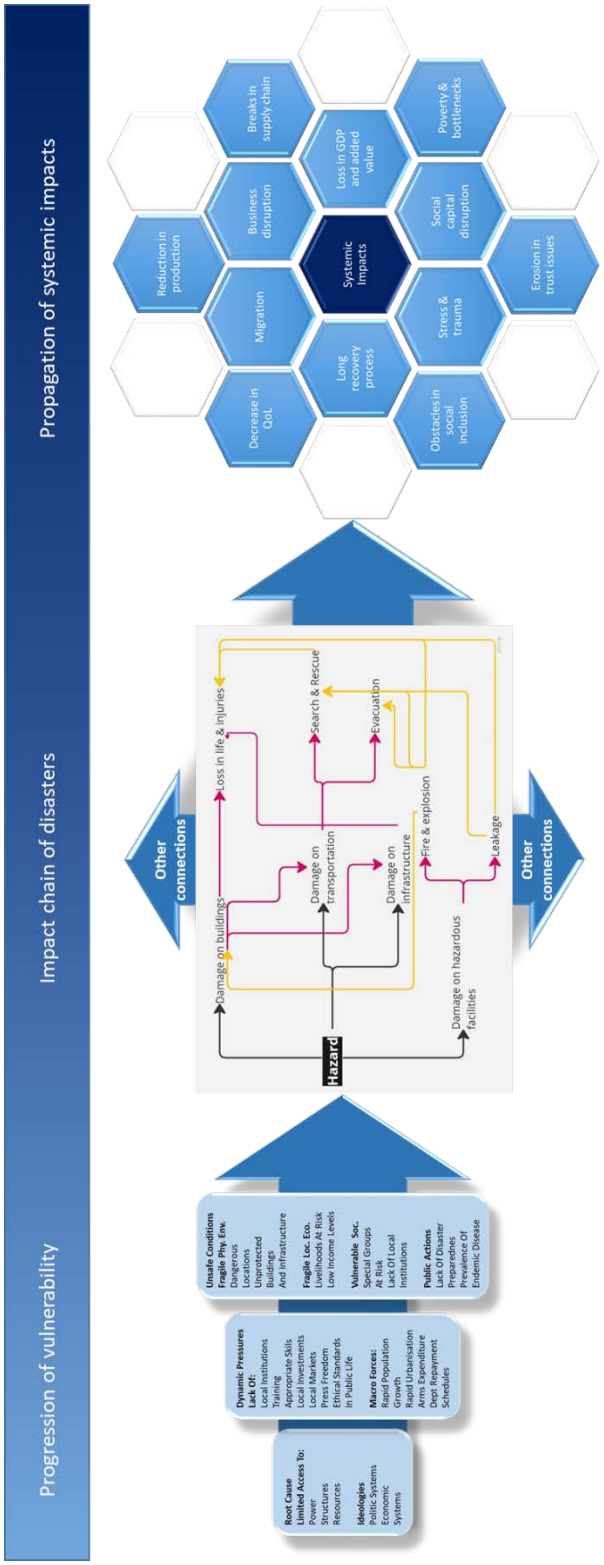

Figure 3 Comprehensive view of disasters

On August 17th, 1999, at 03:02, an earthquake with Mw 7.4 occurred in Gölcük/Kocaeli. According to the official records, 18,373 people lost their lives, 48,901 people were injured, 96,796 houses and 15,939 workplaces were destroyed or heavily damaged. About 250.000 people became homeless and many had to move to other cities (T.B.M.M., 2010). As a more specific example, Südaş (2004) stated that approximately 25% of the residents of Gölcük affected by the 1999 earthquake migrated. According to the reports prepared after the 1999 earthquake, the economic losses caused by the earthquake were around 10 billion USD, corresponding to approximately 4% of GDP (World Bank, 1999; Bibbee et al., 2000). In the damage report prepared by the Turkish Earthquake Foundation, direct losses are estimated to be over 5 billion dollars (Özmen, 2000). On the other hand, this major disaster in Kocaeli, where about 23% of the intermediate goods in Türkiye's manufacturing industry are produced, led to an increase in the import of intermediate goods across the country (Kotil et al., 2007). Therefore, the Kocaeli earthquake is considered notable and a milestone in many aspects. First, it was the first time that Türkiye experienced a big na-tech disaster due to the fire at the Tüpraş Oil Refinery and the leakage and release of toxic substances by industrial facilities. Second, the earthquake showed how cities became vulnerable in the last decades due to rapid population growth and disregard for regulations on construction and planning. Third, with a new perspective, the paradigm shifted from disaster management to risk management. The establishment of novel tools such as the Turkish Catastrophe Insurance Pool (TCIP) in 2000, the law on building consultancy in 2001, the Disaster and Emergency Management Authority (AFAD) in 2009, Türkiye's National Disaster Response Plan in 2012 and the Urban Transformation Law in 2012 had been evaluated as significant progress to cope with disasters and reduce risks.

On February 6th, 2023, at 04:17, an earthquake occurred with a Mw 7.7 in Pazarcık/Kahramanmaraş and lasted for 65 seconds. Then it was followed by a Mw 6.8 aftershock 11 minutes later. About 9 hours later, another earthquake occurred with a Mw 7.6 in Elbistan/Kahramanmaraş and lasted for 45 seconds. Considering the length of shaking, they are longer and even, respectively, than the 1999 Kocaeli earthquake, which lasted 45 seconds. As it can be noticed, even the aftershock of the earthquakes is bigger than the 2003 Bingöl and 2020 Elazığ earthquakes. On February 20th, 2023, two aftershocks with Mw 6.4 (at 20:04) and Mw 5.8 (at 20:07) occurred in Samandağ/Hatay. By March 15th, 2023, more than 15000 aftershocks occurred in the affected zone, of which 44 are between Mw 5.0-5.9 and three are between Mw 6.0-6.9 (KRDAE, 2023) (Figure 4). To understand the impact of these earthquakes on physical structures, the horizontal and vertical ground acceleration records are given in Figure 5 with the comparison of significant earthquakes in Türkiye since 1990. For instance, both acceleration records of the Pazarcık earthquake are 3,5 and 4,3 times higher, respectively of those in Kocaeli earthquake 1999 (İlki et al., 2023). As the gravity is 1.0, a horizontal acceleration of 1.38 and a vertical acceleration of 1.08 reveal the severity of the ground motion.

The February 2023 earthquakes affected 11 provinces, mainly Kahramanmaraş, Hatay, Adıyaman and Malatya. These 11 provinces represent about 16% of the total population of Türkiye. The tremors caused more than 50.000 loss of life, hundred-thousands of injured people and more than 2,5 million homeless. As the final official records have not been announced yet, the figures as of March 6th, 2023, help to understand the severity of physical losses (Table 1). In the 11 affected provinces, there are more than 2,6 million buildings, of which 89% are for residential purposes. Between February 6th and March 6th, 2023, about 34% of the total housing units have been controlled to define damage level. In Kahramanmaraş, Hatay, Adıyaman and Malatya, the ratio is more than 50%. Among the investigated housing units, 27% are either collapsed or heavily damaged, 7% are moderately damaged and 66% are slightly damaged. Even though the investigation processes have not been concluded yet in the most affected provinces, the share of collapsed and heavily damaged buildings reaches 20-25% of the total. After the earthquakes, without official confirmation, about 5 million people moved to other cities, mostly Ankara, Antalya and Mersin, according to the declarations of real estate experts and local agents. So far, the

challenging living conditions of the disaster areas and lasting aftershocks discourage people from turning back.

From the view of the national economy, the affected area represents almost 10% of the GDP in 2021 (Table 2). More specifically, the region generates a notable contribution to the national income due to agricultural, industrial and manufacturing activities. Furthermore, the share of the region in export is 9%, where Gaziantep is leading with 4,64%, then Hatay 1,57% and Adana 1,33% are following respectively. Still, it is too early to assess direct and indirect losses, yet some estimations based on the current market values and loss ratio of the Kocaeli earthquake have been reported. According to the World Bank (2023), the direct economic loss by physical damage is approximately 34,2 billion USD representing 4% of the GDP in 2021. The Presidency of Strategy and Budget (2023) denoted that the total direct and indirect economic losses may reach 103,6 billion USD, 9% of the expected GDP in 2023. Yılmaz (2023) presented probable lowest and highest losses that vary between 77,4-104,8 billion USD, equivalent to 8,6-11,6% of the GDP in 2021.

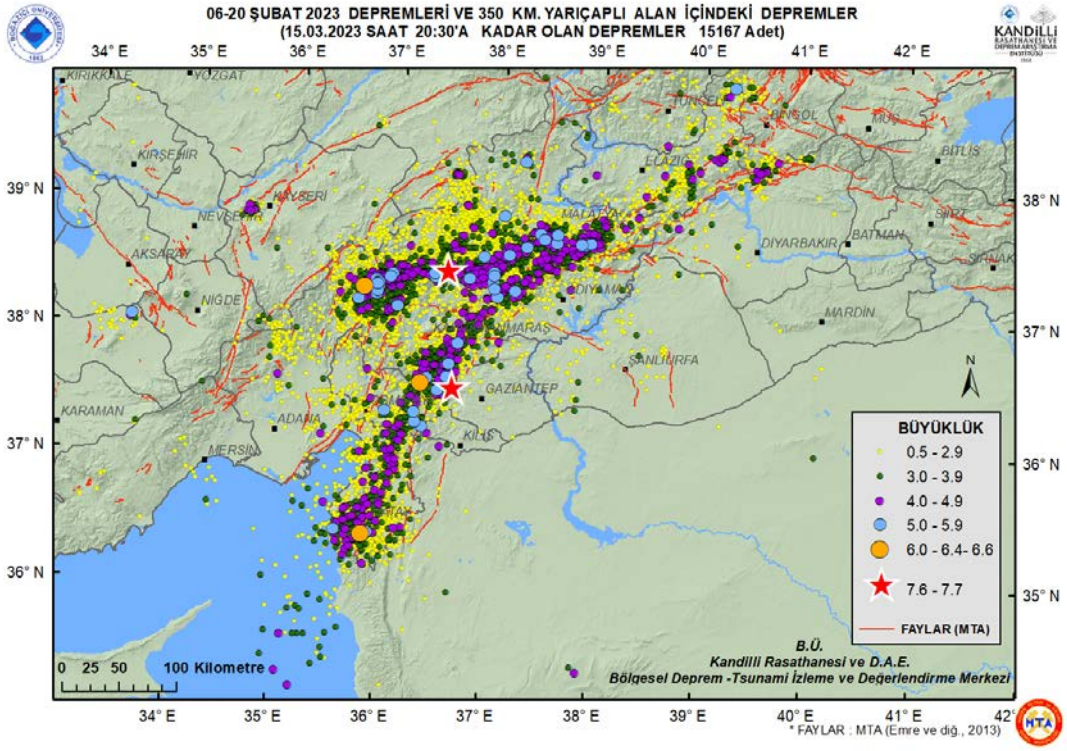

Figure 4 Epicenter of Kahramanmaraş Earthquakes and aftershocks (KRDAE, 2023)

The ongoing recovery process in the earthquake-affected provinces and the lack of reliable and coherent data make the presentation of a comprehensive discussion difficult without any misleading speculations. Nevertheless, following the tangible consequences of the February 2023 earthquakes, some remarks should be noted. The Disaster and Emergency Management Authority initiated the preparation of the Provincial Level Disaster Risk Reduction Plans in 2019 in pilot provinces and then, by the end of 2021, all provinces concluded their plans. These plans enclose the delineation of threats and exposure obtained by previous scientific research and the available database from institutions, different scenarios to reveal risks and strategies in risk mitigation and preparedness. In other words, even though the framework of the plans presents a new perspective, the scientific information on the hazards and vulnerability of settlements has been there for quite a long time, and yet nothing has been done. Referring to the progression of vulnerability diagram by Blakie et al. (1994), the accumulation of adverse decisions on urban plans resulted in a chaotic scene in the earthquake-affected provinces. Besides the performance of the response phase is another research topic related to administrative structures, the field operations, such as search and rescue activities, remained inadequate because of the complexity of the disaster. Regarding the

systemic impacts of these earthquakes, in the medium to long term, some bottlenecks are estimated not only in the economy but also in the humanitarian aspect.

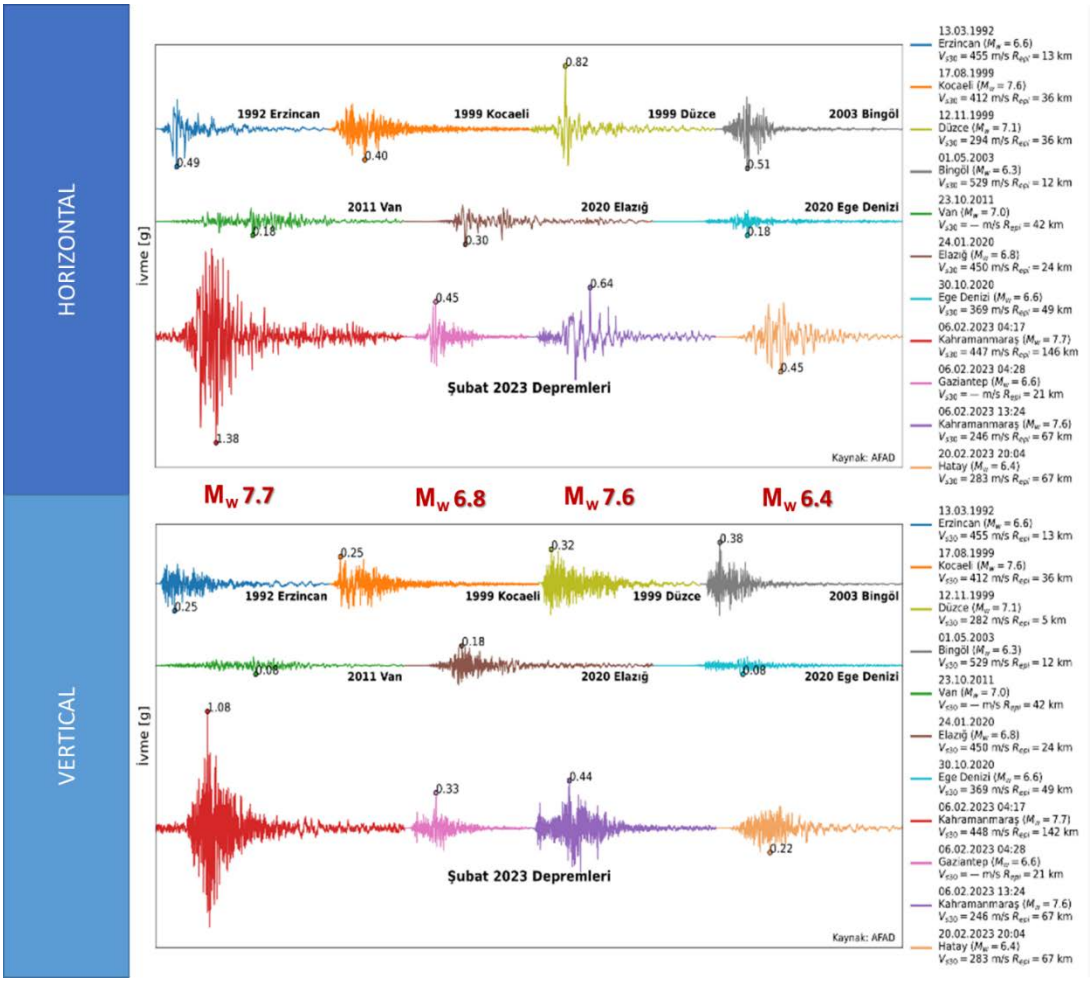

Figure 5 Comparison of ground acceleration records of major earthquakes in Türkiye since 1990 (İlki et al., 2023)

Table 1 Buildings and damage assessment of housing units (Source: The Presidency of Strategy and Budget, 2023)

		Residential Buildings		Housing Units	Damage assessment of housing units (as of March 6th, 2023)		Damage Control Report on Housing Units (as of March 6th, 2023)						
							Collapsed/heavily damaged		Moderately damaged		Slightly Damaged		Collapsed-Heavily damaged units/total
	Nb. of Buildings	#	%		#	%	#	%	#	%	#	%	(%)
Adana	451.117	404.502	89,67	972.561	85.792	8,82	2.952	3,44	11.768	13,72	71.072	82,84	0,30
Adıyaman	120.496	107.242	89,00	216.744	147.700	68,14	56.256	38,09	18.715	12,67	72.729	49,24	25,96
Diyarbakır	225.679	199.138	88,24	563.295	133.034	23,62	8.602	6,47	11.209	8,43	113.223	85,11	1,53
Elazığ	123.713	106.569	86,14	292.406	42.829	14,65	10.156	23,71	1.522	3,55	31.151	72,73	3,47
Gaziantep	305.683	269.212	88,07	893.558	285.903	32,00	29.155	10,20	20.251	7,08	236.497	82,72	3,26
Hatay	406.849	357.467	87,86	847.380	430.529	50,81	215.255	50,00	25.957	6,03	189.317	43,97	25,40
Kahramanmaraş	243.153	219.351	90,21	481.362	278.350	57,83	99.326	35,68	17.887	6,43	161.137	57,89	20,63
Kilis	37.312	33.399	89,51	74.976	31.786	42,39	2.514	7,91	1.303	4,10	27.969	87,99	3,35
Malatya	178.987	159.896	89,33	345.536	192.085	55,59	71.519	37,23	12.801	6,66	107.765	56,10	20,70
Osmaniye	143.080	128.163	89,57	243.436	89.699	36,85	16.111	17,96	4.122	4,60	69.466	77,44	6,62
Şanlıurfa	382.628	347.902	90,92	718.063	211.605	29,47	6.163	2,91	6.041	2,85	199.401	94,23	0,86
Affected Region	2.618.697	2.332.841	89,08	5.649.317	1.929.312	34,15	518.009	26,85	131.576	6,82	1.279.727	66,33	9,17

Table 2 Share in GDP and total export of 11 provinces (Source: TURKSTAT 2021, TURKSTAT 2022)

	Share in GDP (%) (2021)	Share in GDP by kind of economic activity (%) (2021)						Share in total export (%) (2022)
		Agriculture	Industry	Manufact.	Construction	Services	Financial services	
Adana	2	2,5	2,2	2,1	1,7	1,9	1,5	1,33
Adıyaman	0,3	0,8	0,3	0,2	0,3	0,2	0,2	0,04
Diyarbakır	0,9	2,2	0,4	0,2	1,2	0,5	0,4	0,13
Elazığ	0,4	0,8	0,2	0,1	1,3	0,3	0,2	0,14
Gaziantep	2	1,3	3,6	4	1,7	1,5	0,8	4,64
Hatay	1,4	1,3	1,8	1,9	1	1,4	0,5	1,57
Kahramanmaraş	0,9	1,4	1,4	1,3	0,8	0,4	0,3	0,65
Kilis	0,1	0,2	0,1	0,1	0,1	0,1	0	0,04
Malatya	0,5	0,9	0,5	0,5	0,7	0,3	0,3	0,2
Osmaniye	0,4	0,6	0,7	0,7	0,3	0,2	0,1	0,16
Şanlıurfa	0,8	3	0,4	0,3	0,8	0,5	0,3	0,11
Affected Region	9,7	15	11,6	11,4	9,9	7,3	4,6	9,01

5. Conclusion

In the context of cities and urban systems, several common features stand out in studies on disasters: (1) a tendency to identify urban risks through structural damages (potential damages); (2) a focus on cities affected by recent earthquakes; and (3) the evaluation of data over a single period. Considering the direct and indirect effects of disasters, it has become apparent that not only do the settlements face damage, but also the wide geography through urban network systems is affected. On the other hand, the fact that cities and urban systems are dynamic structures reveals that the studies to be carried out in this field should cover time-dependent trends and changes. Furthermore, systemic risk studies display the weakest or puzzling linkages/relations in urban systems, which would cause further problems when confronting hazards. Therefore, the debate on urban resilience is expected to be rooted in the interconnected systems' existence and functioning.

Systemic risk studies show that disasters are devastating not only for the affected region but also for more extensive geography. In other words, the February 2023 earthquakes should be seen as a disaster not only for 11 provinces but for the whole of Türkiye. Likewise, after witnessing the recent earthquakes, the earthquake risk in Istanbul has become a crucial topic once more. However, the problem is not just related to Istanbul; it concerns around 30 million inhabitants in the Marmara Region. Until now, the controversial and fragmented implementations of urban regeneration tools did not respond to risk mitigation efficiently. Additionally, large-scale investments favoring the growth of Istanbul and the Marmara Region have increased the exposure. On the one hand, problems remain from the past, and on the other hand, there are new items in the system to tackle. Furthermore, Istanbul still has an increasing dominance in the contribution to the GDP and export compared to the other provinces. Indeed, not all troubles can be resolved in a short period, yet establishing realistic strategies with integrated actions would be able to raise urban resilience. Therefore, the recent initiatives at both local and central government levels to reduce risks should be evaluated as a second or ultimate chance for the entire country.

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Resume

Assoc.Prof. Seda Kundak received her Ph.D. (2006) in Urban Planning about earthquake risk analysis from ITU. She attended graduate programs on earthquake and disaster resilient cities at the University of Geneva, ETH Zurich and Kobe University. She completed her postdoctoral research at the Politecnico di Milano in the EU 7th Framework Program Project on vulnerability and urban resilience. Between 2008-2009, she contributed to the preparation of consultancy and training materials in the ISMEP (Istanbul Seismic Risk Mitigation and Emergency Preparedness Project) project. She has consulted and authored books published by Istanbul Governorship and AFAD on urban risks and risk mitigation efforts. She was a board member of the Society for Risk Analysis-Europe between 2012-2020 and organized the SRA-Europe Congress in Istanbul in 2014. She was the president of SRA-Europe between 2017-2019. In 2017, she was awarded the international Distinguished Lecturer award by the Society for Risk Analysis (SRA) and Sigma-Xi for her work on risk issues and contributions to science. In 2022, she received the SRA Fellow award for his work in the field of risk analysis and his initiatives to bring together risk researchers, especially in the Eastern and Southeastern Europe. She conducted national and international projects on risk perception, disaster logistics, urban crime and resilience. She is currently working as a leading partner in the PARATUS Project supported under the HORIZON Europe - Disaster Resilient Society 2021 call.

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Agglomeration of population and employment in the urbanization - industrialization interaction: The case of Izmir

Emine Yetiskul*
Fahrettin Kul**

Abstract

As production and economic activities shaped the growth of cities during the pre-industrial era, they are still the most important factors explaining modern urbanization. Economic restructuring is being reshaped with agglomeration economies, bringing spatial restructuring with it. Regional economic growth, emergence of new centers and production foci are formed in the equilibria of positive and negative externalities of agglomeration. Positive externalities do not arise solely from internal economies of scale related to factors of production such as easy accessibility in the region. It also results from external economies of scale, including economies of localization and urbanization. On the other hand, as cities grow the attractiveness of large agglomeration and advantages of economies of scale decrease. Negative externalities in the larger agglomerations may eventually lead to decreasing returns to scale in cities. Economic view of regional science and geography considers cities maintaining equilibrium between two competing forces, i.e., centripetal forces (agglomeration) and centrifugal forces (dispersion). This study examines recent agglomeration and dispersion processes in the settlement pattern from the relationship between urbanization and economic growth. To do so, we take Izmir as a case and use general explanatory variables such as population and employment. Specifically, we investigate spatial agglomeration in the Izmir city region and metropolitan area by using population and employment data of 2009 and 2019. Based on empirical results, we discuss new sub-regions, urban centers, and clustering that emerged due to economies of scale as well as positive and negative externalities of agglomeration.

Keywords: agglomeration economies, clustering, population and employment change, settlement pattern

1. Introduction

The world population is increasingly living in cities. The proportion of the population living in urban areas in 2010 increased from 52% to 56.2% by 2020, and it is expected a reach 68% in 2050 (UN, 2022). Economy is the most crucial factor in explaining this accelerated urbanization and rapid growth of cities. Production and trade in the pre-industrial era also shaped the growth of cities. However, regional or urban centers mainly developed for political, administrative, or symbolic (including religious) reasons. Although these reasons remain essential, their influence has decreased relatively following structural changes in the spatial pattern of production and trade. Especially Post-Fordist and post-industrial economies have changed the structure and scale of production and trade. Both the scale of production and international trade has reached an unprecedented level, as was the scale of urban growth (Paddison, 2001). Within this framework, regions and cities have been restructuring. The long-championed dichotomy between urban and rural has disappeared, and the urbanization-industrialization pair has become the primary determinant of growth. The balance between urban and rural areas has gradually distorted and

*(Corresponding author),Prof. Dr. Middle East Technical University, Ankara, Türkiye, yetiskul@metu.edu.tr
**Research Assist. Karadeniz Technical University, Trabzon, Türkiye, fahrettinkul@ktu.edu.tr
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evolved towards urbanization while city regions, polycentric metropolitan areas and metropoles have been formed.[1]

The current phase of economic and spatial restructuring has brought into question those aspects of cities that had been taken for granted. Even if these aspects are still vital as the primary loci of accumulation, we know that economies of scale come out as a new concept when older concepts are reviewed (Marshall, 1890). From the size distribution of cities to their hierarchical rank in the settlement system or from a city's growth rate to unbalanced development between cities, economies of scale are critical in many issues (Henderson, 2001). Positive externalities do not arise solely from natural advantages such as availability of raw materials, or from internal economies of scale related to factors of production such as easy accessibility in the region. It also results from external economies of scale, including economies of localization and urbanization (Hoover, 1948; Ohlin, 1933; Isard, 1956). Labor market externalities, knowledge spillovers, social capital accumulation, and diversity are also key drivers of agglomeration. Yet cities do not only provide environments to create positive externalities. Increasing scale of a region or city can also lead to negative externalities. Along with the increasing costs of agglomeration, the advancement of technology can change the spatial division of labor, causing the emergence of new centers and poles in a settlement system. Thereby, economic restructuring is being reshaped with agglomeration economies while bringing spatial restructuring.

We already know that the settlement system in Turkey is changing with similar economic and spatial restructuring processes (Tübitak Project Report, 2021). In this article, the İzmir region and its metropolitan area are examined to interpret recent changes experienced in several regions and cities of Turkey. To do so, we resort to general explanatory variables such as population and employment. Regional characteristics and agglomeration trends in the İzmir region are investigated by analyzing the population and employment of İzmir province in the decade between 2009 and 2019. Relevant data on population and economy, such as gross domestic product (GDP), was obtained from the TURKSTAT, Central Dissemination System database. Employment data, on the other hand, was obtained from the Directorate General for Insurance Premiums, Social Security Institution. Employment data has been spatialized using address information and NACE codes (Statistical Classification of Economic Activities) of businesses and workplaces. When these two datasets brought together, we could see spatial patterns of population and employment changes at the district and neighborhood scale as well as their agglomerations in maps.

How the population and employment interactively change in İzmir, and clustering shapes the spatial pattern in the decade after 2009 are investigated with GIS-based analyses. Regional economic growth, the emergence of new centers, and foci are formed in the equilibria of positive and negative externalities of agglomeration. Economies of scale, localization, and urbanization economies are discussed within this framework. Mapping on district and neighborhood scales is employed to depict the metropolitan area's natural boundaries and indicate regional centers. The agglomeration of population and employment changes is captured by neighborhood scale hot spot analysis using the Getis Ord Gi* method. Hotspot analysis is a spatial statistical analysis and mapping technique developed to reveal the clustering of spatial events (see Getis & Ord, 1992 for detailed information). Cluster density is measured for high or low values. High-value regions/neighborhoods are classified as hot (red) spots, while low-value regions/neighborhoods are as cold (blue) ones. In this article, in which we will exemplify the change in the settlement pattern through İzmir, the relationship between urbanization and economic growth is examined with population and employment data between 2009 and 2019.

2. Agglomeration, Localization and Urbanization Economies

From the late 19th century to the 1960s, significant developments in regional economics and economic geography were all explained by agglomeration economies, although scholars were

[1] For more details, see the web page of İzmir City Tübitak Project, *IKTP*

driven by different thoughts and traditions. Weber (1909), Lösch (1954 [1939]), Isard (1956), and Christaller (1966 [1933]) provided major insights into the hierarchy of a settlement system and regional agglomerations while analyzing the location choices of economic activities and defining the structure of basic economic relations (For more details, see Yetişkul, 2012). At the same time, related work on the causes of spatial clustering of economic activities and their effects on regional growth was also undertaken by Lichtenberg (1960) and Vernon (1960). Their research, which emphasized the different characteristics of agglomeration economies, was generally based on the insights of Marshall (1890). Historically, agglomeration is explained as a strategic characteristic of a place or settlement that increases productivity (De Groot et al., 2009). Ease of access to natural resources or trade routes is one of these locational advantages. Prominent thoughts have emerged in recent years to model the structure of agglomeration and its effect on economic growth through trade (e.g., Fujita & Thisse, 2002). Although the origin of these approaches is based on traditional models and explanations, agglomeration economies still draw considerable attention as a result of the ongoing urbanization around the world, which is an agglomeration itself.

Quigley (1998) described four main factors of agglomeration economies (McCann & van Oort, 2009). The first one is economies of scale, which is central to all productivity and growth discussions (Isard, 1956). The existence of economies of scale in production can clearly be observed when we consider the relationship between location choices and transportation costs. If we think the other way around, firms or economic activities would be spatially dispersed to save transportation costs if there were no economies of scale (Fujita & Thisse, 2002). Increasing returns to scale may occur to a single firm due to production cost efficiencies caused by serving a large market, or large numbers of local firms, reduced average cost of producing outputs in that locality. Output increase at a greater rate than input which means an increase in productivity causes agglomeration. Other than internal scale economies, Hoover (1948), Ohlin (1933), and Isard (1956) allocated sources of agglomeration advantages to external scale economies and, more specifically, categorized agglomeration economies by distinguishing localization and urbanization. While localization economies are the geographical concentration of one industry, urbanization economies are the concentration of a variety of industries. The former involves benefits to a firm from expansion in its own industry and clustering. The latter occurs from the intensity of various economic activities and involves benefits to a firm from proximity to other firms (Nakamura and Morrison Paul, 2009). Therefore, specialization and diversity can be directly linked to economic productivity.

Input sharing, the first of three sources of agglomeration economies in Marshall's classic text (1890), is the relatively inexpensive purchase of various intermediate inputs from downstream and/or other firms nearby.[2] Quigley (1998) identifies economies of the localized industry as the second factor of agglomeration economies, which is related to localization economies as well as urbanization. Economies of localized industry arise from the use of shared inputs to produce a variety of differentiated consumption goods demanded by modern culture, fashion, and lifestyle (Katz & Shapiro, 1985). Quigley's third factor in agglomeration economies is efficiency growth and economic productivity that arises from potential reductions in transaction costs. Transaction cost is the sum of the time spent to reach any product and/or service and the expenses related to search and information, bargaining, and enforcement (Cheung, 1987). Agglomeration causes transaction costs to decrease. Similarly, Kim (1987) and Acemoğlu (1996) demonstrate returns to human capital accumulation in a matching context between workers and firms as a result of a decrease in transaction costs, which results in labor market pooling, identified by Marshall as the second source of agglomeration economies. When human capital accumulation takes place, the risks and costs of searching for workers or jobs reduce. Again similar to production, better matching may occur in consumption.

A high level of production caused, whether due to firm size or togetherness of a large number of local firms, supports local employment and produces external economies in that locality. However, the strength of these local externalities varies. Stronger externalities occur in some

[2] Marshall identifies three sources of agglomeration economies: input sharing, labor market pooling, and knowledge spillovers.

industries, while in others, weaker externalities occur (Duranton & Puga, 2000). In any case, economies of scale cause a decrease in the average cost of producing outputs in that locality. There are also externalities characterized by the diffusion of knowledge between firms in a spatially agglomerated industry. These externalities, commonly known as Marshall-Arrow-Romer (MAR) externalities, corresponds to knowledge spillovers, which is Marshall's third source in agglomeration economies (Marshall, 1890). Knowledge spillovers are generated from the interactions among people working in close proximity and the turnover of skilled workers. Even though researchers such as Schumpeter (1934) assert that local monopoly is better for growth than the local competition because it allows for innovator-internalization, Jacobs (1969) argues that diversified urban spaces encourage complementary information exchange among firms, thereby generating new ideas and technologies. Porter (1998) agrees with the localization economies, also adding the competition externalities to MAR's specialization externalities and Jacobs' diversity externalities. He explained why certain regions are able to maintain and even strengthen their growth advantages compared to other regions with their competitive advantage. Once any firm or location assumes a lead in a particular activity, it maintains its competitive advantage over others. This reveals a different type of externality regarding a locality or city (Krugman, 1991).

Even if all production in a city takes place with constant returns to scale and no technological externalities, urbanization economies emerge due to a better match between production and consumption activities or easy exchange. Quigley's (1998) fourth factor concerns the applicability of this matching context against fluctuations in the economy. Although purchases of inputs, and production or sales of outputs are often not stable and in equilibrium, firms, employees, or buyers reduce risks. This necessitates keeping less inventory holding or stockpiling. On the other hand, urbanization economies also offer other externalities to firms and production. Since a city as a large-scale agglomeration operates as a whole on its own, it houses various institutions and organizations, too (McCann & van Ortt, 2009). Universities, research and development centers, trade associations, and professional chambers are located in relatively more populous localities or cities with easy access to metropolitan areas or metropolises. These institutions and organizations, which are not only economic in character but also social, cultural, and political in nature, cause urbanization economies and create varied externalities from the production of knowledge and absorption of know-how to know-how diffusion (Harrison et al., 1997). This stimulates innovation and regional growth as well.

All of these positive externalities, which originated from internal economies of scale, then localization and urbanization economies, explain the sizes of cities, their position in a hierarchical system as well as their growth potentials too. On the other hand, as cities grow the attractiveness of large agglomeration and advantages of economies of scale decrease. Location choices of firms shift to peripheral areas away from the center, providing local advantages outside the agglomeration due to higher transportation costs. Besides, increased crowding, congestion, pollution, and high land prices support this choice (Quigley, 1998). Negative externalities in the larger agglomerations may eventually lead to decreasing returns to scale in cities (Glaeser et al., 1995). In short, the economic view of regional science and geography considers cities maintaining equilibrium between two competing forces, i.e., centripetal forces (agglomeration) and centrifugal forces (dispersion).

3. Agglomerations in İzmir Region and Metropolitan Area

This study examines recent agglomeration and dispersion processes in the settlement pattern from the viewpoint of the relationship between urbanization and economic growth. To do so, we take the İzmir region as a case. Historically, always keeping its central feature, İzmir has come to the fore with its different geographical, economic, historical, and socio-cultural features, such as one of the main port cities of the Eastern Mediterranean (see Yetişkul, 2019 for more details). İzmir, the westernmost settlement of Anatolia and an Aegean city, is the third largest city in Turkey. It is known that regions and cities characterized by agglomeration generally grow faster and at a higher

rate than others. When the economic size and growth potential of İzmir are evaluated together with socio-economic indicators such as income per capita, livability, higher education, and health facilities per capita, it is clearly seen that İzmir is one of the leading localities in Turkey. However, İzmir, characterized as a 'city without excuses' by Keyman and Koyuncu Lorasdağlı (2010), could not benefit from its resources and potentials effectively as well as locational advantages to achieve a leap forward in economic growth in the 2000s (Genç et al., 2021). The question of whether the economy of İzmir is in a period of growth or recession leads us to analyze a polycentric settlement structure or city region formation of İzmir.

Özatağan and Eraydın (2014) analyzed the population and employment data between the years 1990–2000 and found that the clustering of firms and employment spread towards the peripheries of the İzmir metropolitan area while forming new centers in their vicinity. According to their research findings, İzmir has been reorganizing and forming a city region by including peripheral settlements specialized in a particular economic activity. While urban growth moves from the center to the periphery, the historical center of İzmir has transformed into a regional center by functionally integrating with several settlements and various economic activities around it (Eraydın et al., 2008). As the economic geography of İzmir creates new foci, the center of the metropolitan area is shrinking. Tekeli (2018) explained İzmir, where the formation of city regions can be best observed on the basis of İzmir-Manisa linkages. He emphasized that relationships which operated mainly through agricultural production and trade in the past have been reinforced with relocations of various industries from İzmir to Manisa today. Thereby, a new spatial division of population and employment has emerged. In fact, the economic growth in the 2000s mainly took place in the İzmir-centered city region, which surpassed the provincial borders. Özatağan and Güvenç (2013) pointed out that this trend continues in their research.

In this article, we discuss regional development characteristics and agglomeration trends of İzmir, whose economic and spatial structure has been reshaped since the 2000s, using population and employment data for the years 2009 and 2019. In the face of findings, we also make interpretations and derive analogies for the settlement pattern of Turkey. As a matter of fact, the province of İzmir covers industrial clusters such as Aliağa and Torbalı, agricultural production regions around Bergama, Tire and Ödemiş, tourism centers such as Çeşme and Seferihisar, coastal stripes on the shores of the Aegean Sea and inland settlements with a relatively lower contribution to the regional economy, which is a perfect representation of settlement pattern in Turkey. Besides, the urbanization and growth period of İzmir caused the emergence of new city centers. In addition to Konak, which has traditionally been the central business district of İzmir, Karşıyaka has served as a sub-center along the northern and eastern coastline of İzmir Gulf. Lately, Bayraklı on the northeastern coastline has emerged as a new financial center. This economic and spatial diversity is an additional feature that contributes to the growth potential of a region other than agglomeration economies in terms of the regional economy. Urban diversity, when considered in a manner analogous to corporate diversification in a firm's product range, is a strategy that protects regional income from industry-specific crises in demand (Mills, 1972; Dissart, 2003). This mainly protects the labor market. Even if labor mobility within the region is high, economic crises reduce growth as a result of agglomeration economies (Krugman, 1993). Industrial variety at the regional scale is a feature that reduces regional unemployment and supports economic growth.

3.1. Agglomeration of population: 2009–2019

The population of İzmir increased 3.5 times in a 55-year period from 1,234,667 to 4,367,251 people between 2009 and 2019. In the meantime, its settlement structure has transformed from a monocentric city to a polycentric metropolitan area along with numerous spatial agglomerations on its wide provincial spread over 11,891 km². To search the population and employment agglomerations between 2009 and 2019, we group this provincial spread into six sub-regions according to different social and economic characteristics. The metropolitan sub-region covering eleven districts around the inner gulf, and Gediz and Küçük Menderes sub-regions, formed by the basins in the north and south, is the densest and highly productive region of İzmir in terms of both

population and employment numbers. Metropolitan sub-region was 2,972,900 people in 2019. Buca, Karabağlar, and Bornova, central districts in the metropolitan sub-region, have reached population levels of more than 450,000, followed by Konak, Karşıyaka, and Bayraklı, with populations over 300,000 (Figure 1).

Gediz sub-region in the north and Küçük Menderes sub-region in the south define peripheries of the metropolitan sub-region, with populations of 319,701 and 360,269, respectively. A continuation of the Küçük Menderes basin, the Peninsula sub-region, which includes the coastal districts in the west, had a population of 166,987 in 2019. The Bakırçay sub-region, with a population of 273,449 in the far north, and the Bozdağlar sub-region, with a population of 273,945 in the southeastern parts of the province, differ from the metropolitan sub-region in terms of social and economic structure. Proportionally, the increase in both population and employment in these sub-regions is lower. All six sub-regions of İzmir are experiencing socio-spatial processes such as expansion, sprawl, shrinkage and coastalization, similar to the changes observed in Turkey's settlement system.

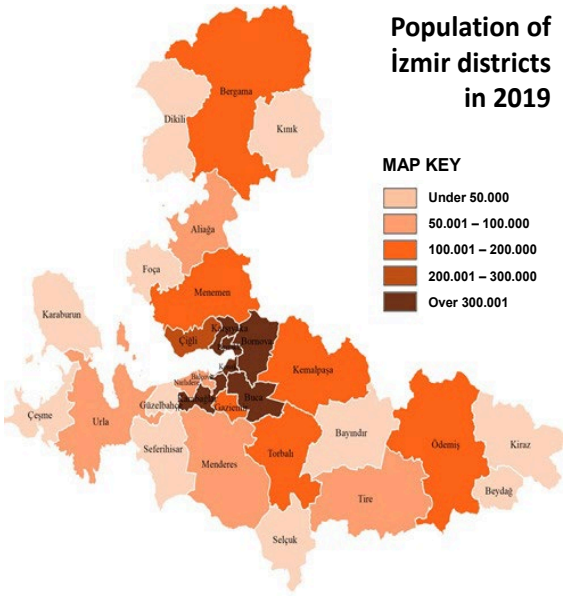

Figure 1 Population of İzmir districts in 2019

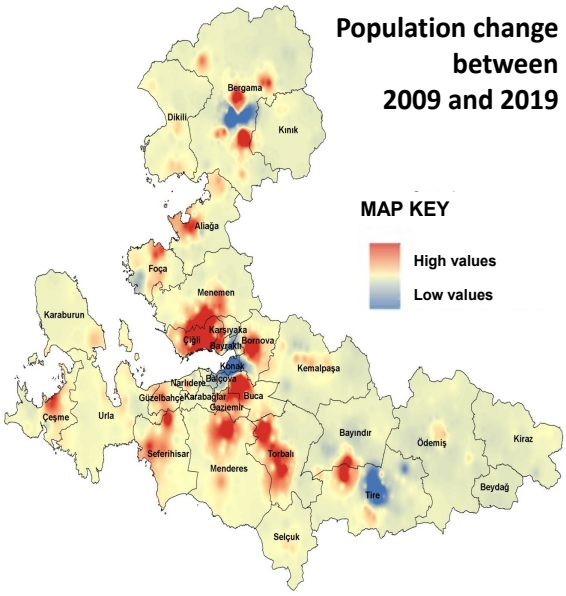

Figure 2 Agglomeration of population change between 2009 and 2019

Hotspot analysis of the population change between 2009 and 2019 reveals that İzmir is spreading from the inner gulf to the outer, and the city center (i.e., Konak district) is shrinking. Population changes represented by color contrast from high (red) —Population Increase— to low (blue) values —Population Decrease— in Figure 2 forms an outer ring of population decentralization around the metropolitan sub-region. Therefore, we may conclude that the shrinkage trend continues, as raised by Özatağan and Eraydın (2014) based on the data for the years 1990 and 2000. Besides, one can easily detect that the metropolitan area has expanded towards the periphery and enlarged its geography reach and hinterland by covering the districts of Menemen, Kemalpaşa, Torbalı, and Menderes –and even Aliağa in the North and Seferihisar in the southwest. From 2009 to 2019, 47% of the population growth of İzmir occurred in the metropolitan sub-region, 14% in the Gediz, and 18% in the Küçük Menderes sub-region. Although Bergama in the north and Ödemiş in the southeast maintain their historical positions as regional sub-centers, population growth remained at a relatively low level between 2009 and 2019. Similarly, the population growth of Bayraklı, Konak, and Balçova districts in the inner gulf slowed down and took low values, even negative values, as cold spots —shades of blue— in the agglomeration map (Figure 2). Bayraklı and Balçova grew only by 1.9% and 2.3%, respectively. In the same period, Konak shrank by 14.5%, and its population decreased from 411,112 to 351,572.

3.2. The economy of İzmir: 2009–2019

In addition to being the third largest city in Turkey, İzmir also stands out as the province with the third highest income level, producing 6.1% of the gross domestic product (GDP) in 2019. According to the chained volume index calculation (of GDP), adjusted for the price effects between 2009 and 2019, İzmir GDP increased from 100 units to 172 units, reaching a total value of 106,349,166 thousand TL (Table 1). The per capita GDP value was calculated as 10,655 $ in 2019. Economic activities are generally divided into three main groups as agriculture (primary), industry (secondary), and services (tertiary) sectors.[3] While the goods produced directly from natural resources are considered as agricultural sector activities, the production of new products from the produced goods is classified industrial sector activities. Activities not producing goods but services, other than the aforementioned sectors, are classified under the service sector. When we calculated shares of production in three main sectors in 2019, agricultural production took 4.3% of the total production, while industry accounts for 29.2% of the total production in İzmir. The remaining 66.5% is produced by the service sector. Accordingly, the distribution of total employment, 1,620,000 in 2019, reveals a similar ranking among primary (agriculture), secondary (industry), and tertiary (services) sectors are 9.3%, 31.0%, and 59.7%, respectively.

Table 1 Contemporary tapered supertall buildings

	2009	2014	2019	2009	2009-2014	2009-2019
	Population*			Population, growth rate (%)		
Population	3.868.308	4.113.072	4.367.251	-	6,3	12,9
Sectors	GDP at chain linked volume index (Thousand TL)**			GSYH, volume index**		
Agriculture (A)	3.164.307	4.274.076	4.543.838	100	135	144
Industry (B, C, D, E, F)	16.350.450	26.021.610	31.084.573	100	159	190
Consumer services (G, H, I, R, S, T)	15.789.162	21.929.141	28.408.002	100	139	180
Producer services (J, K, L, M, N)	13.325.844	16.851.516	20.546.629	100	126	154
Public services (O, P, Q)	6.435.779	7.924.042	9.924.577	100	123	154
Total GDP	61.692.893	86.956.660	106.349.166	100	141	172
	GDP per capita (TL)**			GDP per capita ($)**		
GDP per capita at current prices	16.099	30.235	60.505	10.423	13.830	10.655
	Employment rate (%)***			Labor force participation rate (%)		
Employment – Labor force	-	46,1	47,2	-	53,5	56,1

*TURKSTAT (Central Dissemination System), Address-based population registration system results
**TURKSTAT (Central Dissemination System), Regional accounts
*** TURKSTAT (Central Dissemination System), Regional labor force statistics

Nowadays, business and consumer services account for the majority of urban employment as cities have generally transformed into service-based economies, most of which are characterized by the knowledge-based information society. The interaction between urban economies and knowledge-based service industries explains the increase in economic productivity related to flows and transactions carried out through networks (Castells, 1989). Developments in information and communication technologies have caused the emergence of many new economic activities, and main sectors like industry and service have been divided into sub-sections by specializing in themselves. Depending on the output, the service sector is generally grouped into three further sub-sections, which are consumer, producer, and public services (Table 2) that provide direct services to the consumers, activities targeting business and industry production, and activities that provide service for specific needs to all socio-economic groups of the society without profit, respectively (Hayter & Patchell, 2011). Consumer services include retail, accommodation and food service, and primarily individual services, while producer services include marketing, advertising, research and development, finance, insurance and real estate, leasing, and so forth. When we look at the distribution of these three main service sectors in İzmir, it is seen that consumer services

[3] For the discussion and suggestion, see Şahin et al. (2018).

value the highest, with a rate of 26.7% in 2019. Technology and knowledge-intensive producer services contribute 19.3%, while public services are 9.3%.

Table 2 Distribution of economic activities by sectors

Main sectors	NACE code	Economic activities
Agriculture	A	Agriculture, forestry and fishing
Industry	B, C, D, E	Mining and quarrying, manufacturing and other industries
	F	Construction
Consumer services	G, H, I	Wholesale and retail trade, transportation and storage, accommodation and food service activities
	R, S, T	Arts, entertainment and recreation, other services activities
Producer services	J	Information and communication
	K	Financial and insurance activities
	L	Real estate activities
	M, N	Professional, scientific and technical activities, administrative and support service activities
Public services	O, P, Q	Public administration and defense, education, human health and social work activities
NACE Rev.2 (A10), Statistical classification of economic activities for 10 sectors in the European Community, Revision 2		

3.3. Agglomeration of employment: 2009–2019

The regional and spatial characteristics of employment at the district level are analyzed based on the employment data in 2009 and 2019. The findings in Figure 3 indicate with shades of green color that employment agglomerated in the metropolitan sub-region and its surrounding vicinity. Unlike the population agglomeration, employment disperses a broad region from Aliağa in the north to Torbalı in the south, in addition to the central districts of İzmir. Metropolitan sub-region accounted for 68.5% of total employment in 2016, while Gediz (Menemen and Kemalpaşa districts) and Küçük Menderes sub-regions have 8.4% and 9.2% of total employment, respectively. Altogether, 86.1% of total employment is concentrated in the metropolitan sub-region and its nearby vicinity. However, the economic growth in İzmir was not limited to the inner gulf, which defines the natural borders of the metropolitan area surrounded by a wide belt from north to south. In the hot spot analyses of the employment change at the neighborhood level between 2009 and 2019, economic agglomeration can be followed by Figure 4, with the transition of colors from high (shades of red) to medium (shades of yellow) values and the formation of belts from the inner to the outer.

Having said this, we should also note that regional (agricultural) sub-centers, Bergama and Ödemiş, are remarkable in terms of their population sizes. In addition to the hot spot analyses regarding the spatial agglomeration of population and employment change between 2009 and 2019, we investigate the percentage changes too. As seen in Figure 5, neighborhoods with high population growth are concentrated in the periphery of the İzmir metropolitan area, especially in the Aegean coastal zone. The high values (shades of red) in the coastal settlements reveal the recent coastalization trend in İzmir. Among the thirty districts of İzmir, the districts with the highest population change rates in the ten-year period are Seferihisar, Aliağa, and Torbalı districts, with 55.7%, 52.7%, and 49.2% growth, respectively. Seferihisar in the Peninsula sub-region in the west, Aliağa in the Bakırçay sub-region in the north,and Torbalı in the Küçük Menderes sub-region in the south show clear trends of growth in terms of population. These foci are the points where the red color is darkest, as seen in Figure 5. These districts are followed by Menemen, Menderes, and Güzelbahçe, with population growth rates of 40.4%, 39.7%, and 38.8%, respectively. The Peninsula sub-region, which includes the coastal districts of Karaburun, Çeşme, Seferihisar, and Urla, grew 38.5% between 2009 and 2019, reaching 166,987 people in 2019. This tendency exposes the positive impact of the coastal factor on population dynamics and economic activities in İzmir. In the same period, employment in the Peninsula sub-region also increased from 37,966 to 82,086. This rapid change was observed mainly on the coastal loci of Çeşme, Seferihisar, and Urla (Figure 6).

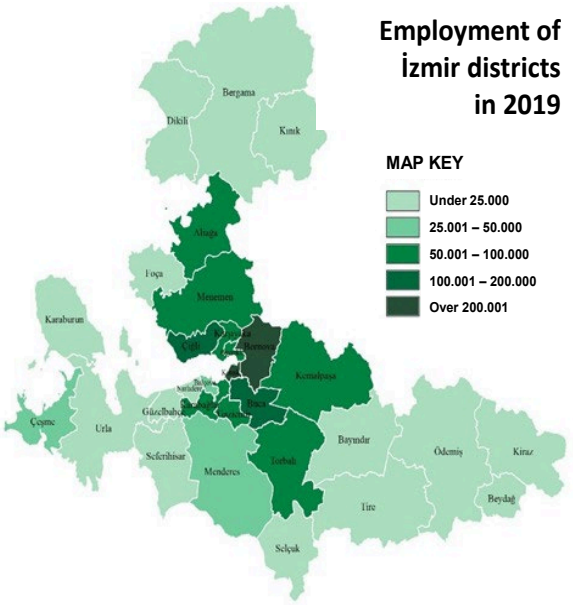

Figure 3 Employment of İzmir districts in 2019

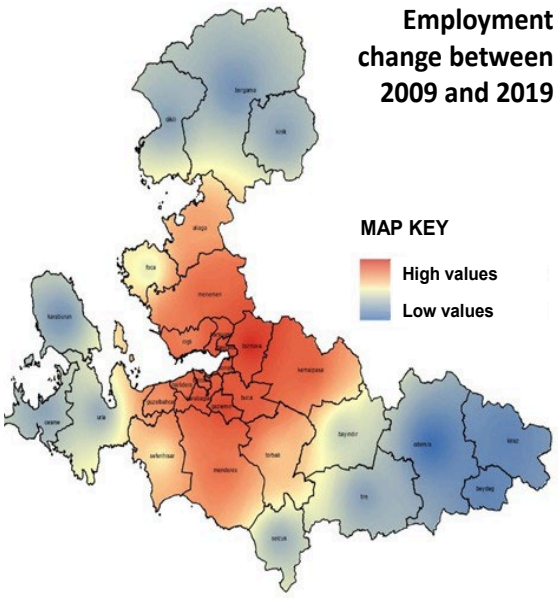

Figure 4 Agglomeration of employment change between 2009 and 2019

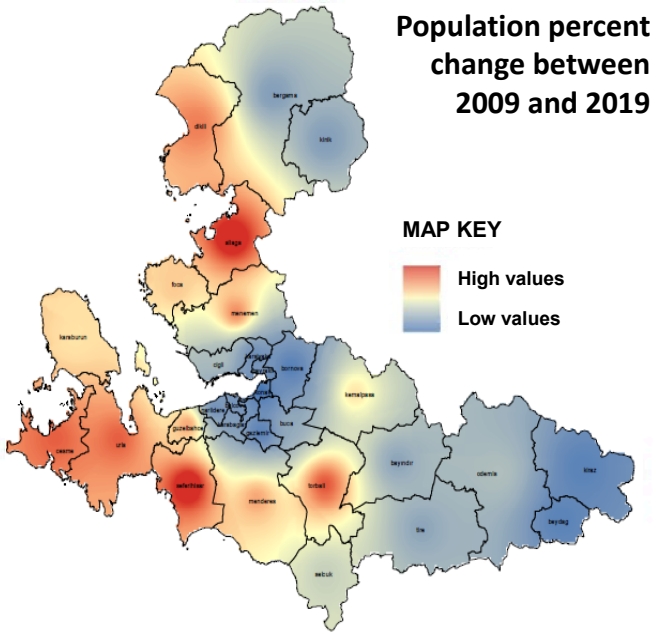

Figure 5 Population percent change between 2009 and 2019

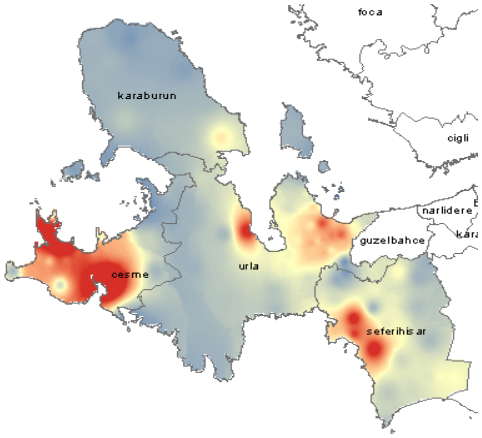

Figure 6 Agglomeration of employment change in the Peninsula sub-region between 2009 and 2019

Having said this, we should also note that regional (agricultural) sub-centers, Bergama and Ödemiş, are remarkable in terms of their population sizes. In addition to the hot spot analyses regarding the spatial agglomeration of population and employment change between 2009 and 2019, we investigate the percentage changes too. As seen in Figure 5, neighborhoods with high population growth are concentrated in the periphery of the İzmir metropolitan area, especially in the Aegean coastal zone. The high values (shades of red) in the coastal settlements reveal the recent coastalization trend in İzmir. Among the thirty districts of İzmir, the districts with the highest population change rates in the ten-year period are Seferihisar, Aliağa, and Torbalı districts, with 55.7%, 52.7%, and 49.2% growth, respectively. Seferihisar in the Peninsula sub-region in the west, Aliağa in the Bakırçay sub-region in the north, and Torbalı in the Küçük Menderes sub-region in the south show clear trends of growth in terms of population. These foci are the points where the red

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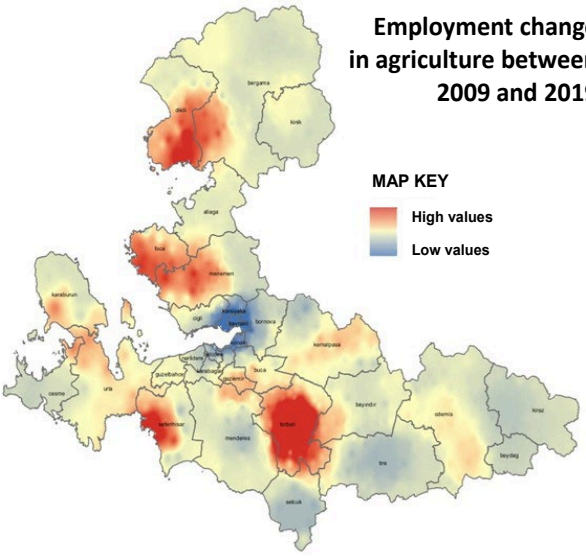


Figure 7 Agglomeration of employment change in the agriculture sector between 2009 and 2019

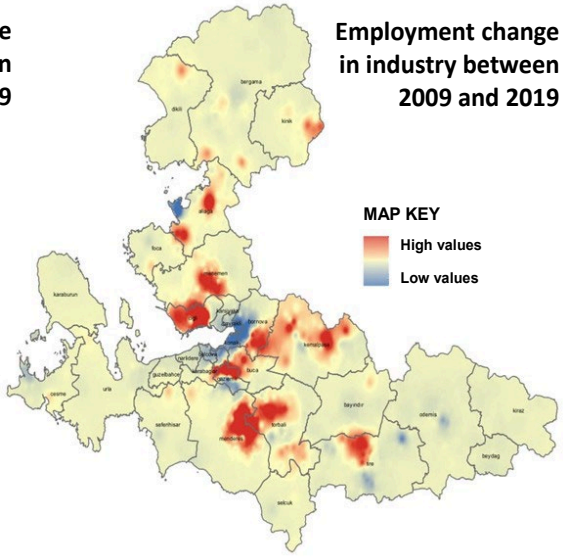


Figure 8 Agglomeration of employment change in the industry sector between 2009 and 2019

Between 2009 and 2019, total employment increased by 63.2% in İzmir—the employment size, which was 1,078,666 in 2009, increased to 1,760,308 in 2019. Concentrated in the metropolitan area and its surrounding vicinity, employment spreads over a wide area, including Aliağa, Kemalpaşa, and Torbalı. Resembling the change in the Peninsula sub-region, employment numbers in the Gediz and Küçük Menderes sub-regions almost doubled. Although employment in the metropolitan sub-region has increased, its share in the province has decreased by nearly 4% in the decade between 2009 and 2019. Hot and cold spots of employment change in terms of agriculture, industry, and services sectors between 2009 and 2019 are also analyzed to find sector-specific spatial characteristics and agglomerations in the region. The agricultural sector, which does not show a significant increase in absolute numbers, grew 102% in this period. While agricultural employment primarily has concentrated around Torbalı and Seferihisar in the south, it has also increased on the northern coast of Foça and Dikili (Figure 7). In the metropolitan sub-region, both agricultural employment and its change rate are observed at low levels.

Between 2009 and 2019, industrial sector employment grew by 33%. In the analysis of the spatial distribution of this change at the neighborhood scale, industrial employment is found condensed with high (shades of red) values around the periphery of the metropolitan sub-region, especially in the organized industrial zones (Figure 8). The increase in industrial employment can be clearly seen from Menemen and Çiğli to Aliağa in the north and from Bornova and Buca to Kemalpaşa in the east. Menderes and Torbalı in the south became a growth focus, and a gradual increase took place in Tire. As expected, industrial employment growth in the inner gulf and rural neighborhoods creates cold spots lower than their surroundings (Figure 8). When we examine agglomeration in service sector, the metropolitan sub-region predominates service employment, and growth between 2009 and 2019 attains its highest level throughout İzmir. The spatial distribution of the 75.8% growth in the service sector employment between 2009 and 2019 presents similar pattern with total employment change, as shown in Figure 4. As employment in

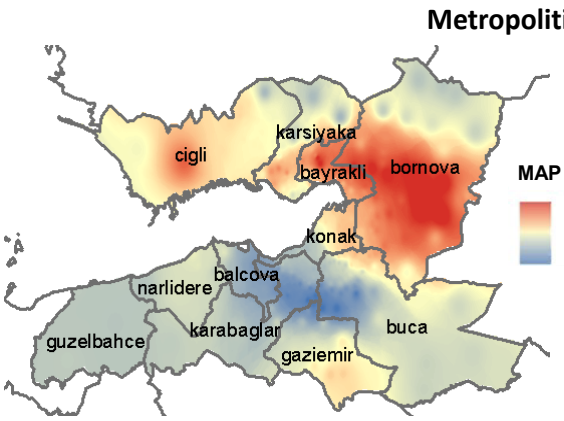
the metropolitan sub-region is concentrated in the service sector both absolute and ratio change (increase) of service employment follows urban bias strikingly. Increase of the service sector in the metropolitan sub-region concentrates in Çiğli and Bornova districts, while the Konak district (traditional city center) enjoys a relatively lower share.

When we focus on settlements in the outer periphery, it is observed that employment in the Bozdağlar sub-region is concentrated in the city centers of the Tire and Ödemiş districts. The agricultural sector has increased, especially in the south of Ödemiş. The most significant change in employment in the Küçük Menderes sub-region was realized with a growth-focused on Torbalı. It can be obviously observed that employment has increased to a certain extent in the south of the Selçuk district. While Kemalpaşa and Menemen districts at the periphery of the metropolitan sub-region stand out in the Gediz sub-region, the agglomeration in the Aliağa district of the Bakırçay sub-region differs from other districts. In the decade between 2009 and 2019, the agricultural sector in the Bakırçay sub-region grew by more than 280%. Although the employment growth rates in agriculture and industry sectors in the sub-region of the metropolitan area were lower than the rates of the province in general, the service sector grew by approximately 70%. This change in the service sector concentrated in Çiğli and Bornova districts and remained at a low level in Konak, the historical city center.

4. Discussion and conclusions

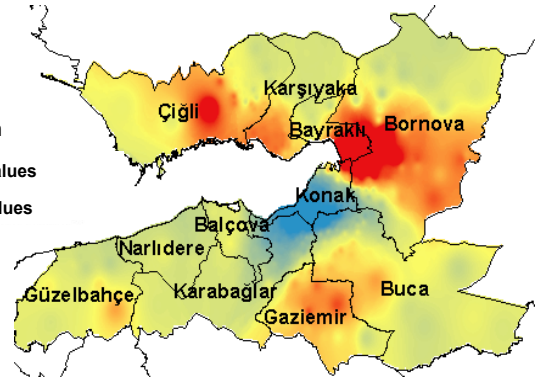
Urbanization has often been seen as synonymous with economic growth, and the population size of cities or urbanization rates have also been used to predict economic growth and even sometimes economic development rather than income level and distribution. Even though Jedwab and Vollrath (2014) showed that urbanization has increased in not only richer countries but also in poorer countries over time and that megacities disproportionately emerged in underdeveloped countries without economic productivity, they also found that urbanization and income were highly correlated for any given year between 1500 and 2010. This strong link between urbanization and economic productivity, which is explained by agglomeration economies, is indisputable. Greater agglomeration means higher local demand and higher local demand enables firms to benefit more from internal economies of scale, thereby allowing them to make more profit and afford higher nominal wages. This increases local demand, attracting new firms to that locality or city, creating a new workforce, and increasing the variety of goods and services produced. Therefore, the increase in the real income of the employees leads to more consumption, expanding the market, and attracting more economic activities (Gianmarco et al., 2001). There exist many interrelated backward and forward linkages that affect the size of cities and economic growth.

İzmir, a city where the population and employment were concentrated around the inner gulf in 2009, has transformed into a city-region that spreads over a vast geography in 2019, mainly involving the surrounding districts such as Menemen, Kemalpaşa, Torbalı, and Menderes. Based on the data from the years 1990 and 2000, Özatağan and Eraydın (2014) found that the metropolitan area of İzmir spread by forming belts from its core to its periphery and that a city region has been formed with new centers in the vicinity. In this paper, we use data at both the district and neighborhood levels for the years 2009 and 2019 and present that the trend of expansion continues up to a certain point. The gravitation of agglomeration has enlarged the metropolitan area from the core to the outer areas, attracting new economic activities and population. On the other hand, with the effect of negative externalities, the city center has shrunk. Growth from the center to the periphery occurs within a regionally wide belt, which emerged as development corridors, including the centers of Menemen, Kemalpaşa, Torbalı, and Menderes. In addition, the Seferihisar corridor and the center of Urla join this “fringed structure” of the metropolitan area, with the significant effect of the coastal trend in the period covering the years 2009-2019.



Employment change (2009 – 2019)

Figure 9 Agglomeration of employment change in Metropolitan sub-region between 2009 and 2019



Employment change in service sector (2009 – 2019)

Figure 10 Agglomeration of service employment change in Metropolitan sub-region between 2009 and 2019

In this context, we can define the natural boundaries of the metropolitan area with Menemen in the north, Kemalpaşa in the east, Torbalı and Menderes in the south, and finally, Seferihisar and Urla development corridors in the southwest. In these main corridors, uninterruptedly integrated with eleven central districts in the inner gulf, population and employment growth have been high in the last ten years. Coastalization has also emerged with rapid population and employment increases from Dikili to Aliağa and from Karaburun and Çeşme to Seferihisar. However, Bozdağ and Bakırçay sub-regions in the outer periphery have been areas where both population and employment have decreased. In these sub-regions, the population and employment are concentrated mainly in the central districts, and both decrease in the rural districts. On the other hand, the population of Konak, which is traditionally the central business area of İzmir, shrank by 14.5%. In the surrounding Bayraklı and Balçova districts, the population growth rate has decreased considerably. However, the shrinking of this city center, which is determined by the population data, cannot be fully supported by the employment data.

Although the employment growth rate of the metropolitan area sub-region is lower than other sub-regions, in absolute numbers, main bulk of service sector increase takes place in this region, especially around Bayraklı and Bornova in the northeast of the inner gulf (Figure 9 & Figure 10). These service sector concentrations merge with Karşıyaka and Çiğli in the northwest and extend to Gaziemir in the south. Athough losing its base, traditional central business district in Konak still serves as the main center of the city region as a whole. Agglomerations in agriculture, industry, and service sectors and the diversity of products and services show the economic level and growth potential of İzmir. As discussed in the sections above, regional or urban diversity is also affecting regional economic growth and development in addition to localization and urbanization economies. Diversified and specialized sub-regions and settlements expanding from the center of the metropolitan core sub-region to the periphery in İzmir have developed thanks to these positive externalities. The growth pole concept of knowledge diffusion and innovation in the economic geography literature, introduced by Perroux (1950) many years ago, assumes that economic growth is achieved in the region by spreading knowledge and innovation to nearby lower-level settlements throughout the hinterland of a growth focus. In line with this assumption, İzmir hosts various institutions and non-governmental organizations such as universities, research and development centers, trade unions, and professional chambers with the potential to spread knowledge to the city region. Yetişkul and Şenbil (2020) emphasize the administrative and organizational strategies and policies of İzmir Metropolitan Municipality, focusing on the quality of life and entertaining participatory, actor-based, entrepreneurial, innovative, and process-involved governance model, supporting a collective economic growth in this backdrop.

Funding

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Resume

Dr. Emine Yetişkul received her bachelor's and master's degrees in city and regional planning from Middle East Technical University, Faculty of Architecture in 1995 and 1998, respectively. She earned her Ph.D. degree in civil engineering (transportation systems and network economics) from Kyoto University, Graduate School of Engineering in 2005. She carried out post-doctoral studies at the University of California, Berkeley, Institute of Transportation Studies. Between 1997-2001 and 2008-2010 she worked as a city planner at the Ministry of Public Works and Settlement, General Directorate of Technical, Research and Implementation. Started to work as a faculty member in METU, Faculty of Architecture, Department of City and Regional Planning in 2010, she is currently Professor of City Planning. Her major research interests include transportation systems, urban and regional economics, city and regional planning.

Mr. Fahrettin Kul graduated from Middle East Technical University, Faculty of Architecture, Department of City and Regional Planning in 2018. He completed his master's degree in regional planning at Middle East Technical University, Graduate School of Applied and Natural Sciences. His major research interests include urban transportation, regional geography and city planning. He is currently research assistant at Karadeniz Technical University, Faculty of Architecture, Department of City and Regional Planning.

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Citizen science projects in the context of participatory approaches: The case of Izmir

Pelin Özden*
Koray Velibeyoğlu**

Abstract

The term "citizen science" refers to scientific activity done entirely or in part by members of the public, frequently in cooperation with or under the guidance of licensed scientists. To better manage natural resources, monitor endangered species, and maintain protected areas, decision-makers, and non-governmental organizations increasingly turn to citizen science-based programs. A broad field, citizen science, offers numerous strategies for involving volunteers in research in various ways while including a whole range of research methodologies. Thus far, citizen science initiatives have been successful in advancing scientific understanding, and the advancements made by citizen scientists give a significant amount of data globally. The subject of citizen science is spreading rapidly, and its legitimacy is increasing. It also involves enhancing scientific research by utilizing a variety of subjects and data sources. Citizen science has the potential to increase stakeholder engagement, bring in new perspectives, and foster new forms of participation. Also, many initiatives are being developed in cutting-edge scientific fields. These programs now aim to solve an urgent issue or provide an answer to a research question while simultaneously enhancing community participation in science and influencing long-term policy implementation. The study utilizes to examine the citizen science projects in Izmir, Turkey according to the concepts and categorizations in the literature review in a systematic way to understand their participation levels and their potential.

Keywords: citizen science, Izmir, levels of participation

1. Introduction

The phrase "citizen science" is a catchphrase for the scientific work done by the general population, frequently in cooperation with or under the direction of qualified scientists and scientific institutions. The term "citizen scientist" refers to a scientist whose research is distinguished by a sense of responsibility to advance the interests of the public sphere; (b) a member of the public who would conduct scientific research, frequently in collaboration with or under the supervision of professional scientists and academic institutions; an amateur scientist (Oxford Dictionary of English, 2014). Basically, citizen science, or in other words civic engagement refers to 'public participation' in scientific research and has a diversified amount of definitions; community-based monitoring, volunteer-based monitoring, participatory monitoring, public engagement, do-it-yourself science, crowd science. Public participation is a phenomenon that affects all facets and levels of society equally and is easily connected to a wide range of issues. In order to get public input and proposals on the governance of human settlements, citizen participation involves educating or working with a number of top-down and bottom-up

*(Corresponding author) Lect. Dr. Izmir Kavram Vocational School, Türkiye pelin.aykutlar@kavram.edu.tr
**Prof. Dr., Izmir Institute of Technology, Türkiye koray.velibeyoglu@iyte.edu.tr
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stakeholders (Fredericks et al., 2020). The scientific research of public participation is called 'citizen science'.

There is a great desire to participate in local and global issues and problems. Contrary to this, in essence, what Hindess (1997) refers to as a "democratic deficit" is to blame when liberal democracies encounter difficulties engaging their populace and achieving their goals. It is widely known that for governments to effectively administer metropolitan areas, citizen participation is essential. In order to create inclusive and sustainable cities, stakeholders must take into account the participation of citizens. Collaboration is essential if the government is to have access to the collective knowledge, suggestions, and skills of the population.

Citizen science projects involving citizen scientists that collect vast amounts of information regarding species occurrence and distribution around the globe have a significant impact on scientific understanding and advancement. Most citizen science initiatives help people to understand the living things they are watching, be the part of the solution. Furthermore, because the results of citizen science initiatives are scientific and informative, creating and implementing public data collecting of these programs requires substantial work (Bonney et al., 2009). At various levels, many citizens would engage in science, to contribute of knowledge. A field with expanding validity, citizen science is quickly expanding. By involving a variety of themes and data sources, it includes advanced scientific research. Stakeholder participation can be increased by citizen science, which can also bring in new perspectives and forms of collaboration. Innovation in scientific fields are the subject of several projects. At this point, they take on the role of providing an urgent solution to a problem or providing an answer to a research issue, while also enhancing community capacity for involvement in science and long-term policy implementation and decision-making. These public policy programs have an impact on every aspect of environmental protection to health and education, to research and innovation in the modern world. Moreover, citizen science has a long history that spans several disciplines, including astronomy, biology, geology, archaeology, biodiversity, monitoring, public health, urban planning and design, architecture, and etc. Collaboration between various scientific, medical, engineering, and social science fields are resulted from these efforts (Hecker *et al.,* 2018).

The aim of the study is to take the portrait of Izmir city in the context of citizen science projects for to understand its potentials and benefits for being resilient. In this study, in order to examine the citizen science phenomenon in Izmir, first of all, we made a literature review and drew a conceptual framework was drawn about the theoretical development, definition and types of the concept of participation approaches and citizen science. Citizen science studies in Izmir were compiled by keyword scanning. The website documents of the studies were defined by examining the conceptual framework drawn on the research purpose and the method. The current situation is discussed by evaluating the examples of citizen science projects in Izmir with the conceptual framework.

2. Participation Approaches

Everyone, who has a connection to the city, is impacted by every intervention, particularly the residents. Cities are living organisms with memories, histories, and identities just like any other evolved being. Participation is a phenomenon that affects all facets and levels of society equally and is easily connected to a wide range of issues. In order to get public input and proposals on the governance of human settlements, citizen involvement involves educating or working with a number of top-down and bottom-up stakeholders (Fredericks et al., 2020).

In the literature, citizen participation is defined in a variety of ways. Citizens distrust intermediary institutions in the political decisions that affect them and expect to have a direct voice in the decisions, which is what participation in the political process means to them (Bishop & Davis, 2002). Nabatchi and Leighninger (2015) define citizen engagement as any activity in which the needs, interests, values, and expectations of citizens are taken into account when making decisions and taking action on matters of public concern. Verba and Nie (1987, p. 133) add the definition "in

ways that citizens desire an instrumental action in which they strive to persuade the government to act" to their definition of "citizen engagement". Creighton (2005) defines participation as the process through which the institutional decision-making of the state incorporates the ideals, needs, and concerns of the population. Government and citizens connect and communicate in both directions to make better decisions (B Seçkiner, 2021).

In principle, participation is what society expects from democracy and is a term that can be used to describe any topic. Implementations of participation, whether made intentionally or unintentionally, eradicate any injustices and contain an equal component. The term "participation" in the study refers to those participants, who actively engage in citizen science projects and are influenced by those activities. To better mediate conflicting interests, advance improved quality of life for all, and raise awareness about complicated issues, there needs to be greater citizen involvement in decision-making about local and global problems (Adams, 2004). The development of policies that are more favored by the populace and boost trust in the government may also benefit from citizen participation (Sousa & Klyza, 2007).

Participation can be effectively managed if the goal is envisioned in terms of what needs to be accomplished when there is a recognized need to involve community members. To understand the issue simple questions like "who," "what," "where," "how", and "when" are required (Sanoff, 2011): (a) Who are the parties to be involved in participation, (b) What should be performed by the citizen participation program, (c) Where should the participation road lead, (d) How should people be involved, (e) When is participation desired in the planning process.

Urban development strategies and the idea of "participation" are revealed via sustainability. The concept of democracy has changed, particularly in the second half of the twenty-first century as a result of the shifting global conditions, the unlimited communication tools created concurrently with technological advancement, and the rising awareness rate with these tools. Participatory democracy has started to take center stage in areas where understanding of representative democracy is insufficient. In many places of the world, participatory methods were carefully explored (P Sertbaş, 2013).

The standard of living can be significantly enhanced by citizen participation in governance. Additionally, it helps foster the development of citizens' abilities, convictions, willingness, and vision. It can also help handle complicated difficulties in public service design and delivery. Democracies have faced challenges in recent years due to the rise in citizen expectations for participation in decision-making, particularly at municipal and regional levels (Khan et al., 2014).

2.1. Levels of Participation

In the literature, there are different definitions of involvement at various levels by many professions, which may change over time as a result of unique situations and contrasting points of view, both in theory and practice.

Shelley Arnstein's (1969) ladder of participation is one of the first and best-known model of public participation. She makes a comparison between citizen participation levels and ladder rungs in it. In the late 1960s, it became increasingly clear how important citizen participation is to societies. In an essay that was first printed in 1969, Arnstein explained and further refined the concept of participation as seen in Figure 1. Thereafter, other scholars frequently based their theories about participation on this article.

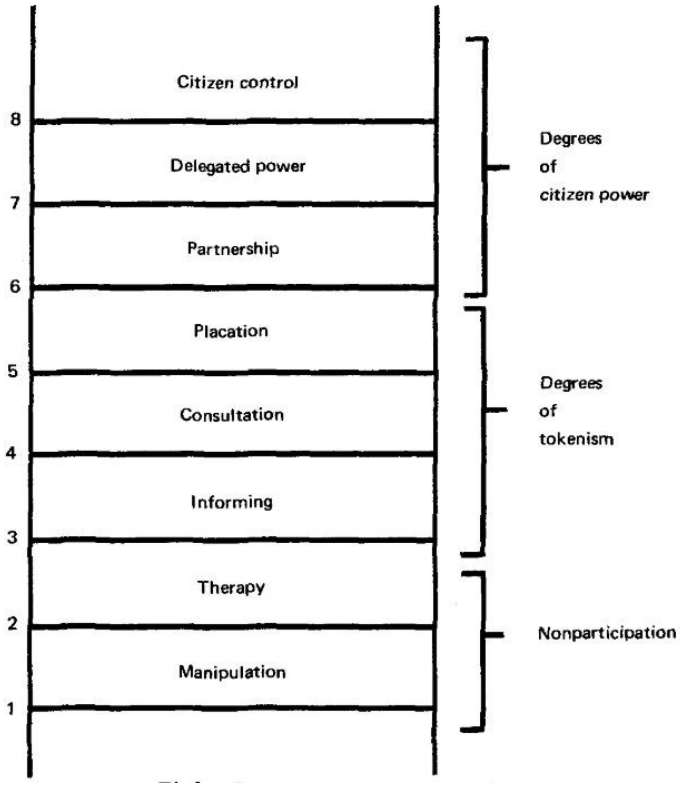
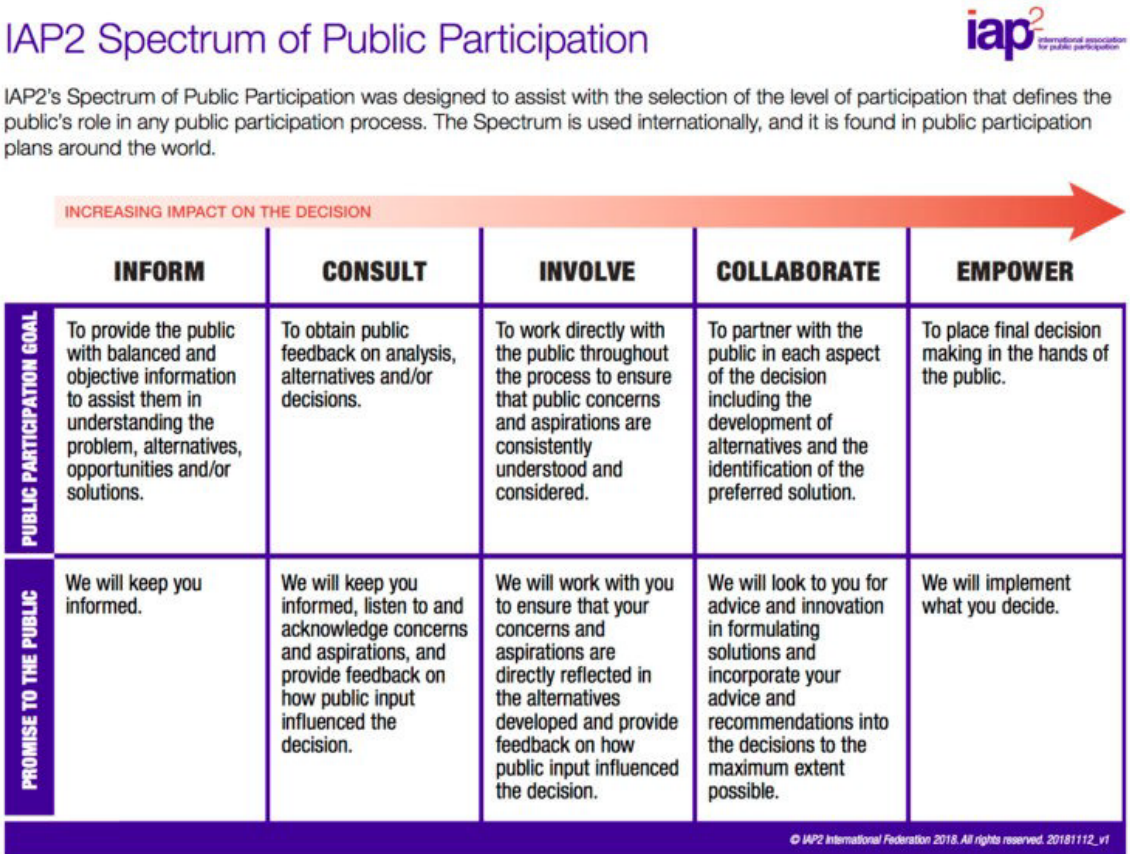


Figure 1 Arnstein's eight rungs on a ladder of citizen participation (Arnstein, 1969)

Economic, political, managerial, and cultural activities are all examples of areas where participatory decision-making may be used. Arnstein contends that not all possibilities for involvement are created equal. Depending on the level of public participation and the ability to influence or affect the outcome, they can be divided into numerous types. She categorized the eight stages into three categories: lack of engagement, varying levels of tokenism, and varying levels of citizen power. The top rung shows citizens participating fully and actively in a relationship with government entities, whereas the bottom rung shows no citizens participation (Arnstein, 1969). She believes that participatory approaches are pointless as long as power is distributed unfairly (Callahan, 2007). The first two steps are manipulation and therapy, which are both forms of non-participation; they are strategies used by those in positions of authority to inform or better participants rather than to ensure that citizens participate. It is typically used to demonstrate participation in user-centered projects, but neither the participants nor the committees established to guarantee participation happens. In other words, at the bottom of Arnstein's ladder, where there is no power for the citizens, it is obvious that there is no participation in the two categories she refers to as manipulation and therapy. According to Arnstein, this deception shows that certain government organizations have offered a fake amount of participation while their real goal is to educate the public on how to accept the task that has already been established. The next phase entails the introduction of therapy, which is another form of non-participation. Such indifference is dishonest and self-serving. The goal, in this case, is to find a way to indicate how the relevant organization disagrees with the views and activities that it does not share but cannot articulate clearly, therefore, it does so by disavowing them through the use of a citizen survey. The ladder has additional rungs for informing and advising. This stage comprises informing the citizens about the reality of governmental objectives as well as their rights, obligations, and alternative remedies. Informing, consulting, and citizen questionnaires may be useful if the information is factual and the information flow is not skewed (Bice, 2018). Because citizens in positions of power continue to have their rights, the level of placation is described as having a higher degree of tokenism because those without the means still have no participation in how decisions are made. Collectively, the last three rungs of the ladder —partnership, delegated authority, and citizen control— represent different tiers of citizen power. A partnership is a sort of business where regular individuals are allowed to

haggle and make deals with influential persons. On the levels of delegated power and citizen control, citizens who lack resources control the majority of the decision-making process. The restructuring of the decision-making power distinguishes the stage characterized as the power of the citizen from the others. Participants may be involved in a variety of collaborations and later on, may even gain control over the decision-making process. Participants at the partnerships level must possess strong leadership, the financial means to cover their time and labor, and the authority to hire their own technique and method organizers. It is crucial for those in positions of authority and their capacity to inflict meaningful sanctions on the plan. At this level, it is possible to assert that the institutionalization of participation and its organization have a substantial impact. Arnstein's highest level, citizen control, was also criticized for splitting public services and fostering secession. It is more expensive and less effective, it allows minority groups "hustlers" to be just as opportunistic and contemptuous of the have-nots as their white predecessors, it is incompatible with merit systems and professionalism, and ironically, it can end up being a new Mickey Mouse game for the have-nots by allowing them to gain control but not providing them with enough financial resources to succeed. These are the criticisms made by Arnstein in her article (Arnstein, 1969).

As we approach the present, another important spectrum of participation was developed by IAPP2 (International Association for Public Participation). IAP2 is a global organization whose members work to advance and develop the practices of public engagement and participation in interactions with individuals, institutions, and other groups that have an impact on the public interest around the world. The five phases of levels of participation are: inform, consult, involve, collaborate, and empower, in accordance with the association. In the early 2000s, it was first schema as seen in Figure 2.



IAP2 Spectrum of Public Participation

IAP2's Spectrum of Public Participation was designed to assist with the selection of the level of participation that defines the public's role in any public participation process. The Spectrum is used internationally, and it is found in public participation plans around the world.

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 1 International Association for Public Participation (IAP2) – Spectrum of Public Participation (IAP2, n.d.-a)

According to IAP2's Spectrum of Public Participation (IAP2, n.d.-a);

An "informing process" aims to educate the public about an issue, its alternatives, opportunities, and/or remedies by giving them accurate, objective information. While communicating with the

public, it is best to be as impartial, truthful, and fact-based as possible. Moreover, the public should be kept informed of the reasons behind the decisions being made by decision-makers including elected officials, public servants and school administrators. Yet, when leaders are not completely open and conceal crucial or relevant facts, or when they disclose skewed information in an effort to misrepresent a situation and influence the public's opinion, an informing process can become problematic.

A "consulting process" seeks input from the general public on analyses, choices, and/or decisions. Participants in a consultation process offer their points of view, ideas, or preferences, and leaders use this information to guide their decisions. By providing public authorities with a more precise grasp of the views, needs, worries, or priorities of those who will be touched by their decisions, consulting enhances the results of a decision-making process at its most effective and advantageous level. Yet, when decision-makers gather public input without considering it or exclude significant constituencies or stakeholder groups from the process.

Working closely with the public throughout the process to ensure that public concerns and goals are continually addressed and taken into consideration is the aim of an "involving process". An engaging process, however, might become problematic if leaders and organizers do not give the training, information, inspiration, or other types of assistance that participants may need to participate fully or competently, or if the chances for public involvement offered are unreliable.

A "collaborative process" aims to involve the public in all aspects of the decision-making process, including the creation of alternatives and the determination of the preferable course of action. Genuine collaborative processes and partnerships place leaders and participants on an equal footing, and those in positions of power share control, management, or decision-making with participants to the greatest extent possible. Yet, when leaders take the advantage of their partners' weaknesses or undermine their authority, a collaborative process can become problematic or dangerous.

An "empowering process" seeks to give the citizens the final say in decision-making. In an empowering process, decision-making authority may be partially or fully transferred from leaders like public officials to participants from the public, or the public may mobilize to create a decision-making process in place of institutional leadership or action on a crucial issue. However, an empowering process can turn problematic or harmful when organizations or individuals are given the responsibility to manage a process that they might not have the resources or expertise to manage effectively, or when institutional leaders, professionals, and experts withdraw themselves from a decision-making or problem-solving process that needs institutional leadership, specialized expertise, or professional skills to reach a successful conclusion or resolution (IAP2, n.d.-a).

The effectiveness of the decisions made by the public, the expression of opinions or proposals, and the way power is distributed during the participation process are all intimately tied to the participation strategy. This section of the study comes to a conclusion by stating that the term "participation approach" can mean a variety of things, from genuine participation to phony participation. In essence, IAPP2 Spectrum of Public Participation (IAP2, n.d.-b) which is based on Arnstein's study (1969) is used to understand participation levels as they developed their methodology in this study.

3. Citizen Science in the Literature

The phrase "citizen science" is a vague word that describes scientific work done by the general population, frequently in cooperation with or under the direction of qualified scientists and scientific institutions. A "citizen scientist" is a scientist, whose work is distinguished by a commitment to furthering the interests of society; (b) a member of the public who conducts scientific research, frequently in collaboration with or under the direction of professional scientists and academic institutions; or (c) an amateur scientist (Oxford Dictionary of English, 2014). One of the pioneers in using the term "citizen science" to describe the expertise of laypeople was Alan

Irwin in 1995 (Irwin et al., 1994). Shortly after, this phrase was modified to refer to a research strategy that gathers or examines scientific data from the general community. Irwin (1995) identified two components of the interaction between the public and science. The first dimension is that science must be sensitive to the interests and concerns of the community. The second component is the potential for citizens to generate trustworthy scientific knowledge.

According to the European Commission Green Paper (Follett & Strezov, 2015), citizen science is defined as the citizens' participation in scientific research activities when citizens actively contribute to science through their intellectual effort, their local expertise, or their tools and resources. The field of citizen science is legitimately growing and spreading quickly. Citizen science frequently increases public interest in science and supports alternate methods of knowledge generation. It is viewed as a collection of initiatives residing under a bigger umbrella of ideas, such as "open science" and "open innovation" (Hecker *et al.,* 2018). The term "citizen science" has many definitions, including do-it-yourself science, crowd science, participatory monitoring, community-based monitoring, and public engagement.

Increased stakeholder participation, new ideas, knowledge, and collaborations are all benefits of citizen science. Several projects are bringing cutting-edge scientific subjects to new audiences, opening up the conversation on the societal ramifications of disciplines. In this regard, citizen science projects are frequently launched to address a current problem or research question while also strengthening the general public's capacity to participate in science and have an impact on the long-term implementation of policies.

Participating in a variety of topics and data sources as part of citizen science contributes to the advancement of scientific research. Citizen science has the potential to increase stakeholder engagement, bring in new perspectives, and foster new collaborations. There are numerous projects being developed in cutting-edge scientific fields. At this phase, they begin to address urgent issues or the research question's solution while also enhancing communities' capacities to engage in science and influence long-term policy decision-making and execution. These public policy programs have an impact on everything from research and innovation to the protection of the environment, health, and education. Moreover, citizen science has a long history that spans a wide range of disciplines, including astronomy, biology, geology, archaeology, biodiversity, monitoring, public health, etc. Collaboration between several fields of research, medicine, engineering, and the social sciences resulted from these undertakings. Projects linked to citizen science and public policy today address a variety of goals, including the protection of the environment, health and education, research, and innovation. In particular, those designed to promote innovation have sparked interdisciplinary collaboration in the social sciences as well as in science, medicine, and engineering. Citizen science also promotes a small amount of interaction between practitioners, important society stakeholders, and public officials (Hecker et al., 2018).

Citizen scientists that contribute a vast amount of data regarding species occurrence and distribution around the world to citizen science projects achieve extraordinary achievement in scientific understanding and progress. The majority of citizen science projects let participants learn about inanimate objects by seeing and understanding the procedures used in scientific studies. Due to the scientific and educational benefits of these projects, creating and implementing public data collection of citizen science programs does really demand substantial effort (Bonney et al., 2009). Several people would engage in science on various levels, each contributing to the scientific knowledge.

The objectives of citizen science initiatives also include funding scientific research conducted by academic institutions, governmental organizations, and non-governmental organizations, adding to the body of scientific knowledge through publications, providing data and analytics to help inform management plans and fostering public awareness of and interest in science (Follett & Strezov, 2015). Citizen science also significantly tackles broader societal issues by engaging citizens in actual research experiences at various stages of the scientific process and using modern communications

techniques to draw in and keep participants. A number of new advancements in information science over the past 20 years, particularly in data informatics, graphical user interfaces, and geographic information system-based web applications that can now be ported to smartphones and other hand-held devices as well, have greatly aided the emergence of citizen science. Problems with sustainability and prioritization in citizen science projects bring up the question of how government funding and partnerships may assist sustain public interest in research for society (Dickinson et al., 2012).

3.1. Levels of Citizen Science

Due to the wide range of fields in which citizen science can be used as well as the diverse organizational and cultural settings of such practices, there are numerous terms that come under the more general category of citizen science. Some examples include community science, collaborative mapping, community remote sensing, locally-based monitoring, and community-based monitoring (Fraisl et al., 2022).

Although it has been challenged throughout the years, Arnstein's ladder served as an inspiration for typologies. Haklay (2018), an expert in citizen science, is in charge of what looks to be a ladder of the citizen scientific engagement as seen in Figure 3.

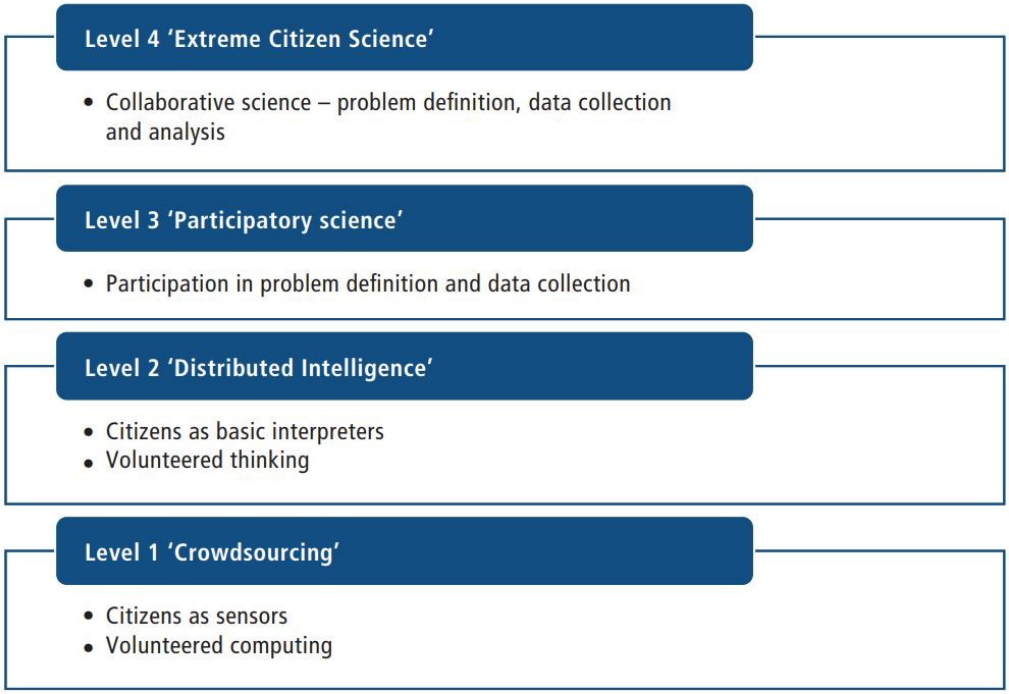


Figure 3 Levels of participation in citizen science (Haklay, 2018)

This classification parallels the ladder of participation described by Arnstein (1969). Eight steps make up the ladder of citizen participation, each indicating a distinct level of involvement. The steps describe the level of citizen participation and the level of influence required for the process and outcomes to be decided from the bottom to the top. For defining the programs and policies that emphasize participation, the ladder makes sense. Although Arnstein used the phrase "the powerful and citizens" in her script, she underlined that neither the term refers to a single entity nor both groups include individuals who have varying degrees of influence. Powerful actors employ various sorts of non-participation at the bottom of the ladder to push their objectives. When participants learn about interventions and express their opinions about them, power holders are said to have received "input." Participation does not result in change, however, because the participant's voice will not have any impact on the intervention. The highest rung on the participation ladder gives citizens more authority to consult with and influence status. The voices of the participants are recognized and addressed. The steps and obstacles needed to get from one level to the next are not shown on the ladder. In real-world circumstances, however, there may be many more levels,

and participants may climb and descend the ladder over time while still participating in the same intervention.

Haklay's (Weber et al., 2019) system classifies citizen science activities in accordance with a four-level structure of participation based on the depth of their interaction with volunteers. In level 4, or so-called extreme citizen science, participants take an active role in the project's development and work to meet their own goals. Extreme citizen science refers to projects where professional scientists have no part at all, and the study is directed entirely by the public. Science with participation is Level 3. Participants are involved in directing the research's course from topic development to data collecting. Level 2 includes distributed intelligence, which provides some essential information before requesting people to collect and analyze data. Crowdsourcing is Level 1 within the process. These are the least inclusive programs and rely solely on volunteers to supply the processing power or collect data from dispersed sensors (Science Europe, 2018).

According to Haklay (2018); there are six different sorts of citizen science programs. They include passive sensing, volunteer computing, volunteer thinking, environmental and ecological observations, participatory sensing, and community science. Participants in the initiative must contribute a resource they already own in order for passive sensing to work. The data was being gathered by using the sensors. Scientists use the data later for analysis. Volunteer computing is the practice of users contributing their unused computing resources on a personal computer, tablet, or smartphone. When the device is not in operation, scientists are permitted to run sophisticated computer simulations. Volunteer thinking refers to the cognitive abilities of persons, who do not engage in passive leisure activities like watching TV.

At the bottom of the ladder, powerful actors use a variety of non-participation tactics. Participants are considered to have provided feedback when they learn about interventions and share their opinions about them. Yet, as participation does not result in change, the participant's opinion will not have any bearing on the intervention. Citizens have more power to consult with and affect status at the top of the scale. Participants' voices are acknowledged and addressed. In these kinds of programs, the participants pledge their capacity to see patterns or analyze data that will later be employed in scientific research. The participants in the environmental and ecological observations type concentrate on observing flora and wildlife or monitoring environmental contamination through the activities. Participatory sensing is the practice of giving individuals more roles and authority. While many environmental and ecological observations adhere to the data collection standards, the process is more assigned and emphasizes the active engagement of the participants in setting what will be collected and examined. Bottom-up science is the ultimate concept in community/civic science; it is suggested and directed by a group of participants who identify an issue that is important to them and address it using scientific methods and tools. In these types of activities, the problem, data collecting, and analysis are frequently carried out by members of the community or in conjunction with scientists or established laboratories (Sui et al., 2013).

The user's dual role as participant and researcher within the environment creates new opportunities for cross-disciplinary, cross-sectoral, and trans-generational environments where communities can collaborate to solve problems, develop group hypotheses, and test existing theories with the aim of comprehending reciprocal systems and modeling potential futures for citizens.

It is not shown how to ascend the ladder from one level to the next or what challenges must be overcome. Yet, there might be a lot more levels in real-world situations, and participants might climb and descend the ladder over time while still participating in the same intervention (Arnstein, 2019).

4. Citizen Science Projects in Izmir, Turkey

Although though citizen science is a relatively young subject of study in Turkey, numerous studies in this area have been conducted using various terminologies. Turkish researchers have just

recently been exposed to the idea of citizen science. In terms of policymaking, the European Union Framework Plan for Research and Innovation's Horizon 2020 initiative, which includes calls for citizen science projects, has been funded by The Scientific and Technological Research Council of Turkey (TUBITAK). As a result, multinational collaborations have indirectly helped citizen science. Another policy change in Turkey related to citizen science is the new open science policy of TUBITAK, which is based on disseminating TUBITAK research in an open-access way and may have an impact on public participation in scientific research (Us, 2020). The first studies on citizen science in Turkey compiled a thorough literature survey and included some first examples. A few governmental enterprises backed by citizen-generated data, an amateur meteorology forum, a policy-making occasion encouraging citizen participation in water research, and more have been described. However, many of these programs do not directly relate to citizen science because they are not open-access or volunteer-based, as the authors have noted (Anbaroğlu et al., 2017). Various citizen science projects and platforms exist in Turkey, according to the present research.

In parallel with these developments, citizen science projects belonging to different disciplines were carried out in the city of Izmir, located in the west of Turkey.

Biyoatlas (2009)

Izmir Biyoatlas Project (Url-1), which is open to the participation of citizens with the support of academicians, who are experts in their fields in order to reveal the herbal diversity of the city under the coordination of the Izmir Metropolitan Municipality Mediterranean Academy, the natural richness and flora of the city will be determined through and this richness will be embraced with the awareness that is created. Determining the plant diversity living in Izmir, determining the location of the plant, photographing the plant, collecting and archiving the basic data in a digital base to be created by the project partners are aimed to verify the data obtained with the contribution of expert academics, to match local, national and Latin names, and to share the information publicly on the internet through the Project of Creating and Sharing the Biodiversity Atlas of the Province of Izmir. During this citizen science project; plant diversity, photographs and location information are clearly determined for the participation of the citizens, and these data will be collected over the web and shared with the existing plant inventory (Figure 4).

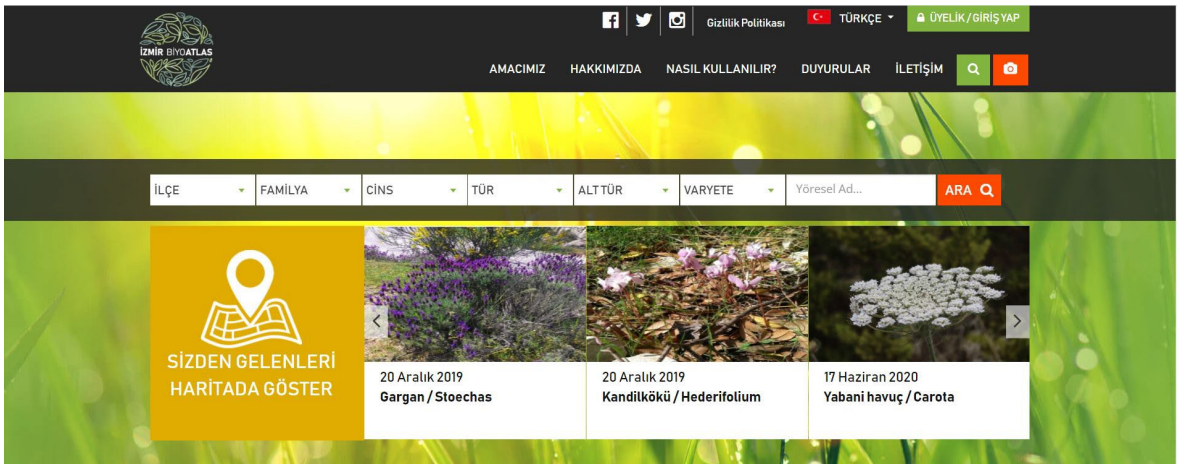


Figure 2 Izmir Biyoatlas Project (Url-1)

Bioblitz Peninsula Citizen Science Practice (2018)

Counting species activity, also known as bioblitz (combination of the words "bio" meaning life and "blitz" meaning raid), has been around in many countries, including the United States and the United Kingdom, as a community science activity to pique interest in nature among the general public. The living things seen in nature are identified by professionals in this exercise, which is open to participants of various backgrounds (Url-2).

Botany science was the theme of the 2018 Bioblitz Peninsula Citizen Science Practice citizen science workshop that took place in Urla, Izmir. In a particular location, citizens were instructed to locate and identify as many species as they could (Url-3). A further citizen science project in Izmir, the 'Biyoatlas' project intends to identify the variety of plant life in Izmir, pinpoint the location of the plant, take a photo' of the plant, and compile and archive the fundamental data in a digital base that will be developed by the project partners. Additionally, it aims to match Latin, local, and national names and to openly publish the information online. These goals were achieved with the assistance of experienced academics.

First, the presentation was given on the goal and reached citizen science practice at the conference held at Bademler Natural Life Village with the involvement of Zeytince Association. Afterward, the fundamentals of botany, how to approach the problem, and the floristic diversity of Turkey and Izmir were given to the participants. In addition, basic details on how to carry out research in citizen science practice are and instructions on how to utilize the smartphone application and responded to queries from the audience were provided in the session. An applicable field trip was included in the meeting with the participants (Figure 5).

Figure 3 Bioblitz Peninsula Citizen Science Practice (Url-3)

PSLifestyle Living Labs (2017)

PSLifestyle is a citizen science project that aims to close the action gap between individual action and climate awareness and to increase citizen participation in sustainability topics. In addition to the large-scale environmental projects mentioned above where citizen scientists are primarily involved in data collection. The Horizon 2020 research and innovation program of the European Union has financed PSlifestyle. In Estonia, Finland, Germany, Greece, Italy, Portugal, Slovenia, and Izmir/Turkey, PSLifestyle foster data-driven momentum for lasting habit change. The initiative's co-creative Citizen Science Lab methodology aims to promote citizens' engaged involvement in localized sustainability challenges in order to develop and commit to practical climate change solutions. The project partner Sistra, who created Lifestyle Test' carbon footprint calculator built the web based tool in 2017. An enhanced version of the application is developed and contextualized as part of the PS Lifestyle project to better reflect the local reality of the target populations. In order to understand the local skills, possibilities, and motivations of the citizens in engaging in more sustainable lifestyles, this was accomplished by co-creating a localized version of the application using citizen science laboratories. In order to develop solutions based on citizen data, the PS Lifestyle project also collaborates with other societal catalysts, such as legislators, corporations, civil-society organizations, and academics (Url-4) (Figure 6-7).

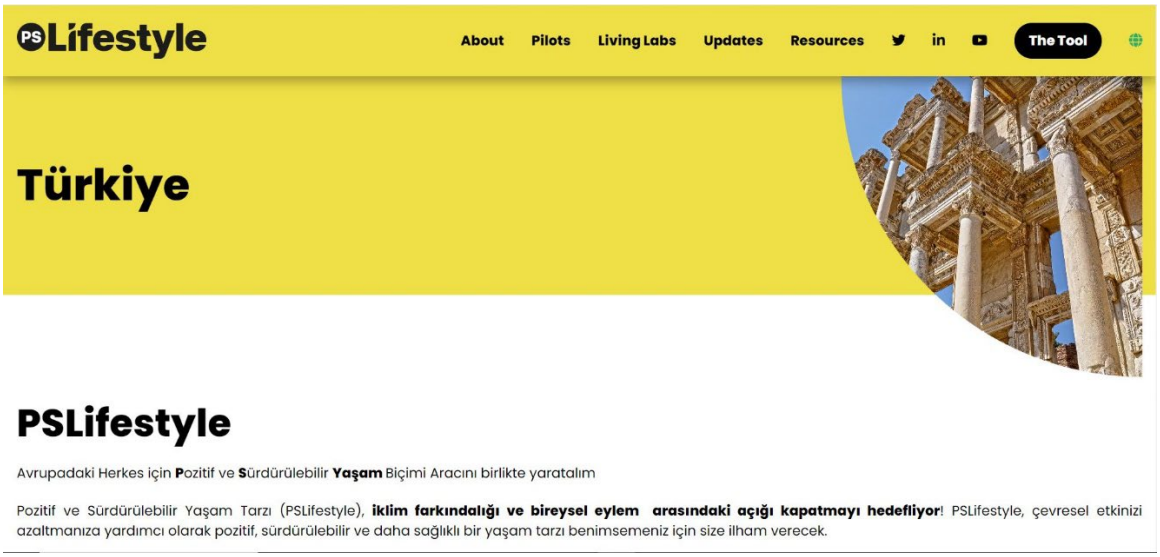


Figure 4 PSLifestyle (web-based tool) (Url-4)

Figure 5 PSLifestyle Living Lab (Url-4)

Citizen Design Science Workshops, Izmir (VTB Atölyeleri) (2022)

Human-centered urban design and development require an understanding of inhabitants' needs, concerns, and perceptions. Modern initiatives emphasize human-centered technology and make an effort to involve citizens in some planning processes. Since then, increased citizen participation has contributed to the development of democratic governance and several related fields. These contributions are seen to strengthen accountable and responsive states, foster a sense of citizenship, and increase good feelings. They consist of elements such as the standard of living, often known as livability or a person's sense of identity. The term 'citizen design science' refers to this innovative approach. New types of citizen participation in urban planning are represented by citizen design science in the context of citizen science concept. Understanding how to impart

knowledge and even wisdom to citizens through the use of citizen design science is central to the program. Many of citizens' strengths in terms of observation, human cognition, experience, and local knowledge are added by the notion of citizen design science in a scientific framework. Citizen design science is a novel method for including residents in the process of urban design and planning (Mueller et al., 2018).

Citizen Design Science Workshops-Izmir were conducted by us in 2022, and collaboration with Karşıyaka Municipality was made in those projects. These projects are the first studies of citizen design science projects in Turkey. Karşıyaka Municipality aims to regenerate the selected areas as parks, green areas, and leftover spaces in Karşıyaka district into qualified public spaces by the help of the wishes and needs of local citizens within the scope of 'participatory co-design process'. Citizens are even given the opportunity to input their ideas for a new physical layout of space in a platform that combines urban design and citizen science and design science in these studies. Citizen Design Science Workshops practices were completed by using digital and analog design tools in four selected leftover urban spaces in Karşıyaka, Izmir. Atakent Car park, Cemal Gürsel Street, Bahar Park and Şehit Ast. Erkan Durukan Primary School were those selected areas that Citizen Design Science Workshops-Izmir implemented (Figure 8).

Figure 6 Citizen Design Science Workshops-Izmir: (1) Atakent Car park, (2) Cemal Gürsel Street, (3) Bahariye-Bahar Park, (4) Şehit Ast. Erkan Durukan Primary School

4.1. Results and Discussion

Bioblitz and Biyoatlas are the citizen science projects that depend on finding and identifying lots of species in a specific area over a period of time. To capture a glimpse of a region's biodiversity, scientists collaborate with citizens. These activities can take place anywhere, in a backyard or a big region, in a rural or suburban setting. The use of smartphone technology and applications will facilitate the collection of photos and biological information about living things. Data is submitted to these programs to create an open-source database that is used by researchers, decision-makers, and communities all across the world. Due to the participants being restricted to resource allocation, these projects are at the most fundamental level of participation. In addition, intellectual participation is at its lowest level. According to Haklay (Sui et al., 2013), the implementation of a comparable level of participation as participatory sensing would urge participants to carry applications and mobile phones as sensors and bring back the digital data to the experiment organizer. Also, they fall under the IAPP2 spectrum's 'involve' level by collecting data.

The PS Lifestyle Living Labs is at the Level 3, participatory science level that citizens help to collect data for the 'climate problem', to co-create and shape visions of a good life with the environment in mind as well as design solutions for turning visions reality. Citizens co-define the tool's content and co-create its features and functionalities. Also, this citizen science project is at the level of 'collaborate' in the spectrum.

Citizen Design Science Workshops-Izmir is a citizen (design) science project in that citizens actively design their environment through their knowledge from observations and experiences, and wishes. This design data transforms the conceptual design and the local citizens design into citizens' environment collaboratively with scientists and expert designers. These workshops are at the Level 3; participatory science that citizens participate in (design) problem and, by using their knowledge and experiences regarding environment, they also bring design data to scientists and expert designers as at the 'collaborate' level of spectrum (Table 1).

Table 1 Levels of Citizen science projects in Izmir

Level of Citizen Science Projects in	Level 1: Crowdsourcing	Level 2: Distributed intelligence	Level 3: Participatory Scicence	Level 4: Extreme Citizen Science
Inform				
Consult				
Involve		Bioblitz- Biyoatlas		
Collaborate			Citizen Design Science Workshops-Izmir & PSLifestyle Living Labs	
Empower				

5. Conclusion

The citizen science studies in Izmir are evaluated within the conceptual framework, Haklay (2018) and IAP2's Spectrum of Public Participation (IAP2, n.d.-b). Citizen science is a brand-new open movement that welcomes contributions to scientific study from a wide range of individuals. Data generated by citizen science initiatives is helping to inform policy-making at the local, national, regional, and international levels. Citizen science acts as a link between many parts of society in order to create significant scientific research. It is conceivable to think of citizen science as the next step in the participatory shift, one that could address the flaws in the democratic system by involving the general people in the scientific method itself. In other words, citizen science promises to advance knowledge, educate the public, and change science from a closed to an open activity in an effort to "democratize" research.

As a result, understanding citizen science participation also contributes to a better understanding of how open science should operate. Citizen science is becoming increasingly recognized as a legitimate scientific field. Since around 2010, the number of papers resulting from citizen science programs has considerably increased. The main fields of study in Izmir, Turkey, and the rest of the globe provide the scientific research in different disciplines. The citizen science projects in Izmir demonstrate the city's potential as in the previous section. A gap is also discovered when it comes to using citizen science methods at higher levels of the participation spectrum. In addition, Izmir, which has a potential in terms of citizen science projects both in local and global scale, to achieve a resilient society, the participation levels of the projects should be increased and developed in terms of double-sided benefits as citizens' awareness and right to the city are increased.

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Resume

Pelin Özden is Lecturer Dr. at Architectural Restoration pr., Izmir Kavram Vocational School. She is an architect and received her Ph. D. degree from Izmir Katip Çelebi University, Department of Urban Regeneration. She has focused her research mostly on spatial analysis, space syntax, participatory urban design, citizen science and citizen design science.

Koray Velibeyoğlu is full professor and chairperson at the Department of Urban and Regional Planning, Izmir Institute of Technology. The main foci of his research are urban design, planning history, knowledge management, nature-based solutions and smart cities. Professor Velibeyoğlu completed two EU-funded H2020 projects entitled "UrbanGreenUP: New Strategy for Re-Naturing Cities through Nature-Based Solutions" and "RURITAGE: Rural regeneration through systemic heritage-led strategies". He also works as researcher in new Horizon Europe projects including EHHUR, Re-Value and CARDIMED.

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Comparison of spatial distribution of pharmacies in Istanbul between 1997-2022

Hasan Mutlu[*]
Başak Billur Mutlu[**]
Vedia Dökmeci [***]

Abstract

In this study, the spatial distribution of pharmacies is investigated in Istanbul by taking into consideration their important role for the health care delivery system. First, the growth of the number of pharmacies is compared with the growth rate of population at the city level during the last two decades within perspective of changes in health care delivery policies. Then, the growth of the number of pharmacies is compared with respect to the population growth rate of the core, intermediate and peripheral zones. The second, the changes in the pharmacy market areas are compared at the city level and in the core, intermediate and peripheral zones within the same period. Third, the regression analysis is used to show the relationships between the number of pharmacies in the districts and the population, number of hospital beds and number of physicians during the same period of time. Suggestions are made for more balanced distribution of pharmacies in order to prevent bankruptcies while sufficient accessibility provided for the customers, and for future research.

Keywords: pharmacies, spatial distribution of pharmacies, İstanbul, comparison of the pharmacy market areas

1. Introduction

At the beginning of the 21st century, Istanbul's population grew very rapidly due to heavy migration from rural areas as a result of globalization, closing dawn of the factories at the country side, and being the most important socio-economic and cultural center of the country, and having the higher quality of health and educational facilities as well as other services (Yazgi, et al., 2014; Koramaz & Dokmeci, 2020) Following this trend, the city has expanded in the periphery through large squatter areas, large middle class housing complexes, upper income villas (Dokmeci & Erdogan, 2021; Oruç & Dokmeci, 2017).

As a result of population increase and changes in the policy of health care provision, the number of pharmacies were increased as a significant component of primary health care services at the city level (Dokmeci & Ozus, 2004). The present study investigates the spatial distribution of pharmacies with respect to the growth of the city, multi-center development of urban structure, changes in population density which have affected the spatial distribution of needs and demand for health care facilities between 1997-2022 (Dokmeci & Berkoz, 1994; Ozus, et al. 2012).

Especially, in developing countries, pharmacists play an important role in providing information and advice on health care worldwide. This pharmacist's role as an advisor has been encouraged in order to reduce the burden of demand on physicians (Rogers, et al. 1998). Presently, this is the case in Turkey due to short supply of physicians as a result of their out-migration because of their unsatisfaction with their salaries (https://www.cumhuriyet.com.tr,2022).

*M.Sc., H3GEN Software Company, Türkiye, hasan@hasanmutlu.com, ** M.Sc., H3GEN Software Company, Türkiye, bbillur@gmail.com ***Prof. Dr. (Emeritus), İstanbul Technical University, Türkiye, vediadokmeci@gmail.com,
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Despite the importance of pharmacies, there remained of many countries have wide variations in the practice of pharmacy, not only between countries but also within countries. Nevertheless, in recent years there has been a significant convergence, driven by a number of key factors. These include World Health Organization declarations concerning the role of pharmacies according to changes in the political climate of many countries (Anderson, 2002).

A study by Sabde et al., (2002) describes the spatial distribution of private pharmacies and their characteristics in Ujjain district, Central India. Another study in India is given by Kamat (1998) on the same subject. A study by Hussain and Ibrahim (2011) illustrates that the process of dispensing practices and medication counselling differ significantly according to the location of pharmacies in Pakistan.

Palupi and Fakhruzzaman (2022) developed a model for efficient distribution of pharmacies. However, they claimed that location as a variable may not be a relevant in smaller countries or developed countries, because the shopping cost may not be a problem.

Review of literature reveals that there is a wide range of research on pharmacy location, efficiency and distribution in different developing countries. The present study compares the number, spatial distribution and their market areas of pharmacies between 1997-2022 in Istanbul and explain the relationships between the number of pharmacies and the characteristics of districts such as population, hospital beds and the number of physicians by the use of regression analysis. Background information is given in Section two. In Section three regression analysis is presented. Conclusion and suggestions for future research take place in Section four.

2. Backround

In 2022, investigation of the spatial distribution of urban pharmacies reveals that in the core area there are 341 pharmacies (6.6%) although the population ratio is 3.8 percent since market area of these pharmacies beyond the boundaries of this area supplied by alternative transformation systems. In the intermediate zone, there are 1437 pharmacies (27.9%) while the population ratio of this zone is 17.7 percent since some of the districts in this zone are higher income districts such as Kadikoy which has the highest number of pharmacies (442) in the city. In the periphery, there are 1778 pharmacies (65.5%) with respect to its population ratio is 78.5 percent in the city which has large squatter areas. Still, the large number of pharmacies in this zone, can be explained by the government policy of free medical care and medicine during the last two decades.

With respect to pharmacy market areas (number of people per pharmacy) while in 1997, the average pharmacy market area was 2494 people, in 2022, average pharmacy market area was increased to 3123 people since the population growth rate was higher than pharmacy growth rate such as between 1997-2022, the growth rate of pharmacies was % 53.7, while the growth rate of population was %74.3.

Comparison of pharmacy market size according to concentric zones reveals that the core area has the smallest pharmacy market area (1368 people) since the population is smaller than the other zones. In 2022, it almost stayed the same as 1369 people due to conservation policies to control the construction in the core area.

In the intermediate zone, in 1997, the pharmacy market size was 1688 people and it increased to 1978 due to changes in the district boundaries. In the periphery, in 1997, the pharmacy market size was 3723 people, in 2022, it increased to 3747 people. During this period, while population growth rate was %116, the growth rate of the number of pharmacies is %115 in this zone.

Despite various pharmacy market sizes in Istanbul, there is a strict control on the market areas in developed countries, such as in Spain 2118 people per pharmacy, in Japan 2222 people per pharmacy, in Greece 1136 people per pharmacy. Also, pharmacy opening and pharmacy location are heavily regulated in Italy (Mangano, 2010). Italian regulation links market entry in each municipal district to the number of residents and the existence of other pharmacies in close

proximity. A pharmacy to population ratio of 1 to 4000 applies to municipalities with more than 12,500 inhabitants, other municipalities are allowed a ratio of 1 pharmacy to 5000 residents.

As another example, Norris (1997) illustrates that in Norway and Finland, the state controls the number and location of pharmacies through a system of pharmacy licensing and their results on provision of services.

In Turkey, in order to prevent the problems of only market-oriented location of pharmacies, such as bankruptcies because of being located near to each other, in 2012 a legal regulation based on certain population size restriction was implemented. However, this regulation could not provide efficient accessibility to customers.

3. Model

In this study, the relationships between the number of pharmacies and the characteristics of the districts are investigated by the use of regression analysis. The variables of the analysis is chosen from the previous studies such as by Dokmeci and Ozus (2004) in order to be able to compare changes of the forces that effect pharmacy location through time.

It is well known that a pure market mechanism can give rise to a density which may not be optimal. Thus, in order to develop more efficient policies to provide balanced distribution of pharmacies with respect to population, there is a need to study forces which attract pharmacies to certain districts at the expense of others.

Table 1 Population and the number of pharmacies, hospital beds and physicians in the districts in 2022

Districts	Distance to CBD (km)	Population	Number of Hospital Beds (Private Hospitals)	Number of Physicians (Private Hospitals)	Number of Pharmacies	Number of Pharmacies Calculated by the Model
Adalar	40	14,522	0	0	9	20.51917746
Şile	84	30,218	0	0	9	25.50873795
Çatalca	55	63,467	0	0	23	32.32559779
Silivri	72	150,183	332	96	47	80.85779037
B.Çekmece	47	201,077	175	85	71	86.09738600
Tuzla	47	197,657	81	59	71	82.94253721
Arnavutköy	35	206,299	0	15	74	80.62742885
Beykoz	22	246,352	120	68	74	84.14659714
Güngören	14	307,573	86	80	75	85.22199712
Çekmeköy	20	193,182	0	0	80	74.29954692
Bayrampaşa	8	269,774	148	80	83	85.73407289
Sultanbeyli	39	302,388	98	69	91	97.50880063
Eyüp	6	356,512	31	34	100	104.6544480
Zeytinburnu	5	292,407	235	147	101	100.0518166
Beyoğlu	4.5	246,152	40	42	102	69.50927036
Bakırköy	14.5	221,336	188	257	105	98.02487567
Esenler	19	458,694	354	84	108	127.2975941
Sarıyer	28	288,959	321	233	108	123.8294534
Beylikdüzü	38	229,115	356	296	109	141.6752792
Kağıthane	14	421,356	33	81	116	117.3889555
Avcılar	27	395,274	333	147	118	135.8507216
Beşiktaş	5	186,067	261	393	120	106.0809169
Sancaktepe	46	278,998	75	68	130	121.3368291
Kartal	33	443,293	31	136	135	128.7175117

Districts	Distance to CBD (km)	Population	Number of Hospital Beds (Private Hospitals)	Number of Physicians (Private Hospitals)	Number of Pharmacies	Number of Pharmacies Calculated by the Model
Başakşehir	20	316,716	0	0	138	116.7089342
Sultangazi	25	492,212	269	112	142	146.5616951
GOP	14	488,258	819	359	145	183.4883939
Ataşehir	23	395,758	790	469	147	181.9225440
Şişli	22	318,217	607	916	162	197.9725845
Bahçelievler	14	600,162	751	659	182	237.2640046
Ümraniye	22	645,238	391	297	189	207.9196467
Maltepe	28	460,955	176	182	190	147.7650766
Üsküdar	13	535,916	672	512	191	202.1273531
Bağcılar	20	749,027	974	535	194	258.3729727
Pendik	52	625,797	182	227	194	195.8028178
K.Çekmece	18	721,911	299	428	222	235.2210278
Fatih	3	428,857	69	98	239	106.4125467
Esenyurt	34	553,369	306	121	248	234.6180706
Kadiköy	20	521,005	1022	657	443	222.6349879

Table 2 Regression Results

Regression Statistics	
Multiple R	0.791485160
R Square	0.626448758
Adjusted R Square	0.594430080
Standard Error	49.63267204
Observations	39

Table 3 Regression Results

ANOVA					
	df	SS	MS	F	Significance F
Regression	3	144590.1	48196.72	19.56510	1.2721E-07
Residual	35	86219.07	2463.402		
Total	38	230809.2			

Table 4 Regression Results

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	17.2846067	17.91349	0.964892	0.341218	-19.0817	53.6509	-19.0817	53.65093
Population	0.00019756	0.000042	4.625220	0.000049	0.000110	0.000284	0.000110	0.0002842
Bed Number	0.03438596	0.053980	0.637001	0.528268	-0.07520	0.143973	-0.075201	0.1439731
Number of Physicians (Private Hospitals)	0.11315341	0.067924	1.665868	0.104666	-.024740	0.251047	-0.024741	0.2510476

The variables of the analysis such as the number of pharmacies, population, the number of hospital beds and the number of doctors are given for the year 2022 in Table 1. The results of the analysis are given in Table 2. According to the results of the regression analysis, adjusted R2 is 0.59 and the most important variable to attract the pharmacies is the number of hospital beds in 2022 (0.11). However, in 1997, the most important variables to affect pharmacy location were population (0.51, the number of physicians in the districts (0.31) and hospital beds (0.26). The reasons for this change can be the growth of hospital beds in the districts to an unplanned degree. The pharmacies are clustered around hospitals according to their capacity. They fill the gap by supplying drugs which cannot be provided by the hospital pharmacies to in- and out-patients as in some other countries (Dokmeci & Ozus, 2004; Kaplan & Leinhardt, 1975).

Thus, the results of the study reveal that with the help of the government free medical care end medicine, although densities of pharmacies in the districts are close to the Italian regulations, their distributions in the districts don't take into consideration accessibility to the customers.

4. Conclusion

This study investigated the spatial distribution of pharmacies in Istanbul by taking into consideration the growth of population, hospital beds, physicians and changes in the government health care policy between 1997-2022.

The health care delivery system is characterized by a gross disparity between different districts according to their rapid development and differences in their socio-economic level. However, spatial distribution of pharmacies reflects quite balanced distribution at the city level due to support of government free health care delivery system and medicine.

Comparison of the pharmacy market areas between 1997-2022, reveals that they increased from 2546 to 3123 people which is smiler to some developed countries such as Spain, Japan and Italy. This varies among the zones of the city but still similar values to developed countries. On the other hand, spatial distribution of pharmacies within the districts, not convenient neither accessibility of customers nor maximization of their profits due to clustering of pharmacies in certain areas result in sometimes in bankruptcies.

It is necessary to develop models for pharmacy location which provides efficient accessibility for the customers and sufficient profits for the pharmacies. Investigation of the purchasing drugs through the internet left for future research.

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Resume

*Vedia (Arpacı) Dökmeci graduated from ITU Faculty of Architecture as an Engineer Architect in June 1962. She received M.S. degree in 1969 (hospital planning) and Ph.D. degree in 1972 (An analytical planning approach to regional health facility systems) from "Columbia University, School of Architecture" (New York). She became associate professor (1979) and professor (1988) at ITU Faculty of Architecture. She conducted research in the summer semesters at "Harvard University-MIT Joint Center" (1976), "University College London" (1979) and "University California, Berkeley" (1980). She taught undergraduate and graduate courses on numerical methods in planning, "location theory" and "transformation of urban systems", and conducted master's and doctoral theses. Her researches were supported by ITU, TUBITAK, SPO and the Ministry of Health and focused on mathematical modeling and applications of facility location selection, health facilities, city and regional planning, urban transformation and real estate development. She has published nine books and more than forty articles alone and with her students, in scientific journals within the scope of "HEAT". She was awarded the Turkish Academy of Sciences (TUBA) Science Award * (1999). She initiated the first "Real Estate Development Program" at ITU (2001-) and served as its chairman (2001-2006).*

Hasan Mutlu is working as Software Developer and Manager at H3GEN Software Company for 2 years where he is co-founder. H3GEN is developing CAD/GIS softwares for civil engineers, urban planners, architects and geological engineers. Mr Mutlu started his career as a freelance urban planner and worked for several architectural and urban design projects as a designer, transportation projects as data and GIS expert. In the last years of undergraduate education, he started to learn software development. He was responsible for designing and managing of city information system, GIS and CAD software and website developments, research about urban models at İstanbul Metropolitan Municipality Planning Department between 2001-2004. At the same time he completed his MS degree at Real Estate Development in İstanbul Technical University and wrote papers about urban development and land values. He worked at Netcad for 15 years and developed softwares about GIS management, CAD/GIS software for road design, hydrology, irrigation, water supply and distribution, sewer system until he founded H3GEN Software Company with 2 partners in 2021. Mr Mutlu prepares papers about subjects like urban development models, CAD, GIS, 3D and optimization which he is interested in.

Başak Billur Mutlu is working as GIS Specialist at H3GEN Software company. Mrs. Billur Mutlu is graduated from Middle East Technical University, Geological Engineering Department at 2001 and completed her MS degree at same university at 2004. She started her career at NETCAD Software company as GIS Specialist at 2005. She prepared several city information system projects for municipalities and GIS projects for governmental organizations. She was responsible for project management, database design and management, education and maintenance of GIS projects and testing, documenting, education of some softwares like Remote Sensing, Electrical GIS, Geographic Archive System, WebGIS between 2005 and 2011. She worked for 1 year at TUBİTAK, GIS and RS Technologies Department as consultant and analyst for GIS projects. At 2012, she continued working at NETCAD Software Company as Project Manager. Mrs. Billur Mutlu was responsible for project management of GIS Projects and she was database designer and manager of some GIS-MIS integration projects. While she was working at NETCAD Company she started Ankara University Computer Programming Department and graduated at 2013.Between 2015 and 2021, she worked as geotechnical department manager at PLANSON Company. Now, she is working as GIS Specialist at H3GEN Software Company.

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An inquiry on rebel cities: How spatial morphology sets the stage for urban movements

Elif Vurucular Kesimci*
Ayşen Ciravoğlu**

Abstract

The common thread to urban movements happening worldwide in recent years is the fact that urban public space is used as a significant setting by city dwellers for expressing their "objections". What has been experienced throughout urban movements when public spaces have been occupied enables us to grasp the meaning of occupied spaces in the city thus allowing us to get to know societies and cities. Therefore, this research has investigated the impact of urban public space on the consciousness, interaction and gathering of city dwellers as well as urban movements. Within the scope of the research, eight "rebel cities" have been analyzed, and have interviews with participants of urban movements from these cities. These are Tunis, Cairo, Barcelona, London, New York, Dublin, Paris, and Hamburg, respectively. The places where urban movements were visible in urban space and their surroundings have been analyzed using the Space Syntax method, and the gathering/unification/integration potential of public space has been spatially investigated by determining the characteristics of urban patterns. Accordingly, the city affects the formation of urban movements with its spatial pattern. In the case of Merida city, which constitutes the control sample and which was not affected by the urban movements that spread to the whole world, this finding is also supported. With the results obtained in the research, the significance of public space, as an essential element contributing to the formation of urban movements, has been proven. This study further reveals the possibility of urban spaces allowing social encounters and its importance in terms of democracy.

Keywords: urban movements, public space, rebel cities, space syntax, spatial morphology

1. Introduction

Cities are spaces that serve a variety of purposes. In our age, due to the impact of globalization, cities are regarded as a commodity, and a rapid transformation process is taking place as cities are reproduced without allowing city dwellers the right to speak.

The common thread to all urban movements is that they are visible in public spaces. The reasons lying behind the city movements happening in recent years include not only economic crises but also the failure to involve city dwellers in the rapid transformation of city spaces and ignoring the "right to the city". This study seeks an answer to the question of why public spaces are chosen. Therefore, the places where urban movements occurred worldwide were determined as a first step. Samples from "Rebel Cities", in Harvey's (2012) terms, were taken and these have been analyzed in terms of spatial morphology focusing on occupied spaces.

*(Corresponding author), Instructor, Bursa Technical University, Türkiye, elifvurucular@gmail.com
**Prof. Dr., Yıldız Technical University, Türkiye, aysenc@gmail.com
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Urban spaces are those that enable city dwellers to come together. According to Harvey (2012), the city is the site where people of all sorts and classes mingle, however reluctantly and agonistically, to produce a common if perpetually changing and transitory life. Coming together in urban space also sets the ground for those who can act together. It is the architecture of the street network that creates the fundamental condition of the civilised city; the natural co-presence in space of many different kinds of people doing many different kinds of thing, who, without knowing each other, create for each other the sense of being part of a civil society" (Hillier, 2013). They have also adopted urban spaces to defend their rights in threatening cases. Open urban spaces are where city dwellers come together in the presence of controlling restrictions and display their defiance in necessary cases. Coming together for action also takes place in public spaces. This makes sense for city dwellers; thus, from time to time, there has been an attempt, throughout history, to control them. The aim of this paper is to reveal the connection of the spaces chosen for urban movements witnessed recently by the entire city and its city dwellers.

Hillier (2012) argues that urban pattern develops a sense of social belonging even though individuals that act differently are unaware of each other. Sense of belonging supports the will to claim the right to the city. In this context, (Nejad, 2013) contends that the location of a public space in a city is more important than its symbolic connotations, and the impact of crowds depends on the spatial characteristics of the place of the protest. In another study related with this topic, Ciravoğlu (2014) argued that places, with their spatial pattern, carry the potential of generating urban movements. The studies previously conducted reveal that the squares of some cities are more effective in bringing together city dwellers and that it is easier for urban movements to emerge in these cities. In this way, it was intended to reveal the possible relations between urban movements and spatial morphology.

In the initiation, for growth and continuity of urban movements, today's communication tools such as the internet and social media play a role. However, although urban movements start in the internet environment, it has been observed that they inhabited urban public space with which city dwellers had one-to-one contact and mostly grew with the occupation of these spaces in which city dwellers from all walks of life participated. The occupation of city spaces that have a place in the memory of city dwellers indicates that "space" has an impact on the consciousness, interaction and gathering of city dwellers and urban movements. With the morphological analyses of the selected spaces and interviews with the participants within the scope of the research, the impact of urban pattern on urban movements is detected. Accordingly, the city affects the formation of urban movements with its public spaces and urban pattern.

1.1. Selection of Case Studies

Within the scope of the research, eight "rebel cities" have been analyzed. The places where urban movements were visible in urban space and their surroundings have been analyzed using the Space Syntax method, and the gathering/unification/integration potential of public space has been spatially investigated by determining the characteristics of urban space pattern. As for the city that has not yet been affected by urban movements included in the control sample, the square which supposedly brings together city dwellers has been taken as the center and analyzed with the Space Syntax method.

There are three important criteria about the selection of the cases study areas. First, cases from the geographies where urban movements were intensified were selected including the USA, Europe and the Arab peninsula[1] (Figure 1). The second criteria can be stated as trying to be as inclusive as possible to cover cases from different cultures and different urban morphologies. Lastly as the year 2011 was an important date for the uprising of events, the cases were limited to the urban protests that took place within the mentioned year.

[1] Even though there are not many protests on the Arab peninsula, as the Tunis case is the starting point of the protests and plays a great role in its spreading all around the world, this geography is thought to be of great importance, therefore is included in the study.

The cities which have been analyzed within the scope of this study include Tunis from Tunisia, which experienced a revolution and inspired the Arab world in 2011; Cairo from Egypt, which was inspired by the previous example and realized a revolution in its own country; London, with its urban movement that started in the ghetto district and spread to the whole country; New York, with its "Occupy" movement that spread to the whole world; Dublin, which was inspired by the USA; Paris, with its "Occupy" movement that started after the process of displacement following urban transformation; Barcelona, which came to the agenda with the Indignados movement inspired by Tunisia and Egypt; and Merida, which was not involved in urban movements, and Hamburg, with its efforts to protect public space.

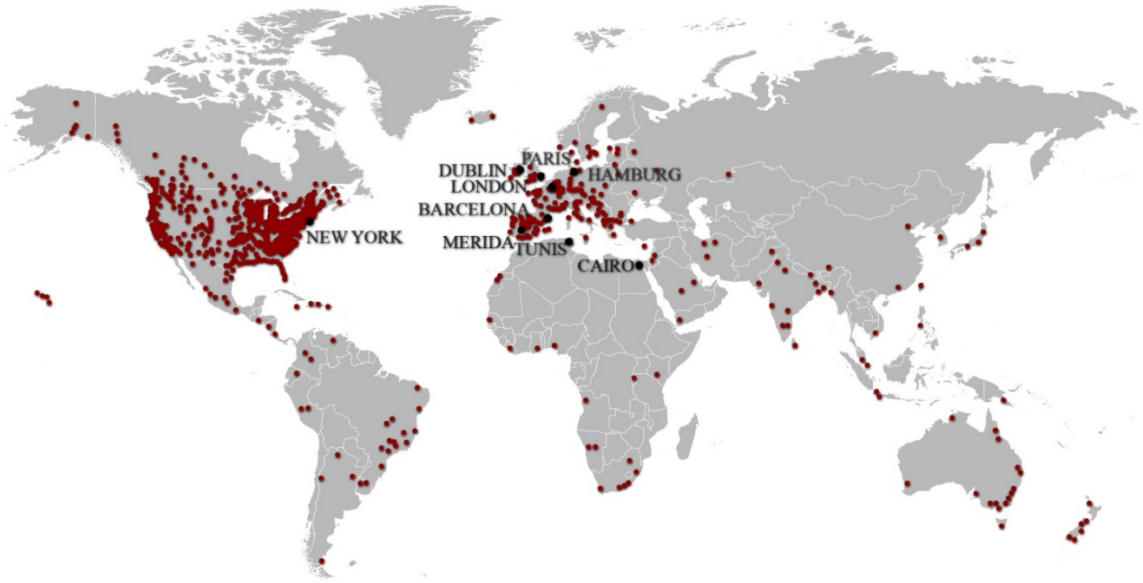


Figure 1 Urban movements and case study areas in the world (Red marks indicate the worldwide urban movements and black marks indicate the selected cities. The illustration is made by authors based on information taken from the following reference: Anon, 2020)

1.2. The Method of the Study: Space Syntax and Interviews with Participants

In order to explain the relation between sociology and spatial configurations scientifically, the Space Syntax model was produced by Bill Hillier and Julienne Hanson at the Space Syntax Laboratory, at the Bartlett School of Architecture and Planning in University College London. Explanation of the philosophy and methodology can be found in Hillier's book 'Space is the Machine' (1996).

In this study the Space Syntax methodology was used to predict pedestrian movement. Therefore, axial maps of pedestrian access were drawn by hand on maps obtained from satellite images of Google Earth (Google, 2020a, b, c, d, e, f, g, h & i). Axial maps are formed by drawing the fewest and longest straight lines of sight and access passing from streets and open areas that would predict pedestrian movement on existing maps of the city. As instructed by the software manual, the size of the examined area should be defined by drawing a circle around the area of interest. This area is called the buffer zone. Therefore axial map is drawn within a 2 km radius which would be a comfortable walking distance of at least 30 minutes around the area of interest. Axes have to intersect on the map (Hillier & Hanson, 1984; Campos & Karimi, 2004; Chen, 2017).

Axial maps were analyzed with the Depthmap software program (Varoudis, 2012) and their integration values were calculated. The Space Syntax methodology determines the relations of the axes with each other as well as their relations to the whole. The integration value shows how many steps should be taken to reach an axis from all the other axes. In this system, the accessibility of an axis is not calculated according to the geometric distance, but the number of axes connected to that axis or the number of "steps" and how many steps it takes to access that axis. In this case, the axis that is connected to its surrounding with the highest number of axes will be the most accessible

and the most frequently used one (Hillier & Hanson, 1984; Hillier, 1996; Jiang & Claramunt, 2002). The integration values of the districts easily accessed are higher. In integrated spaces, one is more likely to encounter people (Hillier et al., 1983; Hillier et al., 1987; Hillier, 1993; Read, 1999). While the whole of the system is considered to be a "global" network, smaller sets of units are regarded as "local" networks. Integration Rn values refer to global integration, Integration R3 values refer to local integration. R3 analysis was carried out as it gives the local integration of the system which predicts pedestrian movement within the system (Jones & Fanek, 1997; Jiang et al., 2000; Dhimn, 2006; Erinsel Önder & Gigi, 2010). While the encounter of every city dweller is possible in the global system, the life patterns of city dwellers and their encounters are analyzed through movement networks in the local system. Therefore, in this study, Integration Rn and R3 values are analyzed and compared. The Space Syntax program colors the axial map to enable the readability of analysis findings. The transition from cool colors (blue, green) to warm colors (yellow, orange, red) indicates an increase in integration values. The Integration Rn and R3 values and colors of urban space axes where urban movements are visible have been taken into consideration.

After the analysis of rebel cities with Space Syntax Methodology, in addition, interviews were conducted with the participants of the urban movements in order to understand the impact of open public places on bringing citizens together and creating urban movements. Thus, the potential of urban dwellers to come together in two dimensions measured by the space syntax method has been confirmed by the citizens of the city.

2. Spatial Morphology Analysis of Rebel Cities

2.1. Spatial Analysis of Case Studies

Results of the analysis in terms of urban morphology of nine urban public spaces as the focus of the study, are presented in this section. In the analyses, the Integration Rn and R3 values have been taken into account. These values indicate the central points of the analyzed region in a global and local scale. The analysis conducted has been based on the gradation of numerical values which indicate the integration potential of the settlement instead of their comparison. Therefore, evaluations were made not based on the integration values of the axes (streets, squares, parks) presented by the spatial syntax analysis of the spaces visible in urban movements but the colors that grade these values and present them in a hierarchical order. Table 1 and Table 3 presents findings of the study. In the following sections, results of each case are discussed.

2.1.1 Spatial Analysis of Bardo Square

When the spatial syntax analysis of Tunis is made, taking Bardo Square as the center, it is seen that the square plays a role in the encounters of people. On the Integration Rn axial map, it is found that the square is the center of the area and that the streets connecting to the square are the most integrated ones among all. As for the Integration R3 axial map, it is determined that there are local centers, one of which is Bardo Square. The highest axis value on the Integration Rn and R3 maps is one of the axes of the square with a Rn value of 1.97308 and a R3 value of 4.25273 and colored red. The five axes of the square on Rn map colored with red and orange. As for the R3 map, the values colored red and orange. These results show that Bardo Square is a frequently used space easily accessed by city dwellers enabling them to encounter each other. Accordingly, this finding explains why it was selected as the occupation space.

2.1.2 Space Syntax Analysis of Tahrir Square

When the spatial syntax analysis of Cairo is made, taking Tahrir Square as the center, it is seen that the regions which are central on local and global scales intersect on Integration Rn and R3 maps. The axes of Tahrir Square are colored red and orange on Integration Rn and R3 axial maps. The axis with the highest value on the Integration Rn map is that of the square with a value of 1.90344 and colored red, while the value is 4.19313 on the R3 map and again colored red. The values of the five axes of the square on the Rn map are colored red and orange. On the R3 map, the

colors ranged from red to light orange. From these results, it could be seen that the axes of the square are used and integrated on global and local scales, and that within the analyzed region, the square is the center that offers city dwellers a chance to encounter each other.

2.1.3 Space Syntax Analysis of Catalunya Square

When Catalunya Square, the occupied space of Barcelona, is analyzed, it is seen that the centers intersect on a global and local scale, which shows that the city space is integrated. These results present a space which provides city dwellers a high possibility of encounter; thus, the space acts as an element that triggers the will in city dwellers to come and act together in an incident. The highest value of the historical square's axes is 2.66552 and colored orange on the Integration Rn map. The same axis has the value of 3.90263 and again colored orange on the Integration R3 map. The five axes of the square on Rn map colored in orange and red. On the R3 map, the values colored in red and yellow. With their high values in the district, the axes of the square provide city dwellers with the opportunity to cross paths. Not only the fact that the analyzed district of the city is integrated but also the axial values of the square justify why urban movements take place there.

2.1.4 Space Syntax Analysis of Paternoster Square

When Paternoster Square and its surrounding area in London is analyzed, it is seen that the Integration Rn and R3 values of the axes reaching the square are high on the axial maps. The highest Integration Rn value of the axis of the square is 1.55967 and colored red. As for the Integration R3 value of the same axis, it is 3.20287 and colored orange. The five axes of the square on Rn map colored from red to yellow. On the R3 map, the values colored of the five axes from orange to light green. The values and colors of the square indicate that the axes of the square are used more frequently than the other axes; thus, offering city dwellers the possibility of encounters which could also be interpreted as the reason for its use as a center during a social event.

2.1.5 Space Syntax Analysis of Zuccotti Park

When Zuccotti Park and its surrounding area in New York is taken as the center and analyzed as the protesting space of the Occupy Wall Street urban movement, it is seen that the centers intersect on a global and local scale. These findings show that the analyzed space of the city is integrated within itself, making the possibility of encounters high, with the added advantage of a low crime rate in the district. The longest axis on the Integration Rn and R3 maps with the highest value is colored red and signifies the axis reaching the square. While the Integration Rn value of this axis is 3.49922, it has a value of 4.57813 on the R3 map. The five axes of the park on the Rn map colored from red to yellow. On the R3 map, the colors range from red to yellow. These results suggest that the park is a densely used space and explain why it was selected for urban movements.

2.1.6 Space Syntax Analysis of Dame Street

Dublin has been analyzed by taking Dame Street as the focus, which is one of the busiest streets and served as the center of urban movements. It has been determined that the axes forming Dame Street have high values on Integration Rn and R3 maps and are colored red and orange. Furthermore, the axes reaching the street have the highest values on local and global scales and are colored red and orange. The street is frequently used by city dwellers; thus, it is an urban space which, in time, has become functional with its shops. On the Integration Rn map, its highest axis value is 1.40844 and colored red while the value is 2.94707 on the Integration R3 map and colored light orange. The values of the five axes of the street on the Rn map colored red and orange. As for the R3 map, the colors range from light orange to green. Although the analyzed district of the city is not integrated, the axial values of the street indicate that it is a used and accessible street on local and global scales where city dwellers can come together.

2.1.7 Space Syntax Analysis of La Défense

The district of La Défense has been constructed as the new center of Paris. When the district is analyzed, it is seen that it is located in the center. The Integration Rn analysis shows that the streets

that form a triangle in the center have the highest values, and that these results do not change in the Integration R3 analysis as well. On global and local scales, the district of La Défense is the only center. According to the Integration Rn analysis, the square has the highest axial value of 2.64722 and colored red. The same axis has an Integration R3 value of 4.37692 and colored red. This axis is the street with the highest value among the analyzed area and indicates a district that is frequently used by city dwellers and where many encounters occur. On the Rn map, the values of the five axes connecting to the square are represented with colors ranging from red to light orange. As for the R3 map, the colors range from red to orange. These results reveal that the analyzed area of the city is integrated and that the square is a significant, frequently-used center and an outstanding space for city dwellers on a local and global scale.

2.1.8 Space Syntax Analysis of Park Fiction

Park Fiction in Hamburg is located next to a church and in a district that city dwellers use. The fact that it is located at a port also increases its use. When an analysis is conducted with the Space Syntax method, it is seen that the Integration Rn and R3 values of the axes connecting to the park are high and that their colors are warm. Of these axes, the highest value on the Integration Rn map is determined to be 1.65091 and colored orange. As for the Integration R3 value, it is found to be 2.85453 and colored yellow. On the Rn map, the values of the five axes of the park colored from orange to yellow. On the R3 map, the values colored yellow and green. These results show that city dwellers frequently come together in Park Fiction, use this space and that it is a center where encounters take place in the district. These findings explain why the center attracts a movement of defense when its presence is endangered.

2.1.9 Space Syntax Analysis of Plaza Espana Square

The only city which did not participate in the “Indignados” movement in Spain is Merida. When this settlement is analyzed with the Space Syntax method, taking Plaza Espana Square[2] as the center, it is seen that the axes of the square in Merida are in cold colors unlike the other cities evaluated, and that the values are low within the settlement although they seem to be high when compared to other settlements. On the Integration Rn map, the axis of the square with the highest value is 1.206170 and colored light orange while the same axis has the value of 2.147590 on the Integration R3 map and colored light green. On the Rn map, the values of the five axes of the square colored from light orange to green. On the R3 map the colors range between light green and light blue. Resulting from the values and colors of the axes of the square within the analyzed region of the city, it could be concluded that the square is not located in a space of the city where people have the possibility to frequently pass by. This condition decreases city dwellers’ possibility of encountering, socializing and gathering. These results explain in terms of spatial morphology why Merida did not participate in the process of urban movements while the other cities confronted with the same problems were involved.

As a result of the analyses conducted and drawing on the Integration Rn and R3 values and colors, it is seen that the occupied spaces of rebel cities are frequently used spaces that attract city dwellers and offer them the possibility of encountering and that the historical square of Merida city, which has not participated in the urban movements, is not used by city dwellers. These findings show that public spaces may ensure democracy as they function as spaces that enable the use by city dwellers.

[2] As there were no urban movements in this case, the most important public space of the city is taken as the center of analysis.

Table 1 Results of the space syntax analyses of rebel cities

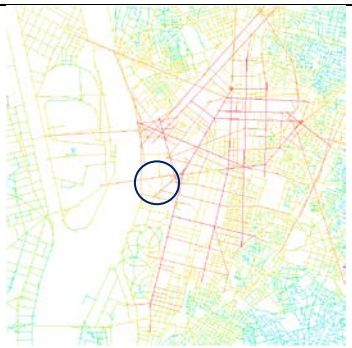
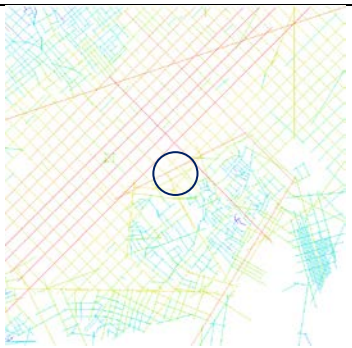
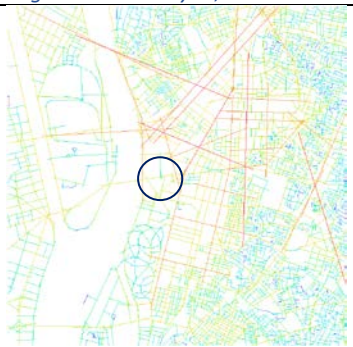
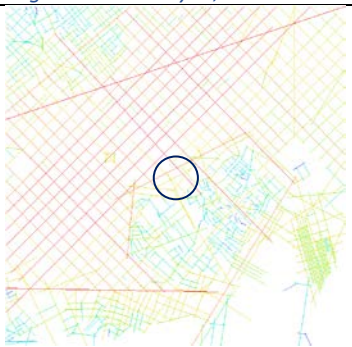
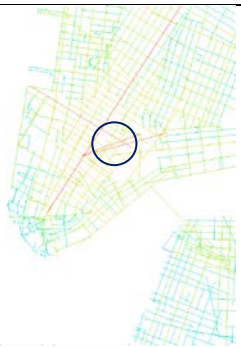
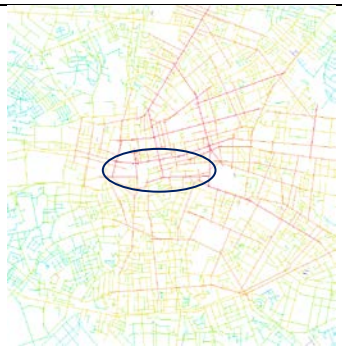
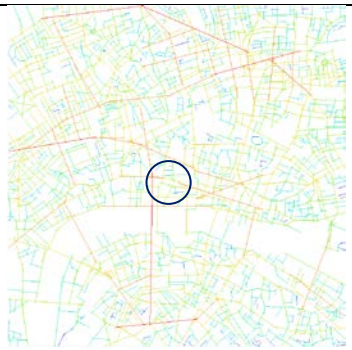
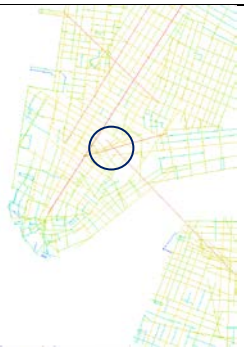
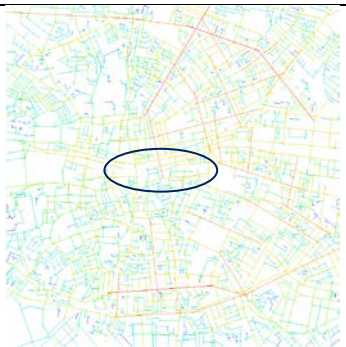
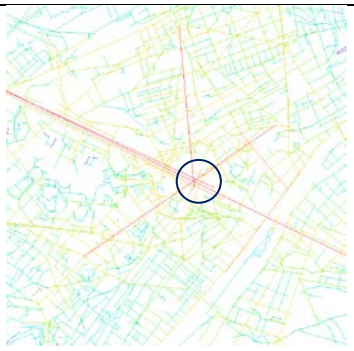
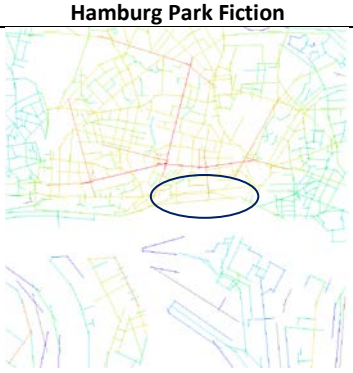
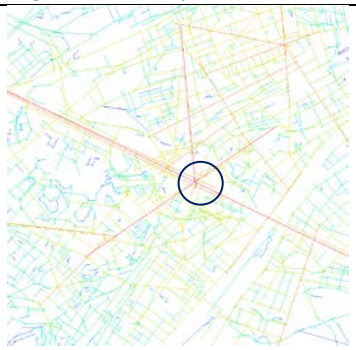
Tunis Bardo Square	Cairo Tahrir Square	Barcelona Catalunya Square
		
Integration Rn analysis; Max=1.97308	*Integration Rn analysis; M*ax=1.90344	*Integration Rn analysis;* Max=3.24998
		
Integration R3 analysis; Max=4.36839	*Integration R3 analysis;* Max=4.49621	*Integration R3 analysis;* Max=4.44704
London Paternoster Square	**New York Zuccotti Park**	**Dublin Dame Street**
		
Integration Rn analysis; Max=1.70889	*Integration Rn analysis;* Max=3.49922	*Integration Rn analysis;* Max=1.45122
		
Integration R3 analysis; Max=3.77497	*Integration R3 analysis;* Max=4.57813	*Integration R3 analysis;* Max=3.92026

Table 1 Results of the space syntax analyses of rebel cities (continued)

Paris La Defence District	Hamburg Park Fiction	Merida Plaza Espana Square
		
Integration Rn analysis; Max=2.64722	*Integration Rn analysis;* Max=1.87217	*Integration Rn analysis;* Max=1.58499
		
Integration R3 analysis; Max=4.37692	*Integration R3 analysis;* Max=3.60563	*Integration R3 analysis;* Max=4.16313

2.2. Evaluation of the Research Findings

In this study, public spaces in cities where urban movements were visible have been evaluated in terms of urban morphology. Thanks to the Space Syntax analysis, interpretations were made using the values and colors of the axes reaching the squares. The findings obtained in the study have been graded and listed according to Space Syntax analysis, as seen in Table 3. In this chart, of the axes of the spaces where urban movements occurred, those with the highest value and their colors as well as the highest axial values and colors of the historical square of Merida are given. On the chart, it is seen that the spaces where urban movements occurred received higher values among the spaces of the whole city, and that they are colored red and orange while the axial values are low, and the colors are cold such as green and blue regarding Merida where urban movements were not observed. According to the listing, the cities with the highest values regarding their public spaces and the values of their axes reaching these spaces have been determined to be Cairo, Paris and Tunis, while the lowest values belong to the city of Merida. The axial values of public spaces in the cities where urban movements were visible thanks to the possibility of city dwellers' encountering have been graded and colored. In the cities where urban movements occur, the integration values and colors of the axes of the areas which are the center of movements indicate that these spaces are used spaces that function as gathering spaces where city dwellers come together. The axial values and colors of the square in Merida city, where urban movements did not take place, show that it does not allow city dwellers to come together or encounter each other in this particular space. These results reveal among many other factors the impact of urban morphology, which determined urban space, on the initiation and continuity of urban movements.

Table 2 Values assigned to color rankings of Integration in Depthmap

RED	ORANGE	L.ORANGE	YELLOW	GREEN	L. GREEN	L. BLUE	BLUE	mean total depth
8	7	6	5	4	3	2	1	low high

Table 3 Rankings and values of five major axes that pass through the squares

Cities	Integration	Integration Rn/R3 and Rankings Values*	Total Values
Tunis Bardo Square	Rn	1.97308 (8), 1.90011 (8), 1.86598 (8), 1.81168 (7), 1.79534 (7)	38
	R3	4.25273 (8), 4.09364 (8), 3.67348 (7), 3.57924 (7), 3.79428 (7)	37
Cairo Tahrir Square	Rn	1.90344 (8), 1.84841 (8), 1.76663 (8), 1.73668 (8), 1.73036 (7)	39
	R3	4.19313 (8), 4.00462 (7), 3.88178 (7), 3.55993 (6), 3.52440 (6)	34
Barcelona Catalunya Square	Rn	2.91660 (7), 2.66552 (6), 2.60111 (6), 2.39954 (5), 2.36069 (5)	29
	R3	3.90263 (7), 4.07421 (8), 3.45493 (6), 3.59845 (6), 3.22581 (5)	32
London Paternoster Square	Rn	1.55967 (8), 1.55285 (7), 1.45849 (7), 1.35938 (6), 1.24391 (5)	33
	R3	3.20287 (7), 3.02686 (6), 2.86072 (6), 2.12546 (4), 1.94509 (3)	26
New York Zuccotti Park	Rn	3.49922 (8), 2.55429 (5), 2.42253 (5), 2.33995 (5), 2.28600 (5)	28
	R3	4.57813 (8), 3.46837 (6), 3.37376 (6), 3.10332 (5), 3.04213 (5)	30
Dublin Dame Street	Rn	1.40844 (8), 1.34945 (8), 1.31630 (5), 1.25989 (5), 1.23997 (5)	28
	R3	2.94707 (6), 2.65963 (5), 2.45816 (5), 2.00481 (3), 2.20820 (4)	23
Paris La Defence District	Rn	2.64722 (8), 2.61260 (8), 2.45712 (8), 2.44838 (8), 2.15640 (6)	38
	R3	4.37692 (8), 4.27743 (8), 3.91054 (5), 4.08934 (8), 3.62994 (5)	38
Hamburg Park Fiction	Rn	1.65091 (7), 1.47852 (6), 1.37758 (6), 1.26379 (5), 1.25543 (5)	29
	R3	2.85453 (5), 2.65303 (5), 2.23929 (4), 2.14242(4), 1.95335 (4)	22
Merida Plaza Espana Square	Rn	1.20617 (6), 1.14284 (5), 1.13158 (5), 1.01305 (4), 0.99830 (4)	24
	R3	2.14736 (3), 1.85728 (3), 2.14759 (3), 1.73254 (2), 1.78416 (2)	13

*Colors are retrieved from the Space Syntax software. They represent the ranking of the integration values within the whole system.

2.3 The Contribution of Interviews to Research Findings

In order to ensure the reliability of the spatial findings, interviews have been conducted with the people who participated urban movements in the cities in question. Of the urban movements analyzed, participants from Tunis, Cairo, Barcelona, London, New York, Dublin and Paris have been contacted and the few responses received has led to the conclusion that urban movements have been forgotten and that interest in them has been lost. The distribution of participants who have responded to the questionnaire are as follows: Tunis (2), Cairo (1), New York (1) and Dublin (4). Those who agreed to participate in the interviews were asked questions to clarify how they perceived the public spaces analyzed within the scope of this research before and after the protests, and they were asked to evaluate how they related to these spaces.

According to the interviews held with two participants from Tunis, it was stated that prior to the urban movements, Bardo Square brought together people from common and different cultures, that they sometimes visited this place to come together with different people. For various activities, the square could address the city and serve as a gathering place for social events as it was easily accessible; however, the access of city dwellers to the square was kept under control. This square, which hosted an urban movement, was a space that could inform people of the city's history and identity, and that different people visited before and after the urban movements and had an opportunity to interact. Furthermore, they stated that the square was a space that had witnessed the history of the city and occupied a space in the memories of city dwellers. Finally, the respondents expressed that, prior to the urban movements, the square had cultural, economic and political functions. It acquired an additional quality of a symbolic space where the public could make itself heard after the movements.

A participant of the interview from Cairo stated that the square where urban movements occurred demonstrated the characteristics of a center; however, it could not be used except for compulsory passage before the urban movements and that there were administrative buildings such as the municipality and the governor's. The square could be easily accessed. The participant also noted that the square where the urban movement took place was a space where different

people came and interacted and that it hosted the history of the city occupying a space in the memory of city dwellers. Finally, the participant expressed that, prior to the urban movements, the space had acquired a symbolic meaning throughout history; however, the space also had an administrative and political function due to restrictions whereas it acquired an additional quality of a symbolic space where the public could make itself heard after the movements.

Another participant of the interview from New York stated that, prior to the urban movements, Zuccotti Park did not have any other significance than being surrounded by many private companies and did not host any activities. The participant stressed that Wall Street was the symbol of economy and capitalism for the USA. Therefore, the park was occupied, adding that it continued to bear the same meaning after the urban movements.

It was possible to receive responses from four participants from Dublin. They stated that Dame Street served as a center addressing the whole city, and they used it for communication with city dwellers and as a passage, adding that the street had a commercial function and was used for shopping, spending time at cafes as well as protests and public demonstrations. They also stated that the space was easily accessible, open to public use and used by different people, adding that it offered freedom for protesting and fulfilled a variety of functions. Furthermore, the activists declared that a diversity of people came together during protests and that the processes continued without conflict or segregation. Finally, the activists noted that although the street functioned as a center before the protests, it had mainly served as a meeting place for young people in their leisure time rather than hosting social activities. It acquired a political significance after the movements and became the first place to come to mind in case of a similar movement.

From the results of the interviews conducted, it is seen that the spaces that were the center of urban movements carried a meaning for city dwellers prior to the movements; however, their meaning expanded after the movements and their use increased. The common characteristic of these spaces is that they are already being used by city dwellers and that the urban pattern provides access for them. When the cities were analyzed with the Space Syntax method by taking the spaces where urban movements were visible, it was concluded that these spaces were accessible and brought together city dwellers. The interviews conducted with the activists who participated in the urban movements support these results.

3. Conclusion

In this study, the morphological characteristics of urban spaces where urban “objections” have become visible were evaluated at a time when urban movements have accelerated. Urban movements selected public spaces where city dwellers could make themselves heard. The research conducted focuses on the characteristics of the connection of these urban public spaces to the urban system. According to the results of the research, public spaces which integrate into the urban system at a high-level exhibit appropriate spatial characteristics for the formation of urban movements. In other words, urban spaces, with their urban pattern, pave the way for urban movements. With the results obtained in the research, the significance of public space, as an essential element contributing to the formation of urban movements, has been proven. This study reveals the possibility of urban spaces allowing social encounters and its importance in terms of democracy.

As a result of the research and analyses conducted, urban spaces where city dwellers may come together have been proven to be significant for urban movements. For the presence of social movements, it is essential that city dwellers have the potential to come together, and those urban spaces provide this possibility. Without the presence of spaces where a society may gather, it would not be possible to expect the development of an identity, history, culture of that society as well as its unity. It has been seen that, with their morphology, urban spaces where urban movements take place allow these encounters. The Space Syntax analyses of the spaces that were central to the movements reveal the priorities of city dwellers’ use regarding these spaces. As a result of the spatial analyses, along with the interviews conducted with participants of the urban movements, it

has been seen that, in terms of morphology, the spaces demonstrate spatial characteristics such as being open to public use, accessibility, allowing the encounters of the public and strengthening their feelings of togetherness. In the cities where urban movements have been observed, the axes of the spaces that are the center of the movements have high integration values. They have the quality of attracting and bringing together city dwellers. These characteristics enable the formation of not only urban movements but also of places that leave a mark in the memories of the city dwellers. As for the case in which urban movements have not been observed, it has been found that the historical square of the city is not of a spatial quality that would allow such encounters.

The presence and accessibility of public spaces as well as unrestricted access to these spaces are vital for the construction of a city where city dwellers dream of seeking their right to it. It is essential for the future of a city that decision makers keep public spaces public instead of allocating urban spaces to a certain urban class and increasing class distinctions. Throughout the design process of these spaces, the aim should be to ensure every intervention to possess the quality of accessibility and inclusiveness and to allow the interaction of city dwellers, inviting them to activities and to strengthen the connection among people, enabling them to act in unity.

This study provides both urban authorities and the public with clues about the spatial morphology of rebel cities. Given that democracy passes through the construction of democratic spaces, the findings revealed by this study are of significance not only to city administrators but also to planners, architects and decision makers. In this process, the fact that the spatial syntax method could be used as a tool to evaluate the potential of urban space regarding urban movements is a finding that sheds light on future research.

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Resume

Instructor Elif Vurucular Kesimci will receive her Ph.D. (2023) in Building Research and Programming about spatial memory in department of Architecture from YTU. In her 13-year-professional-life, she worked in several architectural offices in the building design. She is a full time Instructor enrolled in research and educational activities in undergraduate level in the fields of architectural education, architectural design, philosophy of architecture, building typologies on architecture in Bursa Technical University, Faculty of Architecture and Design, for over 8 years.

Ayşen Ciravoğlu has received her PhD (2006) in Building Research and Programming about Sustainability in department of Architecture from YTU. She is a full time Professor enrolled in research and educational activities in both graduate and undergraduate levels in the fileds of architectural education, sustainable architecture, architectural design, environmental issues and critics on architecture in Yıldız Technical University, Faculty of Architecture. Ciravoğlu has won EAAE (European Association for Architectural Education) Prize in 2002 with her article entitled "On Formal and Informal Studies in Architectural Design Education".

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Beyond luck: The key to profitable residential real estate investments for individual investors in Türkiye

Celal Erdoğdu*

Abstract

Individual residential investors are influenced by the media and their environment in their investment preferences, as they lack the experience of property investors and professional residential investors. Concerns about regret, fears of further property price rises and social circumstances put pressure on investors. Under these conditions, are individual housing investors seeing all the opportunities in the housing market? What types of buyers are taking advantage of these opportunities? This study aims to create tools to help individual residential investors identify opportunity periods in the market, analyse such opportunities retrospectively and test consumer behaviours in response to these opportunities. We analysed the opportunity for access to housing, the opportunity of lower loan interest rates and the opportunity of lower housing prices in Türkiye in the 120 months between 2013 and 2022 using the income-housing price scale. We analysed residential sales (total, credit and cash) in the opportunity periods resulting from the equations set up for the opportunity periods. We tested the criteria for selecting opportunity periods using the analysis of variation (ANOVA) method. We analysed changes in consumer preferences for credit and cash home purchases during periods of opportunity. We found that residential investors did not use the opportunity of accessing residential properties, and that cash home buyers used the opportunities of residential loan interest rates and residential price declines.

Keywords: home, housing, investment, profit, real estate.

1. Introduction

Türkiye's monetary policy, high inflation, urban redevelopment and earthquakes have recently kept demand for residential property buoyant. In Türkiye, 1.5 million houses are sold yearly (TUIK, 2023a). There are 26 million households in Türkiye (TUIK, 2023b), and 26 per cent of them are tenants (TUIK, 2023c), and every household is a potential homebuyer. Unless individual investors are professionally involved in residential investment, they make purchasing decisions under the influence of their immediate environment and the media.

Investing in residential property can be a lucrative opportunity for individual investors, but success in this area requires more than luck. Identifying profitable opportunities in the market requires know-how, experience and a strategic approach. The residential property market has always been an attractive investment option for individual investors. Unlike other investment tools, such as shares or bonds, residential property is a tangible asset that can provide stable income streams and long-term capital growth. However, investing in residential property is not without its challenges. It requires a clear understanding of market trends, and the ability to identify opportunities and make sound investment decisions. Furthermore, individual investors have to decide between complex market conditions such as fluctuating interest rates, residential property prices and economic trends, which makes investing in residential property even more challenging.

*Ms.C. Urban Planner, ISMA University of Applied Sciences, Latvia, celaler@yahoo.com
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This research paper explores the essential factors distinguishing successful residential property investors from those struggling to make a profit. To help individual investors maximise their returns from residential property investments, we will analyse the opportunities available in the residential property market, how to quantify them, and which buyers have made the most of them over the past ten years. This article details effective investment approaches and provides a guide for individual investors looking to benefit from the opportunities in the residential property market.

There are few studies in the literature on the opportunities for investment in the residential sector in Türkiye and the analysis of these opportunities. This article aims to fill that gap. The other parts of this paper firstly present housing and its importance for households, the decision to buy residential property, residential investors and their types, the impact of residential property prices on investors, affordability and its scales, residential property price changes and their consequences in developed and developing countries, the rationality of residential property investors, media and environmental effects in residential property investment, psychological factors in residential property investment, market data in the housing market and analyses of market information. The study's methodology and the analysis stages are then presented. In the following section, the statistics and results of housing accessibility opportunity, housing affordability opportunity and housing price opportunity are presented. The discussion and conclusion share the study's results, limitations and suggestions for future studies.

2. Literature Review:

Residential property is used for consumption and investment (Henderson & Ioannides, 1983). It also accounts for the largest single household expenditure (Ben-Shahar & Warszawski, 2016). The motivations of residential property buyers are to own a dwelling, earn rental income and benefit from the increase in value (Erdoğdu & Büyükduman, 2018).

Residential decisions are complex, involving economic and social motives, and cannot be ranked (Lux et al., 2017). Homeownership indicates people's personalities and lifestyles (Koklic & Vida, 2014). In Triantafyllopoulos and Kandyla's (2010) study, 8% of homebuyers cited homeownership as a way to escape renting, enjoy better accommodation, and leave a legacy for the next generation. Wealth accumulation and long-term capital gains were the most important considerations when investing in property. Wealth accumulation and long-term capital gains were the most important considerations when investing in property (De Bruin & Flint-Hartle, 2003).

2.1. Housing Market Investor Types

Bayer et al. (2020) observe two individual residential property investor types. One is the middleman, and the other is the speculator. Middlemen are always in the market, buying below the market price and selling above the market price. On the other hand, speculators usually enter the market during the boom and buy and sell at the market price. Some amateur speculators enter the residential market during a boom. People may have experience because they buy some products frequently. However, in the case of expensive and complex products, learning based on trial and error is rare (Bazerman, 2001). Gaining experience in the property market based on trial and error can be costly for many people.

Investors can have different impacts on the housing market. Individuals' entry into the housing market as investors increase by 20% if they have recently moved or if their neighbour has started investing in property (Bayer, et al., 2016). Chen et al. (2021) provide evidence of speculators' impact on feedback or momentum trading in the housing market. They found that short-term speculators contribute to price overreactions in shallow markets with limited price information. Market conditions can also influence investors. When price trends are strong, there is little disagreement among investors, but when there is ambiguity, not surprisingly, investors seem to have a much less clear picture (Case, et al., 2012).

Real property investors have a professional investment approach, distinguishing them from residential investors. D'Lima and Schultz (2021) state that property investors are only interested in

the property's investment potential. On the other hand, property investors may be motivated to invest by the opportunities that the property offers.

2.2. Access to Residential Properties

For residential property purchases, personal income and loans are typically combined, with loan leverage up to four times higher in some cases (Alexiou, et al., 2019). The reason for such a high borrowing burden is that housing costs account for a significant share of household income spent. Newman (2010) suggests that housing costs are 'affordable' if they are less than 30-40 per cent of household income. Yates et al. (2007) have introduced a different perspective on housing affordability concerning household income: After subtracting housing costs from household income, a total residual income should be acceptable to the household.

Different scales are needed to implement housing and social policies. In the US, the area median income (AMI) is used to measure who needs affordable homeownership and who does not (Newman, 2010). Another scale used in many countries is the income-housing price multiplier. This scale, used to represent the motivation or interest of the homebuyer to purchase, is the most common (André, et al., 2014). This scale also measures regional and household differences (Hulchanski, 1995). In developed economies: such as Australia, Canada, Ireland, New Zealand, the United Kingdom and the United States, median house prices were generally 2-3 times median household incomes (Demographia, 2012).

There are also opposing views on the definition of the price-income scale and the limitations of its use. Jewkes and Delgadillo (2010) argue that revisions to the scale mean that it cannot be easily applied to individual households. Robinson, et al., (2006) argue that an inherent problem arises from the lack of a specific definition of 'affordability'. Sliogeris et al. (2008) suggest many technical and conceptual scale problems. He notes that the main problem is that incomes and costs change over time, and that, generally, a larger proportion of income is spent on buying property at an earlier age, and a smaller proportion at an older age.

Although objections exist to the definitions, expressions, multipliers and scales used for housing affordability, analysts must simplify approaches and take averages. Comparisons over short periods are much more accurate than over long periods (Paris, 2007).

2.3. Residential Property Price Changes, Emerging Economies and Bubble Effects

The rise and fall of the residential market during the past decade are one of the most important events in modern economic history (Case, et al., 2012). These falls and rises in the residential market attract investors' attention and whet their appetite. Looking at the relationship between incomes and residential prices, the rise in residential prices has been higher than the rise in incomes since 1998 (Shiller, 2015).

Türkiye has long been considered an emerging market. Many property market reports also list it as an 'emerging market'. For this reason, looking specifically at residential property markets and price changes in emerging/emerging market countries will be helpful. Cesa-Bianchi, et al., (2015) analysed residential price changes in advanced and emerging economies and found that residential prices grew faster and were less volatile in advanced economies. However, the global liquidity shock's impact on residential prices and residential consumption is more pronounced in emerging economies than in advanced economies. Coşkun (2016b) notes that there is a traditional demand for residential property due to the increase in demand in the residential market in Türkiye and the increase in prices in recent years, related to the fact that residential property is seen as an investment instrument.

Over the past two decades, Türkiye has experienced rapid urban growth. This change has also attracted the attention of housing investors. In booming cities, residential buyers have higher expectations about future house price increases, and their investment motives are more affected (Case & Shiller, 1988). Many studies have been conducted on residential property price changes. In these studies, residential property prices have been correlated with many variables. Interest rates

on loans and residential property prices are the most prominent among these comparisons. Interest rate is one of the most effective factors on house prices. High-interest rates reduce house prices in the short term (Lorig & Suaysom, 2022). Other research has focused on macroeconomic variables. Case and Shiller (1988) argue that house price booms occurred in well-defined geographical areas, while prices did not rise in most countries, suggesting that macro variables provide only a partial explanation. Good urban design, more integrated urban space and increased exercise add value by increasing property values. (Topçu, et al., 2007).

2.4. Rationality of Investors in the Residential Market

Traditional economic theory postulates an "economic man" who, in the process of being "economic", is also "rational". This rational man is assumed to have a knowledge of the relevant aspects of his environment which, if not absolutely complete, is at least impressively clear and comprehensive (Simon, 1955). Rational investors seek to estimate future income changes best when making investment decisions (Holtemöller & Schulz, 2010). Property decision-making is a rational process that uses real data and leads to an optimal decision (Gallimore & Gray, 2002).

Are individual residential investors able to make rational residential investment decisions? De Bruin and Flint-Hartle (2003) observed that rental property investors made decisions based on incomplete information and limited region-specific and cognitive computational power. This approach makes it difficult to achieve the best in an ever-changing and complex property market. Shiller (2015) comments that people rarely remember the prices of the residential properties they bought at the time of purchase and are surprised by the difference by comparing them with today's prices.

The importance of personal experience in residential property investment was also highlighted in Gallimore and Gray (2002). In the survey of relatively experienced property investors, price rated first (6.28/7.00), personal feelings based on experience rated second (5.89/7.00), interest rates rated third (5.70/7.00), and supply/demand statistics rated fourth (5.59/7.00). Notably, personal feelings based on experience rated second for non-ordinary, relatively experienced residential investors.

De Bruin and Flint-Hartle (2003) observed that residential investors did not conduct any risk analysis or use any techniques and criteria in their residential investments with the "low-risk investment" preference. Unable to cope with the complexity of risk assessment, investors relied on intuitive risk assessments. Similar results were observed by Lux et al. (2017). In a survey of 57 respondents, not a single respondent considered the expected increase in house prices, and 47 respondents did not make any financial comparisons. The reasons given by the respondents for buying a property were uninformed and unsupported by facts: security of tenure, the freedom to furnish their homes as they wish, and the fact that housing offers greater security of savings than other types of investment. Individual sentiment has been found to distract investors from making the right decisions. During the property bubble, amateur speculators acted at the peak of residential prices, expecting prices to continue to rise (Bayer et al., 2016). Shiller (2015) argues that the changing behaviour of residential property prices indicates that the public's interest in speculative price movements has increased.

Residential investment can easily become the subject of many conversations between individuals. In these conversations, parties can naturally influence each other. It was observed that residential investors lacked basic knowledge and tended to interpret events through hearsay, stereotypes and ordinary observations (Case & Shiller, 1988).

There are also studies in the literature that support the view that investors act rationally. D'Lima and Schultz (2021) find that property investors' returns are sensitive to the index and more sensitive to the upward direction. They relate this result to the timing ability of property investors. Case, Shiller and Thompson (2012) argue that home buyers are mainly aware of price trends in the market, especially at the time of purchase. Speculators may not be unreasonable to buy more

frequently as residential property prices rise, as some have achieved reasonable returns (Bayer et al., 2020).

2.5. Media and Immediate Neighbourhood Influence on Residential Investment

Media interest in property markets was relatively low until the 20th century. Today, the media strive to attract public attention to survive and constantly compete with each other (Shiller, 2015). As a result of this competition, attention-grabbing or exaggerated news can sometimes be reported. According to the mental frames theory of cognitive psychology, people tend to be influenced by their mental frames and act in the same way as their family and friends. Moreover, it has been observed that individuals tend to synchronise their frames with those of their friends, family and others with whom they are in contact (De Bondt, 1998).

Do mainstream media and interpersonal dialogue influence residential investors? Information and opinions conveyed by mainstream media have less influence than interpersonal dialogue (Shiller, 1995; Chang, et al., 1999). Tarde (1901) argues that opinions are formed through conversations between individuals and their newspapers and refined through conversations with other people in coffee shops, thus forming public opinion. Katz (2006) puts forward a different idea: the media influence individuals, but it is an "indirect influence".

According to opinions gathered through the media or individuals, people believe it will be more challenging to buy a property in the future, with a significant percentage of pessimistic people rushing to buy a house (Triantafyllopoulos & Kandyla, 2010).

2.6. The Psychology and Stress of Buying a Residential Property

Internal and external pressures can affect the duration and quality of residential investment decisions. Changes in residential property prices, social factors and housing conditions are some of the things that influence individuals. Price changes put pressure on homebuyers. It has been observed that 2/3 of homebuyers have felt pressure to buy due to price changes (Triantafyllopoulos & Kandyla, 2010). Another effect of the change in residential property prices is that homebuyers are worried that they will no longer be able to afford a residential property due to the increase in property prices and that they will not be able to buy a property again. Because of this fear, homebuyers are quick to make offers on residential properties (Shiller, 2015). Homebuyers also experience worries and regrets. Anxiety is often associated with access to homeownership or first-time homeownership by young households (Richards, 2008). Regret can occur when individual investors do not make the right decision. As a precaution against regret, investors believe that by choosing to act in line with the actions of others, they reduce the likelihood of regret (Shiller, 1995; Beltratti, 2004). It can be argued that the reverse is also true for the pressure residential property exerts on individuals. When people are optimistic about the market, house prices rise, but forces are set to bring them down (Shiller, 2015).

2.7. Residential Market Data and Expertise

Some of the data in the residential market can be measured in the markets. To what extent is it possible to measure the residential market with this data that real estate professionals pay more attention to? Shiller (2015), in his research on house price forecasting models, states that half of the variability in house prices can be predicted about a year in advance. He states that the other half, which cannot be predicted due to increased market volatility, has a considerable share.

Research on the market knowledge of individual residential property investors shows that individuals are more knowledgeable about the environment in which they live and have higher hit rates in terms of profits. New entrants to residential property investment pay more for a property and earn less (Bayer et al., 2016). Investors outperform market indices if they live close to the property they invest in, do not use credit (buy cash) and have experience in property investment. In contrast, investors make less profit from the properties they live in compared to other properties (D'Lima & Schultz, 2021). For most people, it is not easy to adjust the timing of their residential property purchase by taking advantage of trends (Shiller, 2015). Coşkun (2016a) mentions that

increasing housing consumer literacy could improve residential demand/ownership/financing by supporting consumers' rational decision-making.

The literature suggests that residential investors follow their instincts rather than apply risk analysis and financial approaches to their investment decisions. As individuals are influenced by each other and the media, housing investors may be in a hurry and under pressure. On the other hand, unlike financial markets such as the stock exchange, where technical analysis can be carried out, the tools available to residential investors are inadequate. While residential investors make low profits on their properties, they can make higher profits on the properties they buy for investment purposes. Residential investors can be more successful with residential investments close to where they live. Residential investors have the most control over house prices when they buy their properties. The research results show that the success rates of residential investors increase when they closely follow the market and are familiar with the data. Individual investors' success can increase under certain conditions in the region they know.

Despite the potential for lucrative returns, individual investors often struggle to succeed in the residential property market due to a lack of market monitoring, experience and knowledge. These raise the question of whether individual investors are missing out on profitable opportunities and whether their decision-making in the residential property market is rational. In addition, there is a need to identify the key factors differentiating successful property investors from those who struggle to inform potential investors of the best practices for successful residential property investment. Many individual investors in the residential property market struggle to make a profit due to a lack of knowledge and experience in identifying and taking advantage of profitable investment opportunities. Our research questions:

- Can individual house investors identify opportunities in the residential property market?
- Can individual investors see all opportunities in the residential property market?
- What type of buyers seize the opportunities?
- What is the role of opportunity periods in the residential market on the behaviour of consumers?

Objectives:

- To test the ability of individual residential investors to identify periods of opportunity in the market using the scales created.
- To analyse the sales of residential property (total, credit and cash) in the period resulting from the equations set up for the opportunity periods and to test the effects of the choice of opportunity periods.
- To analyse the behaviour of credit and cash residential buyers in opportunity periods.
- Analysing residential affordability, loan interest, and price affordability opportunities by income residential price scale over 2013-2022 in Türkiye.

3. Methodology

In this study, we used publicly available databases for 2013-2022. We used some of the data obtained from these databases as they are and edited the data by correcting some of them. The sources, source names and source abbreviations listed in Table 1 are used in the article. The data listed as authors under the source title in the table are listed as edited data.

Table 1 Sources, data and abbreviations

Source	Subtitle	Abbreviation
TUIK, Authors	Adjusted Home Sales	AHP
TUIK, Authors	Adjusted Mortgage Sales	AMS
TUIK, Authors	Adjusted Cash Sales	ACS
TUIK	Consumer Price Index	CPI

TUIK	Inflation	-
CBRT	Real Home Price Index	Real HPI
CBRT	Mortgage Interest Rates	MIR
CBRT	Interest Rates for Deposits	IRD
CSGB	Minimum Wage	-
Authors	Minimum Wage House Price Ratio	MWHPR
Authors	Housing Minimum Wage Scale	HoMiWaS
Authors	Housing Minimum Wage Scale Opportunity	HoMiWaSOpp
Authors	Loan Interest Advantage	LIA
Authors	Loan Interest Advantage Deposit	LIAD
Authors	Loan Interest Advantage Inflation	LIAI
Authors	Cheap Housing Opportunity	CHO

TUIK: Turkish Statistical Institute, TURKSTAT
CBRT: Central Bank of the Republic of Türkiye
CSGB: Ministry of Labour and Social Security of the Republic of Türkiye

In the research, we analysed data on residential property sales (TUIK, 2023a) under three headings: total sales, mortgaged (loan) sales and cash sales. We did not use these sales as raw data. The reason was that there were public and religious holidays in each month, which created a seasonality effect, so we averaged the sales per working day for each month according to the working days in each month. We took each month (which we call the period in the research) to be 30 days and assumed there were 21 working days each month. In a year, there are about 20.7 working days in each month. For ease of calculation, we set the number of working days to 21 so that all periods were comparable. To make this adjustment understandable, we have added the word 'adjusted' at the beginning of the data on sales of residential buildings.

Adjusted Sales (Total, Cash, Mortgage) = [Sales (Total, Cash, Mortgage)] / (Period Working Day* 21)

The inflation rate was calculated from the consumer price index (CPI) published monthly by TURKSTAT and compared with the same month of the previous year.

We did not use the residential loan rate announced by the banks. In order to eliminate the cases where some banks do not prefer to lend housing loans even though the interest rate seems low, we used the residential loan interest rate based on the data of the housing loans used. The interest rate announced weekly by CBRT (2023b) is called the weighted residential loan interest rate. This data, which we receive on a monthly basis, was used in our study as the monthly housing loan interest rate.

Minimum wage data are usually published annually but may be published more than once a year during periods of high inflation. The minimum wage data were taken from the Ministry of Labour and Social Security of the Republic of Türkiye (TCSG, 2023).

In calculating the minimum wage to residential price ratio (MWHPR), Türkiye's average residential size (m^2) can be tracked using monthly building permits or occupancy permits. The average residential size in Türkiye is 120 m^2 in 2021, according to building permits (TUIK, 2023d), and 115 m^2 in 2021, according to occupancy permits (TUIK, 2023d). The difficulty of changing these data every month was overcome by accepting an average size of 100 m^2 for residential properties. For each period, the residential price was obtained by multiplying the residential unit price announced by the CBRT (CBRT, 2023a). This dwelling price was divided by the minimum wage in that period to obtain the MWHPR.

MWHPR = [(Average Residential Size * Average Residential Unit Price) / Minimum Wage]

Our research looked at the periods that might be advantageous for residential investors regarding the timing of residential purchases. Unfortunately, the option that the price of the property purchased lower than the market average could not be included in the scope of our study due to the lack of actual sales data. Of the remaining headings, we thought it might be useful to focus on three, given the availability of adequate data, the fact that they could be produced on an

ongoing basis from the data made available to the public, and the advantage of continuing to measure them at the time of the survey. These headings are;

- Opportunity to access residential property by minimum wage and average residential price (HoMiWaSOpp)
- Opportunity to access residential property according to mortgage interest rate advantage (LIA, LIAD, LIAI)
- Opportunity to invest in residential property according to the decline in real residential property prices (CHO)

Residential Accessibility Opportunity (HoMiWaSOpp): The "minimum wage", the income indicator of the lower income group in Türkiye, is announced by the government every year. We calculated the housing minimum wage scale (HoMiWaS), the number of minimum wages needed to buy an average 100 m² house in Türkiye. In this study, periods identified as lower than the 12-month moving average HoMiWaS value were accepted as opportunities (HoMiWaSOpp). We analysed residential purchases in periods with HoMiWaSOpp regarding loans, cash and total residential sales. MMP: minimum wage residential price multiplier, P: average residential price, M: monthly minimum wage.

$$MMP = P / M$$

$$HoMiWaS = MMP\ 12\text{-}Month\ Moving\ Average$$

$$HoMiWaSOpp = MMP < HoMiWaS$$

Residential loan interest rate opportunity (LIA, LIAD, LIAI): A decrease in the residential loan interest rate increases the use of residential loans, while an increase in the residential loan interest rate decreases the use of residential loans. We analysed residential loan interest rates in three stages:

- The residential loan interest rate lower than the weighted average of the last 12 months was labelled LIA, and the mortgage was accepted as a cheap opportunity.
- The residential loan interest rate lower than the deposit interest rate was labelled as LIAD and the residential loan interest was accepted as a cheap opportunity compared to the deposit.
- The residential loan interest rate lower than the inflation rate was labelled as LIAI, and the residential loan was accepted as a cheap opportunity compared to inflation.

In order for the residential loan to constitute an interest rate opportunity, the difference between the residential loan rate and the deposit rate was expected to be negative. Periods, when the residential loan rate was lower than the deposit rate were considered LIA (loan interest advantage) periods.

To calculate past periods, we compared the previous year's or month's residential loan interest rates. We also compared residential loan interest rates with deposit interest rates and inflation data for 2013-2022. We considered that comparisons with the previous year would not be significant for housing consumers; if the monthly housing loan interest rate was lower than the moving average of the last 12 months' housing loan interest rates, we considered this as a residential loan interest rate opportunity.

In order for a residential loan opportunity (LIA) to occur, the residential loan interest rate at the time of the evaluation must be lower than the moving average of the last 12-month residential loan interest rate. Here, the LIA expression indicates the condition "Mortgage Loan Interest Rate < 12-Month Moving Average (Mortgage Loan Interest Rates)". If this condition is met, the LIA value will be "1"; otherwise, it will be "0".

LIA = Residential Loan Interest Rate < 12-Month Moving Average (Residential Loan Interest Rate)

In the residential loan opportunity deposit (LIAD) calculation, LIAD occurs when the residential loan interest rates are lower than the deposit interest rates offered by banks to their customers. Here, if the quotient of the residential loan interest rate and the deposit interest rate is less than 1, the LIAD condition is met. In other words, the housing loan interest rate must be lower than the deposit interest rate.

LIAD = (Residential Loan Interest Rate / Deposit Interest Rate) < 1

In the residential loan opportunity inflation (LIAI) calculation, LIAI occurs when the interest rate on the residential loan is lower than the inflation rate. Here, if the ratio of the residential loan interest rate and the inflation rate is less than 1, the LIAI condition is met. In other words, the residential loan interest rate must be lower than the inflation rate.

LIAI = (Residential Loan Interest Rate / Inflation) < 1

Chance of a real residential property price decline (CHO) when monitoring the real change in residential property prices, periods of price increases and decreases can be observed. To measure this, we analysed the correlation between the year-on-year real change in the CBRT's residential property price index-HPI (CBRT, 2023b) and residential property sales. Periods, when the PPI declined in real terms were labelled as CHO periods when residential property price was relatively lower (Cheap Residential Opportunity-CHO).

The RPI, which shows quality-adjusted price changes for dwelling units, is calculated by estimating the regression coefficients separately for all periods and strata using the following log-linear regression model (HPI, 2022).

$$lnp_n^t = \beta_0^t + \sum_k \beta_k^t z_{nk}^t + \varepsilon_n^t, \qquad \forall n, t$$

p_n^t : value of residential property n in month t

z_{nk}^t: value of feature k of residential property n in month t

β_k^t : shadow price of the component in in month t

ε_n^t : error term veya disturbance term

The Laspeyres index is constructed for each stratum to calculate the price changes that would occur if the characteristics of the residential properties were held constant.

$$P_i^t = \frac{exp(\widehat{\beta_0^t}) exp\left[\sum_k \widehat{\beta_k^t}\, \overline{z_{nk}^0}\right]}{exp(\widehat{\beta_0^0}) exp\left[\sum_k \widehat{\beta_k^0}\, \overline{z_{nk}^0}\right]}$$

P_i^t: hedonic price index of stratum t in period t

$\widehat{\beta_k^0}$: shadow price prediction for the component in the basis period

$\widehat{\beta_k^t}$: shadow price prediction for the component in period t

$\overline{z_{nk}^0}$: average residential features in the basis period

The analytical steps in our research were as follows

- Identification of opportunity periods
- Test for correct assignment of opportunity periods (logistic regression).
- Continue the analysis if the assignments are correct.
- Descriptive statistics for opportunity and non-opportunity periods

- Analysis of variance (ANOVA) to understand if opportunity and non-opportunity periods differ.
- Analysis of variance (ANOVA) was used to determine whether there was a significant difference between opportunity periods and total residential sales.
- Analysis of variance (ANOVA) was used to determine if there was a significant difference between opportunity periods and mortgaged residential sales.
- Analysis of variance (ANOVA) was used to determine if there was a significant difference between opportunity periods and cash residential sales.

4. Analysis and Results

4.1. Residential accessibility opportunity (HoMiWaSOpp)

According to the HoMiWaSOpp equation, the periods determined as the opportunity; According to the descriptive statistics results of HoMiWaS, Adjusted Home Sales, Adjusted Mortgage Home Sales and Adjusted Cash Home Sales data as seen in Table 2:

- The calculated average HoMiWaS was 13.1 (median 13.7[1]) years for the periods defined as opportunity, and 16.2 (15.37) years for the non-opportunity periods.
- The calculated adjusted home sales average was 104 (105) thousand for the periods defined as opportunity, and 119 (112) thousand for the non-opportunity periods.
- The calculated adjusted mortgage home sales average was 30.7 (31.2) thousand for the periods defined as opportunity, and 34.8 (34.8) thousand for the non-opportunity periods.
- The adjusted cash home sales average is 73.5 (74) thousand for the opportunity periods and 85 (81) thousand for the non-opportunity periods.

Table 2 HoMiWaSOpp Descriptive Statistics

Descriptive Statistics								
	HoMiWaS		Adjusted Home Sales		Adjusted Mortgage Home Sales		Adjusted Cash Home Sales	
	0	1	0	1	0	1	0	1
Valid	78	42	78	42	78	42	78	42
Missing	0	0	0	0	0	0	0	0
Median	15.370	13.760	112.473	105.455	34.805	31.238	81.027	74.089
Mean	16.232	13.110	119.782	104.288	34.844	30.776	84.937	73.512
Std. Deviation	3.221	1.509	30.937	19.809	17.831	12.950	26.301	13.119
Coefficient of variation	0.198	0.115	0.258	0.190	0.512	0.421	0.310	0.178
Minimum	11.900	10.750	62.921	42.783	5.082	6.240	40.089	25.695
Maximum	26.900	15.220	234.951	146.903	133.909	57.811	177.705	114.155

Analysis of variance (ANOVA) was used to test whether or not the HoMiWaS variable differed according to the HoMiWaSOpp distinction; as seen in Table 3, it was found that there was a statistically significant difference between the HoMiWaS means of the opportunity and non-opportunity periods at the 99.9% confidence level. The HoMiWaS value was measured approximately three years higher in the non-opportunity periods.

[1] Mean results are given outside the brackets and median data are given inside the brackets. Example 104 (107), 104 indicates the mean result, and 107 indicates the median result.

Table 3 HoMiWaS ANOVA

Cases	Sum of Squares	df	Mean Square	F	p
HoMiWaSOpp	266.011	1	266.011	35.173	< .001
Residuals	892.418	118	7.563		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	3.122	0.526	5.931	< .001	***

Using analysis of variance (ANOVA) to test whether the adjusted home sales variable differs according to the HoMiWaSOpp distinction, Table 4 shows a statistically significant difference between the adjusted home sales averages of the opportunity and non-opportunity periods at the 99% confidence level. The value of adjusted home sales was about 15 thousand higher in the non-opportunity periods.

Table 4 HoMiWaSOPP Adjusted Home Sales ANOVA

Cases	Sum of Squares	df	Mean Square	F	p
HoMiWaSOpp	6553.655	1	6553.655	8.613	0.004
Residuals	89785.492	118	760.894		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	15.494	5.279	2.935	0.004	**

The analysis of variance (ANOVA) is used to test whether the variable adjusted mortgage home sales differs according to the HoMiWaSOpp distinction; as seen in Table 5, there is no statistically significant difference between the adjusted mortgage home sales averages of the opportunity and non-opportunity periods. We can say that the adjusted mortgage home sales averages for both periods are the same.

Table 5 Adjusted Mortgage Home Sales HoMiWaSOpp ANOVA

Cases	Sum of Squares	df	Mean Square	F	p
HoMiWaSOpp	451.782	1	451.782	1.700	0.195
Residuals	31356.702	118	265.735		

Note. Type III Sum of Squares

Post Hoc Tests *Standard*

Post Hoc Comparisons – HoMiWaSOpp

		Mean Difference	SE	t	p_{tukey}
0	1	4.068	3.120	1.304	0.195

Analysis of variance (ANOVA) was used to test whether the adjusted cash home sales variable differed according to the HoMiWaSOpp distinction; as seen in Table 6, there is a statistically significant difference at the 99% confidence level between the adjusted cash home sales averages of the opportunity and non-opportunity periods. The adjusted cash home sales value was about 11 thousand higher in the non-opportunity periods.

Table 6 Adjusted Cash Home Sales HoMiWaSOpp ANOVA

Cases	Sum of Squares	df	Mean Square	F	p
HoMiWaSOpp	3563.992	1	3563.992	6.972	0.009
Residuals	60320.583	118	511.191		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	11.426	4.327	2.640	0.009	**

We estimated the HoMiWaSOpp opportunity using logistic regression analysis and found that the assignment is correct at the 95% level, as shown in Table 7. The model was statistically significant at the 99.9% confidence level. The model's explanatory power was calculated as Nagelkerke R^2 87.9% and Tjur R^2 81.4%. The independent variables HoMiWaS, CPI, Mortgage Interest Rates and Real HPI were used to estimate HoMiWaSOpp. The variables Home Sales were also included in the model, but as these variables were not statistically significant, they were removed from the model, and the analysis continued. According to the calculation, 39 of the 42 identified opportunity periods were also predicted as opportunities in the model. According to the logistic regression analysis, 75 of the 78 periods identified as non-opportunity by the calculation were also predicted as non-opportunity.

Table 7 HoMiWaSOpp Logistic Regression

Model Summary - HoMiWaSOpp

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	155.387	157.387	160.175	119						
H_1	33.370	43.370	57.308	115	122.017	< .001	0.785	0.879	0.814	0.638

Coefficients

			Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	66.652	21.600	3.086	9.522	1	0.002
HoMiWaS	-8.019	2.270	-3.532	12.478	1	< .001
CPI	-0.231	0.069	-3.348	11.210	1	< .001
Mortgage Interest Rates	1.085	0.341	3.186	10.148	1	0.001
Real HPI	0.593	0.162	3.672	13.484	1	< .001

Note. affordability opportunity level '1' coded as class 1.

Performance Diagnostics

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	75	3	96.154
1	3	39	92.857
Overall % Correct			95.000

Note. The cut-off value is set to 0.5

4.2. Loan cost opportunity (LIA, LIAD, LIAI)

4.2.1 Loan cost opportunity (LIA)

In the residential loan opportunity research, as seen in Table 8, 52 months were lower than the 12-month moving average value of the housing loan interest rate. This was the LIA of opportunity in terms of housing loan interest.

- Analysis of the descriptive statistics of mortgage interest rates, adjusted home sales, adjusted mortgage home sales and adjusted cash home sales data according to LIA classification;
- Mortgage interest rates averaged 12.3% (11.4%) per annum during the opportunistic periods and 16.3% (14.8%) per annum during the non-opportunistic periods.
- Adjusted home sales averaged 117 (107) thousand during the opportunistic periods and 112 (111) thousand during the non-opportunistic periods.
- Adjusted mortgage home sales averaged 41.9 (40.7) thousand during the periods defined as opportunity, and it was calculated as 26.9 (28.8) thousand during the non-opportunity periods.

- Adjusted cash home sales averaged 75 (73) thousand during the periods defined as opportunity, and it was calculated as 85 (80) thousand during the non-opportunity periods.

Table 8 Loan Interest Advantage Descriptive Statistics

Descriptive Statistics

	Mortgage Interest Rates		Adjusted Mortgage Home Sales		Adjusted Home Sales		Adjusted Cash Home Sales	
	0	1	0	1	0	1	0	1
Valid	68	52	68	52	68	52	68	52
Missing	0	0	0	0	0	0	0	0
Median	14.809	11.425	28.788	40.711	111.314	107.607	79.917	73.387
Mean	16.343	12.289	26.902	41.945	112.243	117.126	85.341	75.181
Std. Deviation	4.283	3.079	9.829	19.132	22.735	34.586	22.029	23.569
Coefficient of variation	0.262	0.251	0.365	0.456	0.203	0.295	0.258	0.313
Minimum	10.607	8.297	5.082	10.247	69.622	42.783	53.066	25.695
Maximum	28.948	21.808	44.801	133.909	198.510	234.951	177.705	165.483

In the analysis of variance (ANOVA) conducted to test whether the variable adjusted mortgage home sales differs according to the LIA distinction, as seen in Table 9, it was observed that there was a statistically significant difference at the 99.9% confidence level between the adjusted mortgage home sales averages of the opportunity and non-opportunity periods. The adjusted mortgage home sales value was about 15 thousand higher in the opportunity periods.

Table 9 ANOVA - Adjusted Mortgage Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIA	6667.944	1	6667.944	31.297	< .001
Residuals	25140.540	118	213.055		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	-15.043	2.689	-5.594	< .001	***

*** p < .001

In the analysis of variance (ANOVA) conducted to examine whether the adjusted cash home sales variable is different according to the LIA distinction, as seen in Table 10, it was observed that there is a statistically significant difference between the adjusted cash home sales averages of opportunity and non-opportunity periods at 95% confidence level. Adjusted cash home sales value was approximately 10 thousand lower in the opportunity periods.

Table 10 ANOVA - Adjusted Cash Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIA	3041.787	1	3041.787	5.899	0.017
Residuals	60842.789	118	515.617		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	10.160	4.183	2.429	0.017	*

* p < .05

In the analysis of variance (ANOVA) we conducted to test whether the adjusted home sales variable differs according to the LIA distinction, as seen in Table 11, no statistically significant difference was found between the adjusted home sales averages of the opportunity and non-opportunity periods. We found that credit sales increased during the opportunity periods, and cash sales decreased. We can say that the adjusted home sales averages for both periods are the same. Taken together with the other variance analysis results, the LIA did not affect total home sales.

Table 11 ANOVA - Adjusted Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
credit opportunity ma	702.530	1	702.530	0.867	0.354
Residuals	95636.618	118	810.480		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	-4.883	5.245	-0.931	0.354

In the logistic regression analysis of the LIA opportunity, as shown in Table 12, the correct classification was found to be 86.7%. The model was statistically significant at the 99.9% confidence level. The model's explanatory power was also good, with a Nagelkerke R^2 of 62.1%. The independent variables HoMiWaS, Mortgage Interest Rates, Deposit Interest Rates and Adjusted Mortgage Home Sales were used to estimate the LIA. The variables Real HPI, CPI, Adjusted Cash Home Sales were also included in the model. However, as these variables were not statistically significant, they were removed from the model and the analysis continued. Of the 52 periods we identified, 44 of the 52 with opportunities were also predicted as opportunities due to the logistic regression. As a result of the analysis of 68 non-opportunity periods, 60 periods were predicted to be non-opportunity.

Table 12 LIA Logistic Regression

Model Summary - LIA

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	164.216	166.216	169.003	119						
H_1	89.553	99.553	113.490	115	74.663	< .001	0.455	0.621	0.514	0.463

Coefficients

				Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	13.087	4.419	2.962	8.772	1	0.003
Mortgage Interest Rates	-1.264	0.380	-3.322	11.038	1	< .001
Interest Rates for Deposits	0.826	0.265	3.114	9.697	1	0.002
Minimum Wage House Price Ratio	-0.555	0.224	-2.480	6.152	1	0.013
Adjusted Mortgage Home Sales	0.087	0.049	1.762	3.104	1	0.078

Note. credit opportunity ma level '1' coded as class 1.

Performance Diagnostics

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	60	8	88.235
1	8	44	84.615
Overall % Correct			86.667

Note. The cut-off value is set to 0.5

4.2.2 LIAI for Housing Loans

As shown in Table 13, 33 months when mortgage rates were lower than the rate of inflation were considered to be LIAIs in terms of residential loan rates. In our LIAI classification, the descriptive statistics of the mortgage interest rates, inflation, adjusted home sales and adjusted mortgage home sales data analyses were as follows;

- Mortgage interest rates averaged 15.6% (17.8%) per annum during the periods identified as opportunities, compared to 14.2% (13%) per annum during the non-opportunistic periods.
- Inflation averaged 36.2% (19.6%) per annum during the opportunistic periods, compared to 10.8% (9.2%) during the non-opportunistic periods.
- Adjusted home sales averaged 132 (125) thousand in the opportunistic periods and 108 (106) thousand in the non-opportunistic periods.
- Adjusted mortgage home sales averaged 38,000 (32,000) in the opportunistic periods, and 32,000 (34,000) in the non-opportunistic periods.
- Adjusted cash home sales averaged 94,000 (92,000) in the periods defined as opportunities, and 76,000 (74,000) in the non-opportunity periods.

Table 13 Loan Interest Advantage Descriptive Statistics

Descriptive Statistics

	Mortgage Interest Rates		Inflation		Adjusted Home Sales		Adjusted Mortgage Home Sales		Adjusted Cash Home Sales	
	0	1	0	1	0	1	0	1	0	1
Valid	87	33	87	33	87	33	87	33	87	33
Missing	0	0	0	0	0	0	0	0	0	0
Median	13.030	17.797	9.219	19.583	105.864	124.691	34.357	32.030	73.520	92.049
Mean	14.197	15.612	10.848	36.230	107.611	132.148	31.685	37.995	75.926	94.153
Std. Deviation	4.398	3.895	4.354	28.784	21.541	36.241	11.690	24.433	18.929	28.018
Coefficient of variation	0.310	0.249	0.401	0.794	0.200	0.274	0.369	0.643	0.249	0.298
Minimum	8.766	8.297	6.134	8.297	42.783	62.921	5.082	13.592	25.695	40.089
Maximum	28.948	21.575	25.240	85.515	192.889	234.951	57.811	133.909	144.896	177.705

In the analysis of variance (ANOVA) we conducted to test whether the Adjusted Home Sales variable differed according to the LIAI distinction, as seen in Table 14, we found that there was a statistically significant difference between the adjusted home sales averages of the opportunity and non-opportunity periods at the 99.9% confidence level. The value of adjusted home sales was about 25 thousand higher in the opportunity periods.

Table 14 ANOVA - Adjusted Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAI	14404.781	1	14404.781	20.745	< .001
Residuals	81934.366	118	694.359		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	-24.537	5.387	-4.555	< .001	***

*** p < .001

In the analysis of variance (ANOVA), we conducted to test whether our adjusted mortgage home sales variable differed according to the LIAI distinction. Table 15 shows no statistically significant difference between the adjusted mortgage home sales averages of the opportunity and non-opportunity periods. We can say that the adjusted mortgage home sales averages were the same for both periods.

Table 15 ANOVA - Adjusted Mortgage Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAI	952.471	1	952.471	3.642	0.059
Residuals	30856.014	118	261.492		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	-6.310	3.306	-1.909	0.059

In the analysis of variance (ANOVA) we conducted to test whether our adjusted cash home sales variable differed according to the LIAI distinction, as seen in Table 16, there was a statistically significant difference between the Adjusted Cash Home Sales averages of the opportunity and non-opportunity periods at the 99.9% confidence level. The adjusted cash home sales value was approximately 18 thousand higher in the opportunity periods. Evaluated in conjunction with other variance analyses, the fact that loan sales did not change suggests that buyers did not view loan rates as an opportunity in the opportunity periods when residential loan rates were below inflation. In this respect, we found that, although the interest rates of the public banks were kept low, the fact that there were not enough residential loans in the market (low limits), and the high-interest rates of the private banks were ineffective in the sales on loans. One thing that stood out during that period was that those who had bought a house for cash had bought or invested in more houses during high inflation.

Table 16 ANOVA - Adjusted Cash Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAI	7949.079	1	7949.079	16.769	< .001
Residuals	55935.497	118	474.030		

Note. Type III Sum of Squares

		Mean Difference	SE	t		p_{tukey}
0	1	-18.228	4.451	-4.095	< .001	***

*** p < .001

In our prediction of the LIAI opportunity based on logistic regression analysis, we found that 86.7% of the assignments were correct, as shown in Table 17. Our model was statistically significant at the 99.9% confidence level. The model's explanatory power was also good with a Nagelkerke R^2 of 64%. The independent variables HoMiWaS, mortgage rates, deposit rates and real HPI were used to estimate the LIAI. Home sales variables were also included in the model but were excluded as they were not statistically significant. Of the 33 periods we identified as opportunities, 24 were also predicted as opportunities by logistic regression. Of the 87 non-opportunity periods, 80 were predicted to be non-opportunity.

Table 17 LIAI Logistic Regression

Model Summary - LIAI

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	141.161	143.161	145.948	119						
H_1	70.980	80.980	94.917	115	70.181	< .001	0.497	0.640	0.530	0.443

Coefficients

				Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	-9.495	2.613	-3.634	13.205	1	< .001
Mortgage Interest Rates	-1.294	0.342	-3.781	14.296	1	< .001
HoMiWaS	-0.797	0.284	-2.801	7.848	1	0.005
Interest Rates for Deposits	0.877	0.243	3.614	13.062	1	< .001
Real HPI	0.229	0.055	4.181	17.482	1	< .001

Note. Campaign vs Inflation level '1' coded as class 1.

Performance Diagnostics

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	80	7	91.954
1	9	24	72.727
Overall % Correct			86.667

Note. The cut-off value is set to 0.5

4.2.3 Residential Loan Opportunity Deposit (LIAD)

The eight months when the resident loan rate was lower than the deposit rate (Table 18) were LIADs of opportunity regarding residential loan rates. The analysis of descriptive statistics of mortgage rates, deposit rates, adjusted house sales and adjusted mortgage house sales data according to our LIAD classification;

- Mortgage interest rates averaged 16.4% (15.9%) per annum during opportunistic periods and 14.5% (13.3%) during non-opportunistic periods.
- Interest rates on deposits averaged 17.9% (18.4%) per annum during the opportunistic periods and 11.4% (9.8%) per annum during the non-opportunistic periods.
- Adjusted home sales averaged 115,000 (117,000) in opportunistic periods and 114,000 (109,000) in non-opportunistic periods.
- Adjusted mortgage home sales averaged 33,000 (31,000) in the periods defined as opportunity and 33,000 (34,000) in the non-opportunity periods.

Adjusted cash home sales averaged 81 (80) thousand in the opportunity periods and 81 (76) thousand in the non-opportunity periods. Regarding standard deviations, the standard deviation of the opportunity period was approximately 7 thousand, and the standard deviation of the non-opportunity period was 24 thousand.

Table 18 Loan Interest Advantage Descriptive Statistics

Descriptive Statistics

	Mortgage Interest Rates		Interest Rates for Deposits		Adjusted Mortgage Home Sales		Adjusted Home Sales		Adjusted Cash Home Sales	
	0	1	0	1	0	1	0	1	0	1
Valid	112	8	112	8	112	8	112	8	112	8
Missing	0	0	0	0	0	0	0	0	0	0
Median	13.311	15.926	9.771	18.373	34.127	31.300	108.712	116.822	76.136	79.785
Mean	14.454	16.433	11.435	17.922	33.416	33.489	114.324	114.841	80.909	81.352
Std. Deviation	4.327	3.563	4.168	3.480	16.292	18.303	28.835	24.035	23.920	7.277
Coefficient of variation	0.299	0.217	0.364	0.194	0.488	0.547	0.252	0.209	0.296	0.089
Minimum	8.297	12.982	5.264	13.273	5.082	10.247	42.783	85.897	25.695	73.520
Maximum	28.948	21.808	22.852	22.170	133.909	57.811	234.951	146.903	177.705	90.250

In the Analysis of Variance (ANOVA), we analysed whether our adjusted home sales variable was different according to the LIAD distinction; as seen in Table 19, there was no statistically significant difference between the Adjusted Home Sales averages of the opportunity and non-opportunity periods. We noted that both periods' Adjusted Home Sales averages were the same.

Table 19 ANOVA - Adjusted Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAD	1.989	1	1.989	0.002	0.961
Residuals	96337.159	118	816.417		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	-0.516	10.457	-0.049	0.961	-0.516

In the analysis of variance (ANOVA), we conducted to analyse whether our adjusted mortgage home sales variable was different according to the LIAD distinction; as seen in Table 20, there was no statistically significant difference between the adjusted mortgage home sales averages of the opportunity and non-opportunity periods. We noted that both periods' adjusted mortgage home sales averages were the same.

Table 20 ANOVA - Adjusted Mortgage Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAD	0.040	1	0.040	1.481×10-4	0.990
Residuals	31808.445	118	269.563		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	-0.073	6.009	-0.012	0.990

In the Analysis of Variance (ANOVA), we examined whether our adjusted cash home sales variable differed according to the LIAD distinction; as seen in Table 21, there was no statistically significant difference between the adjusted cash home sales averages of the opportunity and non-opportunity periods. We noted that both periods' adjusted cash home sales averages were the same. We analysed the results together with other variance analyses. We found that in the opportunity periods when residential loan rates were lower than deposit rates, loan rates were not perceived as an opportunity by buyers. The difficulty of monthly follow-up could be considered as a factor.

Table 21 ANOVA - Adjusted Cash Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
LIAD	1.464	1	1.464	0.003	0.959
Residuals	63883.12	118	541.382		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	-0.443	8.515	-0.052	0.959

Regarding predicting the LIAD opportunity with logistic regression analysis, as shown in Table 22, we found that the classification was generally correct at 95%. Our model was statistically significant at the 99.9% confidence level. The exmodel's explanatory power also at the Nagelkerke R^2 level of 52%. However, the correct assignment rate for the opportunity period was at a very low level of 25%. Only two of the eight opportunity periods were also predicted as opportunities in the logistic regression. All of the 112 non-opportunity periods were predicted as non-opportunity. The results of the analysis of variance and the logistic regression taken together showed that the periods when mortgage rates were lower than deposit rates could not be defined as opportunities. The fact that loan rates were lower than deposit rates in only eight months of the ten years complicated the analysis.

Table 22 LIAD Logistic Regression

Model Summary - credit opportunity

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	58.783	60.783	63.571	119						
H_1	31.834	43.834	60.559	114	26.950	< .001	0.458	0.519	0.368	0.201

Coefficients

				Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	24.976	12.065	2.070	4.285	1	0.038
Minimum Wage House Price Ratio	-0.804	0.381	-2.113	4.465	1	0.035
Mortgage Interest Rates	0.099	0.137	0.725	0.525	1	0.469
Real HPI	-0.182	0.123	-1.483	2.200	1	0.138
Adjusted Mortgage Home Sales	0.026	0.032	0.837	0.701	1	0.403
Adjusted Cash Home Sales	0.002	0.024	0.087	0.008	1	0.931

Note. Credit opportunity level '1' coded as class 1.

Performance Diagnostics

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	112	0	100.000
1	6	2	25.000
Overall % Correct			95.000

Note. The cut-off value is set to 0.5

4.3. Cheap Housing Opportunity (CHO)

We defined 32 months with negative annual real house price changes as a cheap residential opportunity (CHO). Our analysis of the descriptive statistics of real HPI, adjusted home sales and

adjusted mortgage home sales data according to our CHO classification (Table 23) provided the following findings:

- The calculated Real HPI average was 111 (109) for the periods defined as opportunity and 125 (118) for the non-opportunity periods.
- The calculated adjusted home sales average was 117 (117) thousand for the periods defined as opportunity, and 113 (107) thousand for the non-opportunity periods.
- The calculated adjusted mortgage home sales average is 29 (30) thousand for the periods defined as opportunity and 35 (35) thousand for the non-opportunity periods.
- The calculated adjusted cash home sales average was 88 (81) thousand for the periods defined as opportunity, and 78 (74) thousand for the non-opportunity periods.

Table 23 Cheap Housing Opportunity Descriptive Statistics

Descriptive Statistics

	Real HPI		Adjusted Home Sales		Adjusted Mortgage Home Sales		Adjusted Cash Home Sales	
	0	**1**	**0**	**1**	**0**	**1**	**0**	**1**
Valid	88	32	88	32	88	32	88	32
Missing	0	0	0	0	0	0	0	0
Median	118.040	108.895	106.888	117.225	34.524	30.304	73.994	81.033
Mean	125.151	111.389	113.218	117.496	34.946	29.224	78.272	88.272
Std. Deviation	27.588	8.867	29.596	25.213	16.501	15.400	23.590	20.577
Coefficient of variation	0.220	0.080	0.261	0.215	0.472	0.527	0.301	0.233
Minimum	100.000	101.440	42.783	69.622	10.732	5.082	25.695	63.382
Maximum	223.630	123.330	234.951	192.889	133.909	57.811	177.705	144.896

According to the analysis of variance (ANOVA), we conducted to analyse whether the Adjusted Home Sales variable differed based on the CHO distinction, there was no statistically significant difference between the adjusted home sales averages in the opportunity and non-opportunity periods. the adjusted home sales averages for both periods were the same (Table 24).

Table 24 ANOVA - Adjusted Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
CHO	429.539	1	429.539	0.528	0.469
Residuals	95909.609	118	812.793		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	-4.278	5.885	-0.727	0.469

According to the analysis of variance (ANOVA, we conducted to analyse whether the adjusted mortgagee home sales variable differed based on the CHO distinction, there was no statistically significant difference between the adjusted mortgage home sales averages in the opportunity and non-opportunity periods. The adjusted mortgage home sales averages for both periods were the same (Table 25).

Table 25 ANOVA - Adjusted Mortgage Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
CHO	768.280	1	768.280	2.921	0.090
Residuals	31040.205	118	263.053		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}
0	1	5.722	3.348	1.709	0.090

According to the analysis of variance, we conducted to analyse whether the adjusted cash home sales variable differed based on the CHO distinction. There was a statistically significant difference

at a 95% confidence level between the adjusted cash home sales averages in the opportunity and non-opportunity periods. Adjusted cash home sales value was measured as approximately ten thousand higher during periods of opportunity (Table 26). The times when annual real house price changes are seen and considered as opportunities by cash buyers, who have the cash available to buy a property outright.

Table 26 ANOVA - Adjusted Cash Home Sales

Cases	Sum of Squares	df	Mean Square	F	p
CHO	2346.765	1	2346.765	4.500	0.036
Residuals	61537.810	118	521.507		

Note. Type III Sum of Squares

		Mean Difference	SE	t	p_{tukey}	
0	1	-10.000	4.714	-2.121	0.036	*

* p < .05

The prediction of CHO opportunity, constructed using logistic regression analysis, showed that the correct assignment was generally achieved at 92.5%. Our model was statistically significant at a 95% confidence level. The explanation level of the model was at a good level of Nagelkerke R^2 83.9%. The independent variables HoMiWaS, mortgage interest rates, deposit interest rates, adjusted cash home sales, adjusted mortgage home sales and HPI were used to estimate CHO. Of the 32 periods we defined as opportunities, 25 were also predicted as opportunities by logistic regression. 86 of the 88 non-opportunity periods were predicted to be non-opportunities. The correct assignment rate was 78.1% for opportunities and 97.7% for non-opportunities.

Table 27 Cheap Housing Opportunity Logistic Regression

Model Summary - CHO

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	139.180	141.18	143.967	119						
H_1	36.284	50.284	69.796	113	102.896	< .001	0.739	0.839	0.755	0.576

Coefficients

				Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	42.036	16.830	2.498	6.238	1	0.013
Mortgage Interest Rates	-2.598	0.908	-2.863	8.195	1	0.004
Interest Rates for Deposits	5.567	1.729	3.219	10.361	1	0.001
HPI	-0.226	0.073	-3.080	9.486	1	0.002
Adjusted Cash Home Sales	0.178	0.081	2.214	4.901	1	0.027
HoMiWaS	-3.208	1.147	-2.797	7.826	1	0.005
Adjusted Mortgage Home Sales	0.141	0.072	1.973	3.893	1	0.048

Note. CHO level '1' coded as class 1.

Performance Diagnostics

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	86	2	97.727
1	7	25	78.125
Overall % Correct			92.500

Note. The cut-off value is set to 0.5

5. Discussion and Conclusion

Property is a valuable household asset (Zorn & Sackley, 1991; Henderson & Ioannides, 1983). Many economic and social motivations exist behind accessing this valuable asset (Erdoğdu & Büyükduman, 2018; Lux et al., 2017). One of the reasons for investing in property is to get out of renting and the other is to increase wealth while saving (Triantafyllopoulos & Kandyla, 2010; De Bruin & Flint-Hartle, 2003). Individuals usually start to invest in property when they buy a property for themselves or when they see their neighbours buying a property for investment, but speculators

in the market also encourage individuals to invest in property (Bayer, et al., 2016; Fu & Qian, 2014). There are different types of property investors, including intermediaries and speculators. There are differences between residential and property investors; property investors are professional in their investments (D'Lima & Schultz, 2021). In residential investment, decisions based on personal experience, incomplete and limited information, and hearsay come to the fore (De Bruin, Flint-Hartle, 2003; Gallimore & Gray, 2002; Lux et al., 2017; Case & Shiller, 1988). Residential investors do not do proper risk analyses and financial comparisons and may even invests at price peaks (De Bruin & Flint-HArtle, 2003; Bayer et al., 2020).

Individual residential investors are influenced by each other and by the media. The influence of the media is less visible than that of individuals, but the media also has indirect influences. Over time, individual investors internalise the opinions they hear from the media and the individuals around them (Shiller, 1995; Triantafyllopoulos & Kandyla, 2010; Katz, 2006; Shiller, 2015). The media, individuals' opinions, and the fear of regret can harm residential investors and homebuyers. The fact that individuals do not carry out risk analysis and financial comparisons on residential investments makes it difficult for residential investors to succeed. As a result, residential investors pay more for houses when they are just starting and make less profit when they invest in the property they will live in (Bayer, et al., 2016; D'Lima & Schultz, 2021).

In the literature review, we examined the importance of residential property to households, motivations for buying residential property, types of residential property investors, starting to invest in residential property, differences between residential property investors and other property investors, residential property affordability scales, investor behaviour in response to residential property price changes, residential property prices and investors in developing countries, the influence of investors on the residential property market, the influence of the residential property market on investors, personal experiences of investing, investors' approaches to finance and risk analysis, sources of investor influence, pressures and stresses on residential property investors, situations in which residential property investors' profits rise and fall.

We aimed to find indicators that could be produced for the housing market to make investors more sensitive to market data in residential investment. Our research sought to answer the following questions: Can indicators be created to enable residential investors to profit more from their investments? Are there periods of opportunity for residential investors? Can residential investors identify periods of opportunity within the market dynamics? How sensitive are investors to opportunities in residential investment? To find answers to these questions, we analysed publicly available data on the residential property market.

The first topic of our research was whether investors were interested in residential investment in periods when the price of a property became 'accessible' to income, according to the minimum wage (income) property price multiplier scale. In the residential property accessibility scale (HoMiWaS), we analysed the existence of periods of opportunity (HoMiWaSOpp) in the research period 2013/2022. We measured a total of 42 periods as HoMiWaSOpp for 120 months. During this period, we measured HoMiWaSOpp at an average of 13.1 years. Non-opportunity periods were measured at 16.2 years. During the HoMiWaSOpp periods there were 104 thousand property sales, 30 thousand loan sales, and 73 thousand cash sales.

We observed that property sales decreased by 12%, loan sales by 11% and cash sales by 14% in the opportunity periods. The expected result was an increase in sales in the opportunity periods. We tested the opportunity periods using logistic regression. We found that 39 of the 42 periods were accurately identified as HoMiWaSOpp. We found that 75 of the 78 periods were accurately identified as non-opportunity periods. In the non-opportunity periods, the figures were 119,000, 34,000 and 85,000 respectively. We found that between 2013 and 2022, residential property investors in Türkiye did not consider the opportunity of access to residential property by minimum income.

The second topic of our research was whether the opportunity presented by favourable residential loan rates relative to other indicators had attracted the interest of residential investors. In our first comparison, we referred to the periods of opportunity when residential loan rates were lower than the previous 12-month moving average as LIA. We calculated 52 months out of 120 periods from 2013 to 2022 as LIA. We calculated the residential loan rate to be 12.3% in the LIA periods and 16.3% in the non-opportunity periods. During the LIA periods, residential sales were computed as 117,000, credit sales as 41,000, and cash sales as 75,000. In the non-LIA periods, the figures were 112,000, 26,000, and 85,000, respectively. During the LIA periods, we found that house sales increased by 4%, loan sales increased by 56%, and cash sales decreased by 12%. We tested the opportunity periods using logistic regression. 44 of the 52 periods we identified as LIA, and 60 of the 68 non-opportunity periods were correctly identified. According to the results of our analysis, in the LIA periods, cash buyers reduced their number of purchases by taking advantage of the opportunity, loan purchases increased, and the increase of only 4% in total house purchases may be indicative of cash buyers taking advantage of the opportunity.

We called the second of the three indicators of credit affordability the periods when residential loan interest rates were lower than the rate of inflation, LIAI. We defined 33 months out of 120 periods in the 2013-2022 period as LIAI. We calculated the housing loan interest rate as 15.6% in LIAI periods and 14.2% in non-opportunity periods. We calculated the annual inflation rate to be 36.2% and 10.8% in the LIAI periods. We calculated that in the LIAI periods, there were 132,000 house sales, 38,000 loan sales and 94,000 cash sales. In the non-LIAI periods, the figures were 108,000, 32,000 and 76,000, respectively. We calculated that house sales increased by 22%, credit sales by 19%, and cash sales by 24% in the LIAI periods. We tested the opportunity periods using logistic regression. We found that 24 of the 33 periods were accurately identified as LIAI, and 80 of the 87 periods were accurately identified as non-opportunity periods. According to our analysis, cash buyers took the opportunity, and cash property sales increased in the LIAI periods. The difference between the mean values of cash sales was not statistically significant at a 95% confidence level but was statistically significant at a 90% confidence level. Although the opportunity periods were accurately identified, the results may not have been as expected under opportunity conditions because the opportunity period was affected by one of Türkiye's crisis periods.

We named the third of the three indicators of loan affordability the periods when residential loan rates were lower than deposit rates, as LIAD. We calculated eight months out of 120 periods in the 2013/2022 period as LIAD. We calculated the residential loan interest rate as 16.5 per cent in LIAD periods and 14.5 per cent in non-opportunity periods. We measured the deposit interest rate as 17.9% per annum and 11.4% per annum in the LIAD periods. Home sales were 115,000, credit sales were 33,000, and cash sales were 81,000 in the LIAD periods. In the non-opportunity periods, we calculated 114,000, 33,000 and 81,000, respectively. We tested the opportunity periods using logistic regression. Only two of the eight periods we identified as LIAD were accurately identified. All 112 periods were accurately identified as non-opportunity periods. According to the analysis of variance (ANOVA) we conducted for total residential sales, loan residential sales and cash residential sales in the LIAD periods, there was no significant difference between the mean values. According to variance analyses combined with other analyses, LIAD periods may not be perceived by buyers as an opportunity to obtain a residential property loan. This result can also be explained by the difficulty of following the LIAD monthly. According to the results of the analysis of variance and the logistic regression evaluated together, periods in which the interest rates on residential loans are lower than the interest rates on deposits cannot be defined as LIAD. In the 120 months, the loan rates lower than deposit rates for only eight months made the analysis challenging.

The third theme of our research was the relationship between the real year-on-year change in residential property prices and residential property sales. The periods in which residential property prices fell in real terms were referred to as CHO. We analysed whether the possibility of a negative change in residential property prices attracted the attention of residential property investors. We

identified 32 months out of 120 periods in 2013-2022 as CHO. We calculated the real house price index as 111 in CHO periods and 125 in non-opportunity periods. In CHO periods, residential sales were calculated as 117 thousand, loan sales as 29 thousand and cash sales as 88 thousand. In the non-opportunity periods, they were calculated as 113 thousand, 35 thousand and 78 thousand, respectively. We tested for periods of opportunity using logistic regression. We accurately identified 25 of the 32 periods as CHO. We accurately identified 86 of the 88 periods as non-opportunity periods. We analysed CHO by total residential sales, loan residential sales and cash residential sales using analysis of variance (ANOVA). We found no statistically significant difference between the CHO and non-opportunity periods in terms of the mean values of total residential sales. No statistically significant difference was found in the means of credit house sales during the CHO periods and non-opportunity periods. However, a statistically significant difference was found between the means of cash house sales in the CHO periods. According to our analysis, cash buyers might consider the CHO periods as opportunity periods.

The challenges we encountered in our research were in interpreting the data. In the last decade, Türkiye experienced many events that can be described as crises. These include the Gezi events (2013), the Russian aircraft crisis (2015), the 15 July coup attempt (2016), the Pastor Brunson crisis (2018), COVID-19 (2020-2021) and currency shock (2021). In addition to these major crises, there were also relatively minor events. Although the opportunity periods were accurately identified, the results may not have been as expected by the opportunity conditions because the opportunity period was affected by one of the above periods.

As a result of our research, the changes in cash residential sales were particularly noteworthy. We concluded that cash residential buyers took advantage of the LIA, LIAI and CHO opportunities. HoMiWaS, the minimum income residential property price scale, did not affect residential property sales. We believe that the 19% purchasing power advantage of HoMiWaSOpp over non-opportunity periods should not be overlooked. HoMiWaSOpp has 42 period of 120-months period. We believe that LIA has not received the attention it deserves due to differences in residential loan rates between public and private banks in Türkiye and occasional residential loan promotions. We believe the LIAD should be analysed again for when Türkiye reaches a stable economic structure and when banks offer different interest rates on housing loans depending on their capital structure. The LIAD has not proved to be a helpful indicator due to the monetary policies implemented in Türkiye. Like the LIA, we believe that the LIAD should also be re-analysed in the future.

For future research, we recommend surveying residential property buyers in Türkiye to find out whether they make rational decisions and what they pay attention to when buying a property. They are interested in changes in residential loan interest rates, real residential property prices and changes in foreign currency-indexed residential property prices. The results of this research will be helpful for the scales to be developed in the future. Secondly, we can propose to study the effects of the opportunity scales we have developed for different income groups. The findings of this research will reveal whether there are differences in approach between different income groups.

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Resume

Celal Erdogdu is a PhD candidate in the Department of Business Administration at the ISMA University of Applied Sciences in Latvia. His research focuses on the housing market, home price changes, affordability, gas station valuation, and hotel valuation. Currently he is writing his thesis and works as a real estate valuer.

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A systematic review on artificial intelligence applications in architecture

Buse Bölek[*]
Osman Tutal[**]
Hakan Özbaşaran[***]

Abstract

Since the advent and usage of artificial intelligence approaches in architecture, a significant number of studies have focused on integrating technological solutions to architectural issues. Artificial intelligence applications in architectural design range from intelligent material design to architectural plan solutions. The ubiquity and distribution of research in this field, as well as the rising use of artificial intelligence techniques to solve design challenges, require an analytical classification of the essential literature review. This article presents a descriptive and analytical review of the work on artificial intelligence applications in architecture. A strong review has been made that identifies and addresses the gaps in artificial intelligence and architecture; and the literature review is transformed into statistical plots. The study's findings indicate a growing interest in artificial intelligence in the field of architecture. There is a need for novel research to be conducted in these areas using advanced technology and techniques.

Keywords: algorithm, architectural design, architecture, artificial intelligence, computational design

1. Introduction

Architecture is one of the oldest known professions, and its historical formation is based on a long process. Throughout this process, there have been different definitions of what architecture is. Despite the presence of architecture, these theoretical definitions were developed somewhat belatedly. In terms of the presentation of definitions, all socio-cultural trends have influenced architecture. Therefore, there are numerous refined, elaborate, and poetic definitions of architecture throughout history. According to Vitruvius, architecture is the design of spaces that are safe, adequate for their function, comfortable, give people the pleasure of living, and evoke a sense of the sublime (Vitruvius, 2005). The definition of Le Corbusier is masterful, accurate, and majestic plays of the masses brought together under the illumination of architecture (Corbusier, 2007). Additionally, Ludwig Mies Van der Rohe defines it as the spatial manifestation of the era (Conrads & Bullock, 1976). This transition from ancient architecture to modernism and then to postmodernism resulted in changes in the definitions of architecture, which have left their mark on architecture.

The theoretical and existential evolution of the concept of architecture has led to a variety of architectural design tools. In the architectural literature, artificial intelligence is one of the most recent techniques. The fact that artificial intelligence contains iterative processes and design procedures that include problem definition, concept generation, and evaluations creates an overlap between the two disciplines. Thus, parallel to technological advancements, artificial intelligence,

*(Correspondin author) Buse Bölek, Eskisehir Technical University, Türkiye, busebolek@ogr.eskisehir.edu.tr,
**Prof. Dr., Eskisehir Technical University, Türkiye, otutal@eskisehir.edu.tr, ***Assoc. Prof. Dr., Eskisehir Osmangazi University, Türkiye, ozbasaran@ogu.edu.tr, / Article history: Received 12 March 2023, Accepted 17 April 2023, Published 30 April 2023

which is present in nearly every aspect of our lives and is used to solve multilayered and difficult design challenges, has begun to emerge in the discipline of architecture. Initially, artificial intelligence was used in the fields of imitating the thinking and learning processes; however, now it is also used in the fields of building relationships with new advances, analyzing the methods of forming relationships, and replicating relationships. Approaches in the field of architecture that utilize artificial intelligence offer the opportunity to take problem inputs and to discover multiple optimal solutions in a reasonable amount of time. Distinct subfields of artificial intelligence employ various technological developments, including computational, iterative, reproductive, and developmental methods. As a result of these advancements, the artificial intelligence models produce the most appropriate output possible. Due to the fact that these methods are applicable not only as problem-solving techniques but also as simplified mathematical models that resemble the architect's perspective, artificial intelligence can be used to create a wide range of architectural products. These developments have led to the addition of inventive, smart, and productive elements to the field of artificial intelligence architecture. Architecture, is an art form (like sculpture and painting), but the most significant distinction is that the architect's art is functional and focuses on finding practical answers to issues (Rasmussen, 1964). The concept of functionality, which is of considerable importance in the field of architecture, is one of the most crucial variables in the complexity of design issues. Functionality can be spatial; it also plays a prominent role in the processes of obtaining solutions, such as discovering a form based on performance. With the development of technology, the use of artificial intelligence in the problem-solving process can yield major benefits.

Artificial intelligence is the broad category for the technology that enables a computing system with a non-biological structure to demonstrate all of the cognitive capacities of logic, self-awareness, comprehension, reasoning, problem solving, and creativity (Artut, 2009). This technology is based on the outputs produced through learning by adopting rules, reasoning, benefitting from cognitive disciplines, and self-correction (Bingöl, et al., 2020). In 1956, the phrase “artificial intelligence” was first used in a Dartmouth, United States, symposium attended by the leading scholars (Gülşen, 2019). Therefore, it has been possible to discuss the existence of artificial intelligence for over fifty years. In recent years, however, the usage of artificial intelligence has become widespread due to advancements in processing power, the availability of huge amounts of data, and the creation of new algorithms (Atalay & Çelik, 2020). The interdisciplinary approach provided by artificial intelligence to architectural problems can provide a highly expansive perspective. Artificial intelligence is used in a variety of architectural design domains, such as obtaining multiple proposals in a short period of time, obtaining variations of existing designs quickly, obtaining materials with optimal properties, obtaining quick results with decision support systems, and developing environmentally conscious approaches. While artificial intelligence can handle the pragmatic portion of design challenges in architecture and AI studies, the architect retains authority over the contextual, socio-cultural, and historical linkages of the design. The integration of artificial intelligence and architecture will reach a point that will be debated in the future during architectural periods thanks to inter-disciplinary approaches.

There have been numerous proposals and developments in the literature pertaining to the use of artificial intelligence in architectural design. While the studies concentrate on a particular problem and serve as design support mechanisms, they also employ multiobjective methodologies that manage numerous design inputs simultaneously. This study was conducted to categorize all of these approaches and assess the scope of artificial intelligence's influence in the field of architecture. Since the emergence of artificial intelligence, a wide field of work has emerged in the process of solving architectural design problems, and these are performance based, form finding, spatial programming, multi objective optimization, restoration works, and design tool development.

Artificial intelligence, which is prevalent in practically every part of our lives today, has begun to be implemented in architecture for a variety of purposes (Table 1). Within the scope of the

investigation, the research in the literature was classified under six primary categories. Some research serves several purposes, despite the fact that these broad categories permit the achievement of various more particular aims. For instance, while trying to optimize thermal loads and ventilation in skyscrapers, this approach has been developed so that it can give correct suggestions in various climatic conditions (Zhao, et al., 2020; Chen & Yang, 2017).

Table 1 The initial and sub-purposes of architecture's usage of artificial intelligence.

Initial Purposes	Sub-Purposes
Performance based	Energy-saving Maximum benefit from daylight Passive design solutions Facade design
Form Finding	Building envelope design Parametric designs Modular architecture Facade design
Spatial Programming	Site plan suggestions Plan solution suggestions Mass settlement proposals on an urban scale
Multi-objective	Applications of active and passive systems Mass and facade recommendations for maximum benefit from daylight
Restoration	Completing the missing parts of the structures Transferring important structures to digital platforms
Design Tool Development	Developing algorithms that solve various design problems

By developing performance-based designs using artificial intelligence-based methodologies, optimal solution ideas for energy sources, such as saving from diverse energy sources and maximizing the usage of non-renewable energy sources, are generated. Using utilitarian approaches such as facade solutions, mass orientations, and good design for passive systems, studies have been conducted to determine the optimal solution suggestions based on the building's location. In addition to being one of the sub-goals in the process of achieving these solutions, achieving the optimal form can also be one of the primary objectives of this integrated work area. This demonstrates that most design challenges entail multi-objective methods. In form-finding procedures, artificial intelligence enables the use of context-based design parameters to approach the most suitable outcome. It is used to optimize forms based on several contextual inputs, particularly in parametric designs (Caetano, et al., 2020).

Renovation projects are one of the most significant areas of study in architecture. Since the entire built environment leaves a significant carbon imprint, maximizing the lifespan of a structure contributes to environmental solutions. For these reasons, applications of artificial intelligence are used in building rehabilitation projects and for estimating the missing elements of ancient buildings. The fourth strategy involves the creation of design development tools. These tools offer outputs or recommendations in particular problem-solving domains. It is essential to create these tools in order to get closer to viable architectural solutions (Gallo, et al., 2020).

This study presents a detailed review of the works on artificial intelligence in architecture to determine where we are in the process of integrating AI into architecture by classifying them according to their inferences to the parameters. The research methodology part of the paper defines the study field and performs a literature-based keyword analysis to clarify prospective keyword discovery. Findings' second part comprises the statistical data of the papers in accordance with the established research framework, according to the publishing years, the countries in which they were published, their objectives, the algorithmic technique, and the programming languages used. In the conclusion part, the evaluation of the collected research and the architectural applications of artificial intelligence are described.

2. Research Methodology

This article identifies interpretable patterns and gaps in academically published journals using descriptive statistics and knowledge-based representations. The literature search is carried out using the cross-content reading method (Aslan, 2016). Furthermore, the acquired data were

categorized using the parameter extraction technique. Using this strategy, the most discussed research-related categories were identified, while the insignificant ones were eliminated. This classification evaluates research under six main categories for a more structured presentation (Figure 1). In the initiation phase, the most relevant keywords are identified based on the literature research. Scopus, Sciencedirect, ProQuest, Thesis Center (Council of Higher Education - Türkiye), and/or Google Scholar indexed, preferably highly cited, in English between 2012 and 2022, and based on the keywords "artificial intelligence", "machine learning", "deep learning", "expert systems", and "evolutionary" were chosen as the key terms for this study. In the second phase, to widen the search area, the keywords "form finding", "spatial programming", "site plan optimization", "shape grammar", and "architectural optimization" were added, and the research scope was selected. In the third phase, the present state of the relationship between artificial intelligence and architectural studies was investigated. In the fourth phase, 214 articles and 28 theses were chosen among 1700 articles and 87 theses relevant to the subject. In the fifth phase, the research was categorized by publication year, country, objective, algorithmic technique, and programming language. Finally, based on the achieved analysis and categorization results, a research model for the classification of studies in the field of architecture with artificial intelligence was developed.

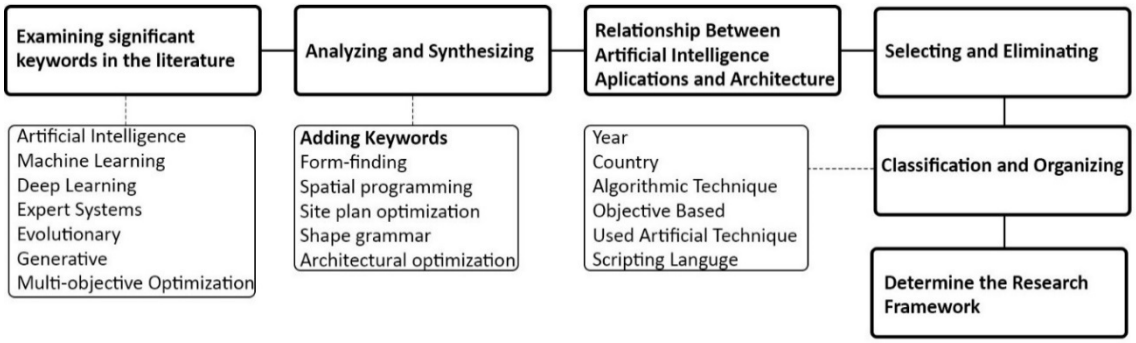

Figure 1 Research Flowchart

The number of studies in the literature connected to productions made with architecture and artificial intelligence has been determined as a result of the literature search and classification of the studies that were discovered as a consequence of these searches. Stun charts are used to display this data. In conclusion, assessments of the area were made based on these statistical findings.

2.1. Background Research

Within the scope of the research, the studies' keywords are one of the essential factors that serve to categorize them. An analysis was carried out on the keywords identified in the 242 studies that were included in the research. As a result of this study, the VOSviewer software was used to generate a network map of the terms in the literature (Figure 2). This analysis yielded the results of studies conducted on artificial intelligence in the subject of architecture, revealing which subfields of artificial intelligence are most prevalent. Based on this conclusion, it has been determined that there are more studies in the literature on six major issues in the field of architecture: expert systems, machine learning, evolutionary design, generative design, multi-objective optimization, and deep learning.

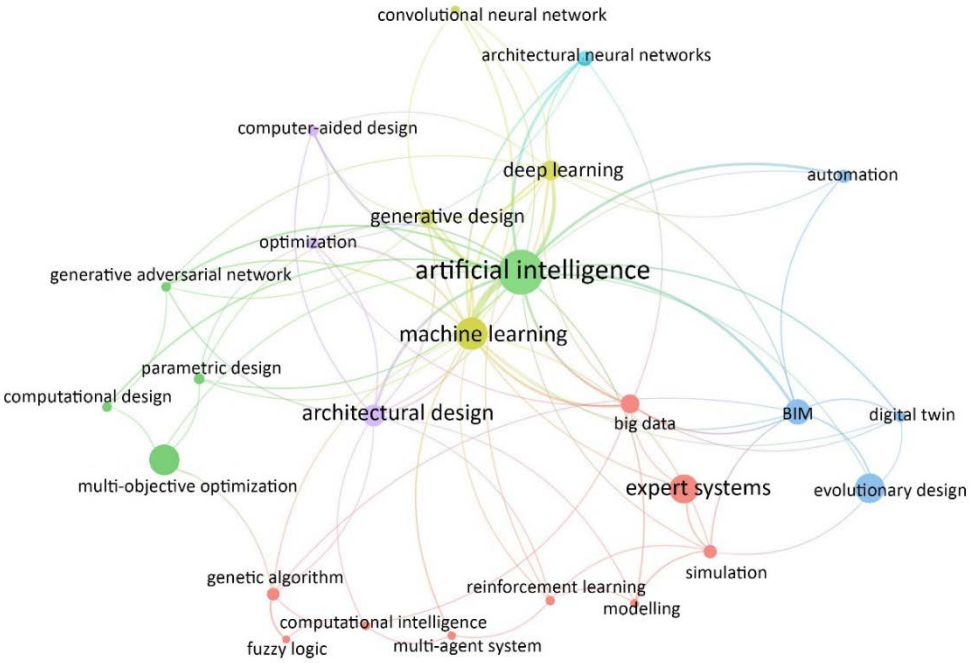

Figure 2 Keyword network analysis of the studies on artificial intelligence and architecture

In the literature on artificial intelligence, it is defined as the capacity to comprehend and learn from vast quantities of data in order to accomplish certain goals and tasks (Kaplan & Haenlein, 2019). In 1943, McCulloch and Pitts introduced their Boolean circuit model of the brain, in which artificial intelligence initially appeared as an abstract idea. In 1950, Turing's research into "information processing machines and intelligence" laid the theoretical groundwork for computer science (Pirim, 2006). These foundations have spawned numerous artificial intelligence methodologies and subdisciplines (Table 2).

Table 2 Definitions of concepts in the literature related to artificial intelligence subcategories, definitions and history

ARTIFICIAL INTELLIGENCE SUBCATEGORIES	GENERAL DEFINITION
Expert systems	Expert systems are intelligent computer systems that provide solutions to a given problem at the expert level (Bohanec & Rajkovič, 1990).
Machine Learning	Machine learning is a field of study that seeks to comprehend and build methods that use data to improve performance on specific tasks (Wang, et al., 2009).
Evolutionary Algorithms	In artificial intelligence, an evolutionary algorithm is evolutionary computation, which is a population-based metaheuristic optimization technique. An evolutionary algorithm uses evolutionary-inspired mechanisms including reproduction, mutation, recombination, and selection (Link-1).
Generative Algorithms	A generative algorithm classifies data by imitating its production. Enables the rapid development of new ideas (Link-2).
Multi-objective Optimization	Multi-objective optimization provides concurrent, conflict-free resolution of competing objectives (Toffolo & Benini, 2003).
Deep Learning	Deep learning is a strategy for artificial intelligence based on artificial neural networks that employs multiple processing layers to gradually extract higher-level data features. It learns data representations rather than specialized problem-solving methodologies (Zhang, et al., 2018).

These disciplines have also enabled numerous developments in the field of architecture. Expert systems, one of the earliest forms of artificial intelligence, have been utilized in the design process to produce the optimal outcome from the combination of various inputs. Expert systems have aided in the production of solutions to multi-layered design issues in this area. Within the scope of expert systems, life cycle assessment in architectural studies, holistic analyses of environmental performance (Sartori, 2021), building energy-saving designs based on real-time simulations (Mirarchi, et al., 2020), various emergency situations in building renovation systems to the building portfolio designing building envelopes that adapt to the climate (Kim & Clayton, 2020), and energy

performance analysis of various facade systems (Abediniangerabi, et al., 2020) are all used in the process of obtaining utilitarian solutions.

Machine learning, a subfield of artificial intelligence, is a technical strategy with transformative potential in architecture, as well as in numerous other fields. Due to its ability to change, it has been used in many fields, such as estimating energy savings (Banihashemi & Wang, 2017), predicting the growth of city plans (Xia & Tong, 2020), and coming up with architectural aesthetic variations (Zhou & Park, 2021).

Significant contributions have been made by evolutionary algorithms to the realization of computational principles in architectural design. In continuation of the concept of evolutionary algorithms, generative algorithm approaches were used to find the most effective solution. In architecture, these algorithms are used for parametric design optimization (ElBatran & Ismaeel, 2021), sustainable architectural approaches (Chatzikonstantinou & Sariyildiz, 2017), and form finding (Yan, et al., 2022).

In addition, the evolution of artificial intelligence techniques has led to the emergence of multi-objective optimization methodologies, which have enabled the simultaneous resolution of multilayer problems. This method has been effective in the majority of simulations. Finally, deep learning techniques which are among the most recent approaches, are used in the production and classification of urban textures, as well as providing solutions in the field of architecture that other approaches cannot.

3. Findings

After reviewing 1700 articles and 28 theses, it was determined that 242 studies demonstrated artificial intelligence and production methods in the field of architecture. These studies were organized according to six primary categories, which were as follows: the year in which they were published; the country in which they were created; the objective of the study; the algorithmic technique used in the publication; the programming language employed in this study; and the artificial intelligence technique.

It has been seen that as artificial intelligence methods have improved (Table 1), the total quantity of publications in the field has increased (Figure 3). At least in part, this rise can be explained by the fact that the architects are now able to write code in a more straightforward way thanks to the visual scripting languages (Boshernitsan & Downes, 2004).

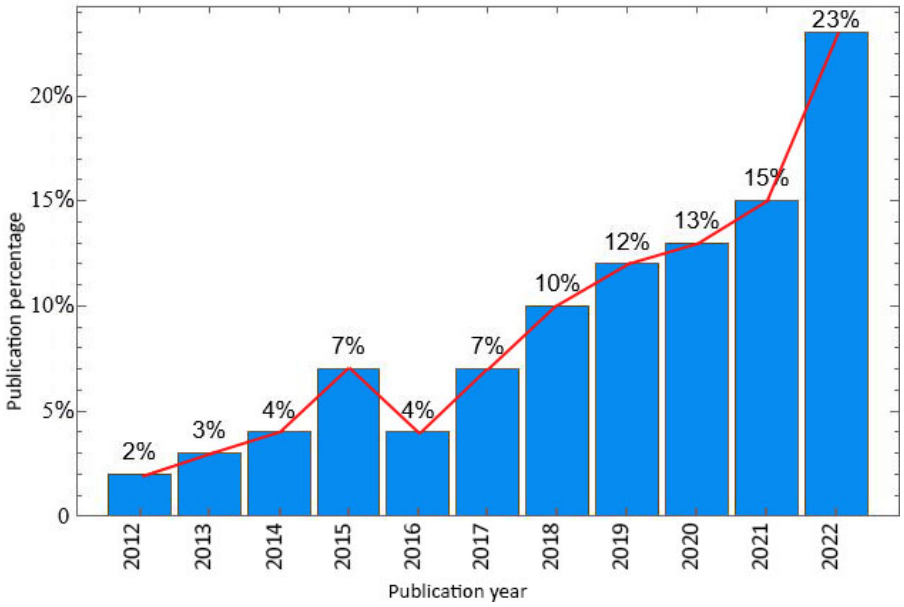

Figure 3 The quantity of articles classified by publication year

China has a significant number of publications compared to other nations whose authors contributed to these surveys' collections during that time (Figure 4). Examining the research from China reveals that the reasons for this are to provide optimal solutions and energy efficiency in skyscraper designs, as China has a large population. It has been noted that Italy and the United States are two other countries with the highest publication rates (Kong, et al., (2012).

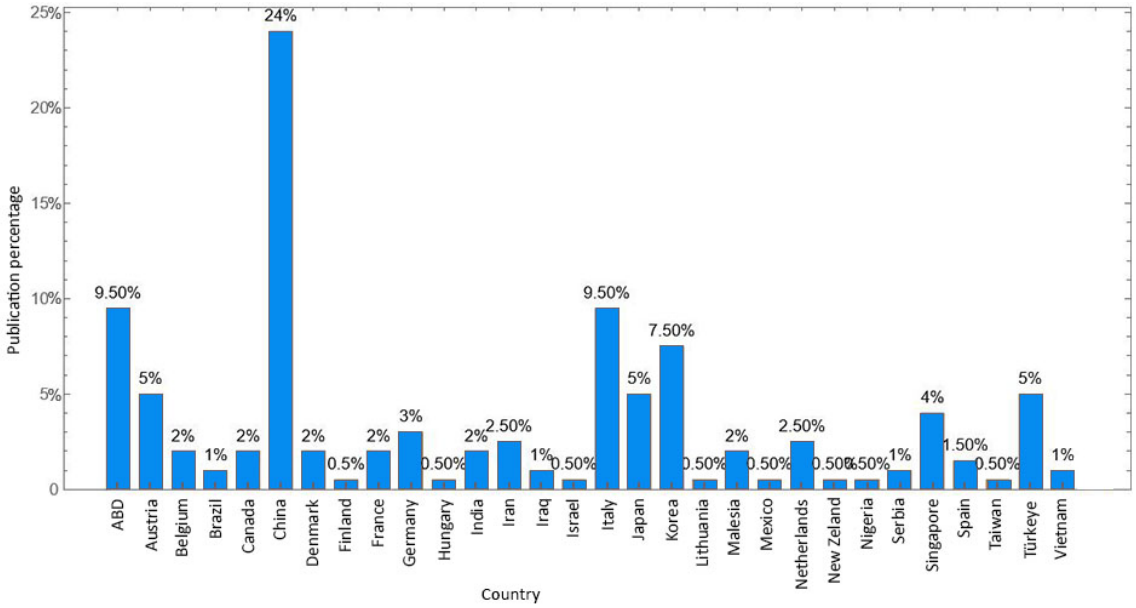

Figure 4 The quantity of articles classified by country

The analyzed studies cover a range of disciplines, including architecture and artificial intelligence applications. Based on their research objectives, these study disciplines can be grouped into six categories (Figure 5). With 43% of 242 studies, performance-based studies represent a significant portion of the literature. Table 3 lists some of the studies from which we acquired this substantial numerical ratio (Table 3). The performance-based category includes studies that focus on the energy performance of buildings. On the other hand, the multi-objective optimization category comprises studies that aim to optimize both energy performance and other design requirements simultaneously. Therefore, some of the performance-based research falls under the multi-objective optimization category.

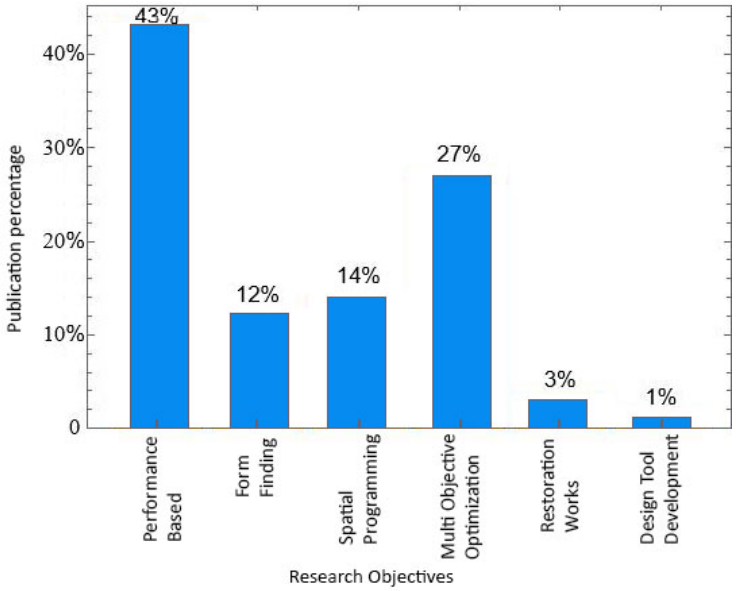

Figure 5 The quantity of articles categorized based on their research objectives

Table 3 The significant studies that based on their research objectives

Category	References
Performance based	(Rahimian, 2022), (Han, 2022), (Xu, 2022), (Jia, 2021), (Singh & Geyer, 2022), (Paterson, et al., 2017), (Baghdadi, et al., 2020), (Wang, et al., 2019), (Li, et al., 2018), (He, et al., 2021), (Singaravel, et al., 2018), (Lin, et al., 2021), (Chokwitthaya, et al., 2019), (Gan, et al., 2019), (Olu-Ajayi, et al., 2022), (Zou, et al., 2021), (Li, et al., 2019), (Chou, Bui, 2014), (Wortmann, 2019), (Schwartz, et al., 2021), (Scherz, et al., 2022), (Sun, et al., 2015), (Mangan, 2021), (Ruiz, et al., 2017), (Singaravel, et al., 2018), (Toniolo, Leon, 2017),
Multi objective optimization	(Singaravel, et al, 2018), (Chardon, et al., 2016), (Natephra, et al., 2018), (Yousif & Bolojan, 2021), (Chardon, et al., 2015), (Liu, 2022), (Zhuang, et al., 2021), (Zhang, et al., 2021), (Baydoğan & Şener, 2014), (Chen & Pan, 2015), (Chen & Yang, 2017), (Si, et al., 2019), (Razmi, et al., 2022), (Carbonari, et al., 2019), (Kim & Clayton, 2020), (Yi, 2019), (Pilechiha, et al., 2020), (Mukkavaara & Shadram, 2021), (Marcolino, et al., 2015), (Seghier, et al., 2022)
Spatial programming	(Nisztuk & Myszkowski, 2019), (Ng, et al., 2019), (Buruzs, et al., 2022), (Karadoğan, 2021), (Doukari & Greenwood, 2020), (Raman & D'Souza, 2019), (Xia, et al., 2020), (Wang, et al., 2022), (Xiong, et al., 2022), (Liu & Lee, 2022), (Zheng, et al., 2020), (Shen, et al., 2020), (Yong & Chibiao, 2022), (Guo & Li, 2017), (Bei, et al., 2019), (Uzun, 2020), (Güleç, 2014), (Şen, 2022)
Form finding	(Yan, et al., 2022), (Guo, 2022), (Cai & Li, 2021), (Radziszewski, 2017), (Bao, et al., 2022), (Zheng & Yuan, 2021), (Yan, et al., 2022), (Müezzinoğlu, 2022), (Aldemir, 2014), (Zheng, 2022)
Restoration works	(Gade, et al., 2018), (Mulero-Palencia, et al., 2021), (Morbidoni, et al., 2020), (Kamari, et al., 2018), (Jiang, et al., et al., 2022)
Design tool development	(Jalaei, et al., 2015), (Cichocka,et al., 2017), (Gade, et al., 2018)

According to the algorithmic methodologies employed in their research, 242 studies have been categorized. The results of these studies suggest that genetic algorithm-based techniques are extensively employed in the published works (Figure 6). Although evolutionary algorithms were developed earlier than genetic algorithms, the reason behind the prevalence of the latter in architecture is the discipline's versatility in applying generative algorithms to various contexts such as form diversification, facade suggestions, plan proposals, and site plan layouts (Su & Yan, 2015). Other techniques include machine learning techniques such as CNN (Płoszaj-Mazurek, et al., 2020; Ng, et al., 2019) and ANN (Naji, et al., 2016), in addition to genetic and evolutionary algorithms, which are extensively employed.

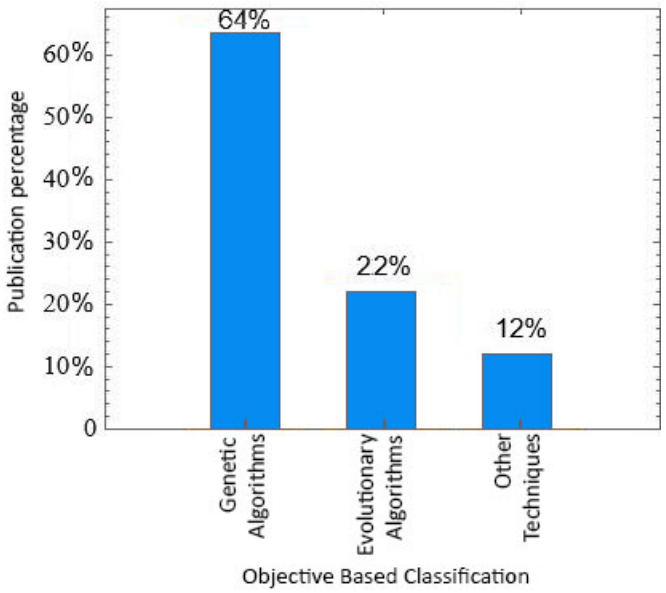

Figure 6 The quantity of articles classified by algorithmic technique

Studies in the literature that are related to architecture and artificial intelligence typically employ visual programming languages (Figure 7). Even an architect who is not familiar with the

process of putting together any code can use visual programming languages since they enable the mixing of different instructions through the use of a drag-and-drop interface. Rapid optimization was accomplished by the utilization of technologies for artificial intelligence that are accessible through these programming languages. As a result, a large number of studies have been completed with the indirect use of artificial intelligence as a ready-made tool rather than employing it directly.

Grasshopper and Dynamo are two examples of commonly used visual programming languages. These two interfaces accomplish their functionality by integrating with a variety of drawing applications. When comparing the two visual programming languages, Dynamo appears to be more advantageous to Grasshopper. This is due to its unique characteristics, which facilitate a greater level of engagement with diverse stakeholders, particularly in the context of BIM-based initiatives.

In general, open source programming languages are more accessible than visual scripting languages. Open source programming languages can be acquired and used without cost or licensing restrictions, whereas visual scripting languages are typically only accessible via licensed programs that utilize their interfaces. Therefore, not all works created with visual scripting languages are readily accessible or usable by individuals who lack access to these licensed programs.

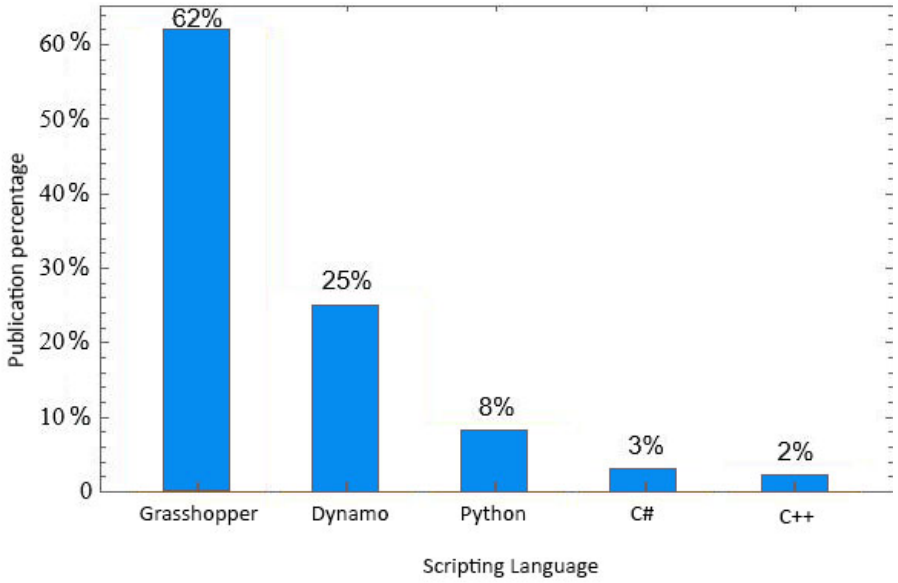

Figure 7 The quantity of articles classified by programming language

4. Concluding Remarks

The studies that used artificial intelligence in the field of architecture were searched on the Scopus, Sciencedirect, ProQuest, Thesis Center (Council of Higher Education – Türkiye), and Google Scholar directories. An iterative technique was utilized to identify the appropriate keywords for this study. This approach was executed in accordance with the research design outlined in the methodology part (Figure 1). 87 theses were analyzed using the cross-reading technique, and 1700 articles were gathered through the research. As a result of the evaluation, 214 articles and 28 theses were evaluated as works that involve architecture and artificial intelligence. The evaluation outcomes were categorized into six primary groups and given as statistical data. The outcomes of the collected data are listed below.

- The investigations in this area tend to utilize pre-existing frameworks. The focus of research is on the applications of artificial intelligence rather than its development. Therefore, it is suggested that future studies direct their attention towards the innovation of artificial intelligence in order to further advance the field

- Recent research using artificial intelligence optimization algorithms has not favored modern algorithms, despite the fact that the research was conducted in recent years. This circumstance affects optimization results.
- Significantly more architectural and artificial intelligence disciplines have been synthesized in China than it is done in other nations (Figure 4).
- Autodesk's Revit-Dynamo and Robert McNeel & Associates' Rhinoceros-3d-Grasshopper pairs dominated artificial intelligence research. It has been determined that no (reachable) free and open-source development platform exists.
- The authors of remarkable research are those who employ the disciplines of architecture and engineering together (Piira, et al., 2022; Liang, et al., 2022; Olu-Ajayi, et al., 2022; Pilechiha, et al., 2020).
- Architects have focused considerable attention on energy efficiency, which has been a significant issue in recent years. (Aksoy & Çağdaş, 2014; Kerdan & Gálvez, 2022; Seyedzadeh, et al., 2019; Li, et al., 2019).
- The incorporation of AI-based approaches has enabled architects to analyze and optimize previously difficult-to-solve complex design problems, thereby facilitating the emergence of interdisciplinary studies in the field. Also, the increase in interdisciplinary research follows an exponential growth trend (Figure 3). This trend reflects the increasing potential of advanced technologies and computational methodologies to revolutionize architectural research and practice and open up new avenues for architectural innovation and creativity.

In recent years, as interdisciplinary research on this topic has increased the use of artificial intelligence approaches to solve architectural problems has become more prevalent. These interdisciplinary collaboration strategies are expected to accelerate progress.

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Resume

Buse Bölek, who graduated with first place honors from the Architecture Department at ESOGU (Eskisehir Osmangazi University), has subsequently obtained two years of significant professional experience as an architect in an office environment. Presently, she is pursuing doctoral studies as a TUBITAK 2211 scholarship recipient, with a specific emphasis on augmenting her proficiency in a variety of artificial intelligence and software skills that are indispensable to the field of architecture.

Prof. Dr. Osman Tutal is currently working at Eskişehir Technical University, Faculty of Architecture and Design, Department of Architecture. His researches mainly focus on sustainable urban and architectural design which include accessibility, universal design/inclusive design/design for all and emergency architecture. He has numerous Project Management experiences and publications about accessibility for all.

Associate Professor Hakan Özbaşaran is a member of ESOGU (Eskisehir Osmangazi University), Department of Civil Engineering, Mechanics Division. He, as the coordinator of the Artificial Intelligence in Structural Engineering (AISE) Research Group, conducted artificial intelligence projects such as "Development of an expert system to simplify the design process of structural system plans for reinforced concrete residential buildings" and "Accelerating the structural optimization processes with machine learning". He has authored papers on artificial intelligence, structural optimization, and applied mechanics.

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Analyzing design and planning trends in medical research laboratories and workplace environments: A benchmarking study

Zahra Zamani*

Abstract

Architects and planners typically rely on past experiences and exclusive methods to determine the allocation of space and planning costs. However, the actual space allocations and physical attributes of laboratory and workplace environments require further exploration, highlighting the need for more research. To address this knowledge gap, this study compared three medical research facilities' architectural, casework, and module properties to identify essential space allocations, physical attributes, and future research directions. The study utilized REVIT models to collect floor plans of three medical research facilities within the last twelve years, with variables of interest including room classification size, Building Gross Footage (BGSF), Departmental Gross Footage (DGSF), laboratory module size, and module quantity per laboratory. Space Syntax analysis was used to compare connectivity measures across the three buildings. The findings demonstrated a trend towards laboratory spaces that maximize collaboration, flexibility, and efficiency while balancing open and private workspaces. Laboratory support spaces per laboratory room increased, potentially due to a demand for greater flexibility and spatial needs. Lab workstations were relocated outside laboratory areas to enhance safety and reduce costs. The analysis also revealed a shift towards smaller lab modules with larger widths to reduce redundancy, support safer distances, reduce travel distances, and increase the number of modules per lab. Furthermore, contemporary lab workspaces had higher connectivity values, indicating a trend towards more connected, collaborative spaces that encourage meetings and spontaneous interactions. This study highlights the importance of continuously evaluating and optimizing laboratory space allocation and design to promote productivity, efficiency, and collaboration in medical research facilities. Future research should conduct longitudinal studies using empirical data to address the limitations of current research.

Keywords: Medical research facilities, laboratory spaces, Benchmarking, module properties, space syntax, efficiency

1. Introduction

Benchmarking is a fundamental process in the industry for assessing products, metrics, and practices against competitors to identify areas of improvement and success (Kahn et al., 2002). This continuous process enables companies to access a broader database of marketplace dimensions and data-driven best practices. However, benchmarking presents challenges, including data quality and time-consuming data gathering due to evolving data systems, definitions, and staff training. Standardized definitions and practical training are necessary for successful and comparable benchmarking efforts. Permission barriers and the fear of losing a competitive advantage in the market have resulted in a reluctance to share benchmarking data in the building industry (Kahn et al., 2002; Kelly & Pingel, 2022). Therefore, addressing these challenges is crucial for effective benchmarking and to facilitate knowledge sharing and collaboration within the industry.

*(Corresponding author) Ph.D., BSA LifeStructures, USA, zzamani@bsalifestructures.com
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In laboratory metrics, understanding trends that support diverse work styles, collaboration, comfort, productivity, or privacy needs is necessary. The rapid transformation of science, methodologies, technologies, and the workplace has profoundly affected laboratory metrics. Although a limited number of commonly used key performance indicators exist, research investigating the effects of workplace strategies in the laboratory has produced a new paradigm and a shift in lab design metrics. Social and cognitive factors are significant in innovation and knowledge access, such as face-to-face communication with peers, a valuable metric related to information exchange, individual effectiveness, or team performance (Ancona & Caldwell, 1992; Ancona, 1990). Incorporating these factors into laboratory metrics is crucial for promoting effective knowledge sharing and collaboration within the laboratory setting.

The allocation and organization of laboratory spaces are crucial for ensuring the quality of work and compliance with accreditation processes. The laboratory layout affects traffic patterns, workflow, safety, and functionality outcomes, making it essential for planners, designers, and facility managers to consider benchmarking lab design for optimal work procedures, workflow, collaboration, and staff productivity. An optimized laboratory space can yield a better return on investment for Science and Technology (S&T) organizations. Renovating laboratories to cater to different scientific disciplines or research types can be expensive. It may not be possible for smaller projects with limited budgets to engage stakeholders in the design process. Nevertheless, more studies are necessary to summarize and evaluate university research centers' spatial needs and trends, highlighting the need for further research.

In summary, benchmarking and laboratory metrics are crucial for enhancing industrial and laboratory practices. However, they present various challenges that must be addressed to ensure their effectiveness. Effective benchmarking can be achieved by establishing standardized metrics definitions, providing practical training to key personnel, and addressing permission barriers. Similarly, incorporating social and cognitive factors into laboratory metrics can promote effective knowledge sharing and collaboration within the laboratory setting, ultimately leading to improved outcomes. These efforts can help foster innovation and enhance productivity in both industrial and laboratory settings.

The present study aims to address the gap in the literature regarding the physical attributes and workspace metrics of science and research buildings from 2009 to the present. It also seeks to evaluate trends in laboratory casework to create flexible and adaptable laboratory environments. Moreover, the study aims to identify best practices for laboratory design and provide recommendations for future laboratory renovations. This information will be valuable for laboratory planners, architects, and engineers on similar science and technology projects. By thoroughly evaluating laboratory spaces, this study seeks to contribute to the knowledge base of laboratory design and improve laboratory workspaces' efficiency, functionality, and safety.

2. Methodology

2.1. Projects in the study

This research aims to analyze the evolving design metrics and benchmarks in interdisciplinary research facility design by examining the wet laboratories of three medical research facilities constructed within the last twelve years. The three projects under examination are the Indiana University School of Medicine Research Institute III (built-in 2009), the Indiana University Neurosciences Research Building (built in 2014), and the Children's Mercy Kansas City Children's Mercy Research Institute (built in 2020).

To ensure a comprehensive comparison, the study presents an overview of the three project characteristics and key features in Table 1. At the same time, Figure 1 illustrates an overview of the timelines. This research is significant as the design of research facilities plays a crucial role in shaping interdisciplinary research teams' research outcomes and productivity. Thus, it is vital to understand the priorities and paradigms in this field.

Figure 1 An overview of the project timelines (Image copyright: Author).

Table 1 Key Characteristics of the three Science and Technology buildings

Project	year	SF	Key Features
Joseph Walther Hall	2009	254,000	• 200-seat auditorium • 23,495 SF vivarium • BSL-3 research and vector production. • Cell repository • Class 10,000 clean room • DNA and serum repository • Chemistry, anatomy, gross anatomy, physiology, and toxicology laboratories
Neurosciences Research Building	2014	140,700	• Connection to outpatient neurosciences clinic • Vertical vivarium • Business incubator • Interdisciplinary teams of researchers with a disease-oriented focus • Academic medical research • Behavioral studies, neuropharmacology, electrophysiology, electrochemistry, molecular, genetics, cell biology, functional imaging, biochemistry, proteomics, computational and clinical neuroscience
Children's mercy research institute (CMRI)	2020	395,000	• Connection to outpatient, inpatient, and provider buildings • GMP facility • BSL3 research space • Mass spec space • Sequencing space • Café and 400+ person auditorium • Genomics, clinical pharmacology, immunotherapy, health outcomes, and population health

2.2. Data collection

This study utilized REVIT software for room and area measurements analysis. The data obtained from the REVIT model was exported to EXCEL and JASP software for statistical analysis. The researchers focused on specific metrics previously applied in studies examining the physical attributes of laboratory spaces that affect operational costs, technology requirements, flexibility, and collaboration outcomes.

The study evaluated three key programming metrics to inform space planning decisions. The first metric is Departmental Net Square Feet (NSF), which refers to the physical floor space available in a room or the usable floor area assigned to an open area for a given function or use. This metric is calculated from the inside wall-to-wall or the lines of the functional split. It excludes corridors, information technology (IT), mechanical, electrical, plumbing (MEP) shafts, or vertical circulation within a departmental boundary.

The second metric is Department Gross Square Footage (DGSF), which includes the sum of NSF, walls, partition thickness, and departmental corridors. It excludes shafts, IT, MEP, public or multi-departmental corridors, or public toilets. Toilets, housekeeping closets, and other support spaces

given to a department are included in the DGSF. The third metric is Building Gross Square Footage (BGSF), which includes the sum of DGSF plus IT, MEP, stairs, shafts, elevators, public corridors, public toilets, lobbies, exterior wall thickness, and other non-programmed spaces. Including these additional spaces provides a comprehensive picture of the entire building area, which is essential in accurately forecasting future facility needs.

To ensure clarity and consistency in the application of programming terminologies, the study applied the following definitions for sub-departments: 1) offices, which comprises enclosed offices, workrooms, and open offices; 2) conferences, which includes conference rooms, phone rooms, or gathering rooms; and 3) the laboratory department, which includes laboratory rooms and laboratory support spaces. Due to the limited sample size, the study included different laboratory types in the research lab classification group, such as neuroscience, immunobiology, cell respiratory, open lab, genomics, or Biosafety Level 3 (BSL3). Research lab support rooms included equipment, cold rooms, lab storage, glassware wash, and gowning. In addition to departmental classifications, the study defined collaborative spaces as the combination of open-office rooms and conference spaces. Figure 2 provides an example of sub-department classification for one of the floor plans.

Figure 2 An example of sub-department classification of the Walther Hall floor plan (Image copyright: Author).

2.3. Lab Modules

Effective laboratory design is a crucial component of laboratory planning, encompassing various interior design elements, such as casework, workstations, benches, and equipment. Modular design, a vital aspect of laboratory planning, is imperative as it offers maximum flexibility, variability in space, increased efficiency opportunities, and reduced costs. The creation of a lab module, which is the minimum space required for lab occupants and equipment to function safely and effectively, involves the consideration of usable zones on both sides of an aisle, including countertops, utility cores, casework, benches, and equipment. Therefore, adopting a practical modular design approach is essential for achieving efficient lab operations.

To analyze the laboratory design in this study, the width, depth, and the number of lab modules in each lab were recorded. Additionally, the components of the lab module metrics were collected

at a micro-scale level (Figure 4). These components include the linear feet, count, and square footage of lab benches and workstations, lab benches with a sink, ELNFT, which is lab space, fixed bench, loose equipment, and Biosafety Cabinets (BSC), and ELNFT/Fume Hood ratio. These metrics are essential in creating flexible and adaptable laboratory spaces that optimize efficiency, productivity, and collaboration.

Using smaller lab modules and a higher ratio of lab bench/lab workstation count can be effective strategies for creating more flexible and adaptable laboratory spaces. This approach is instrumental in creating multidisciplinary research spaces, where lab design and equipment allocation are critical in facilitating collaboration, communication, and innovation. Figure 3 provides an example of lab rooms with multiple modules as the space unit.

Figure 3 Lab modules are the unit of space for laboratory design that enable flexibility for future modifications (Image copyright: Author).

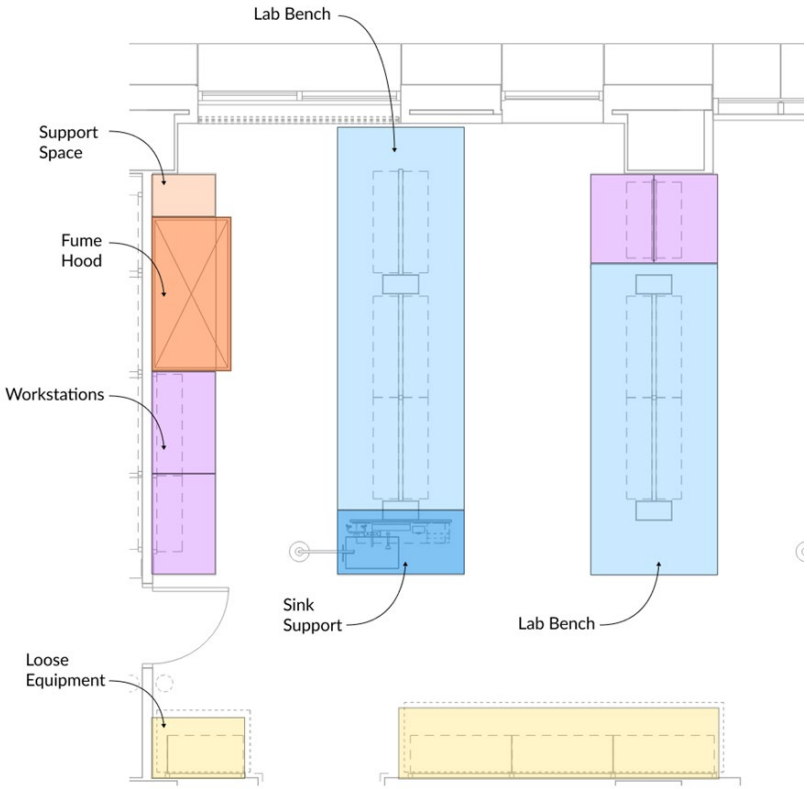


Figure 4. Components of lab modules include benches, equipment, fume hood, and lab workstations (Image copyright: Author).

2.4. Space Syntax

Space syntax is a sophisticated analytical methodology that utilizes mathematical algorithms to quantify spatial configuration accessibility and visibility (Hiller, 1996). Specifically, this approach generates numerical values that reflect the number of linked spaces on floor plans without changing direction, which indicates the visibility of spaces (Hiller & Hanson, 1984). Research has demonstrated that configurational accessibility is related to human behavior in research buildings,

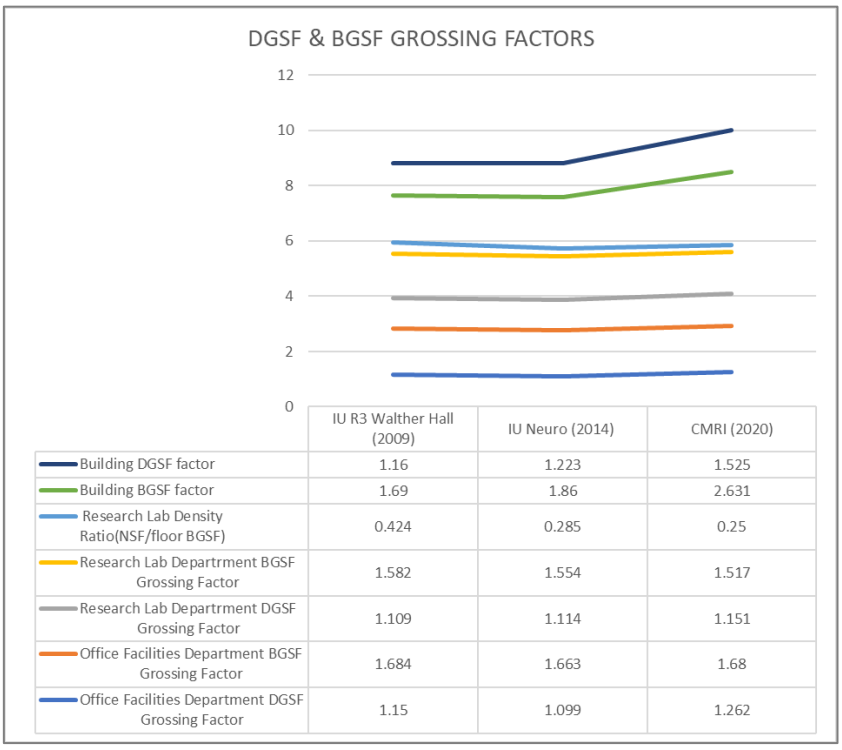
including collaboration and face-to-face communication (Hiller & Penn, 1991; Penn, et al. 1999; Toker & Gray, 2008). For instance, Penn et al. (1999) found a favorable association between employee-perceived usefulness and increased levels of spatial accessibility in research settings. They suggest higher accessibility leads to more significant work-related communication and movement opportunities, which may enhance innovation outcomes.

Recently, Zamani & Gum (2019) utilized space syntax to investigate the link between spatial attributes and staff work behaviors in an activity-based flexible office. Their results indicate that increased interaction, spatial connectivity, and seated connectivity are significantly correlated. Furthermore, departments were more likely to mix in spaces that were highly accessible and had less seated connectivity. Overall, space syntax analysis can provide valuable insights into how spatial configuration impacts human behavior and work outcomes in research buildings and can guide designers and planners in creating more effective and efficient workspaces.

3. Results

3.1. Design and Programming Trends

An ANOVA statistical analysis assessed significant mean differences across three projects. Figure 5 illustrates the trend for NSF, DGSF, and BGSF factors. The ANOVA results indicated no significant difference across the projects in terms of DGSF or BGSF grossing factors (P > .05). When examining the trend of key room sizes, ANOVA analysis revealed that AVG lab support and collaboration space sizes significantly increased over time ($F(2, 11) = 10.54$, $p < .05$); ($F(2, 12) = 19.965$, $p < .001$, Figure 6).



	IU R3 Walther Hall (2009)	IU Neuro (2014)	CMRI (2020)
Building DGSF factor	1.16	1.223	1.525
Building BGSF factor	1.69	1.86	2.631
Research Lab Density Ratio(NSF/floor BGSF)	0.424	0.285	0.25
Research Lab Departrment BGSF Grossing Factor	1.582	1.554	1.517
Research Lab Departrment DGSF Grossing Factor	1.109	1.114	1.151
Office Facilities Department BGSF Grossing Factor	1.684	1.663	1.68
Office Facilities Department DGSF Grossing Factor	1.15	1.099	1.262

Figure 5 Departmental NSF, DGSF, and BGSF relationships.

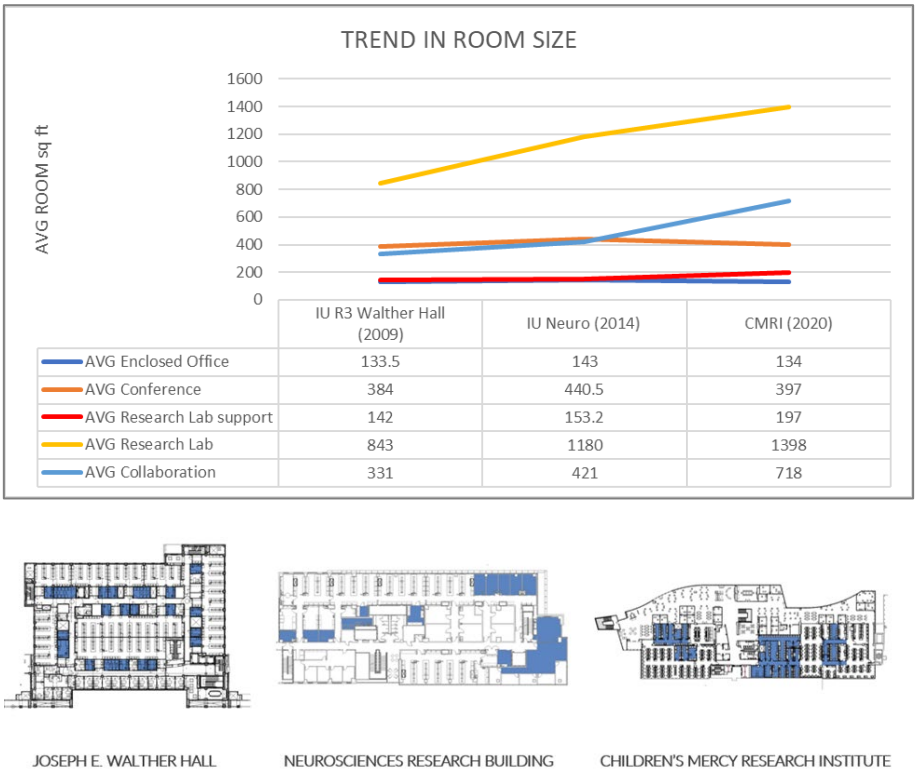


Figure 6 The trend in laboratory and workplace square footage.

According to the findings presented in Figure 7, the ratios of a laboratory to lab support square footage and quantity decreased significantly over the years ($F(2, 11) = 12.087$, $p = 0.002$; $F(2, 11) = 4.893$, $p = 0.03$). The results depicted in Figure 8 compare the three projects and enclosed office spaces, indicating a significant increase in the ratio of enclosed office to lab spaces (SF).

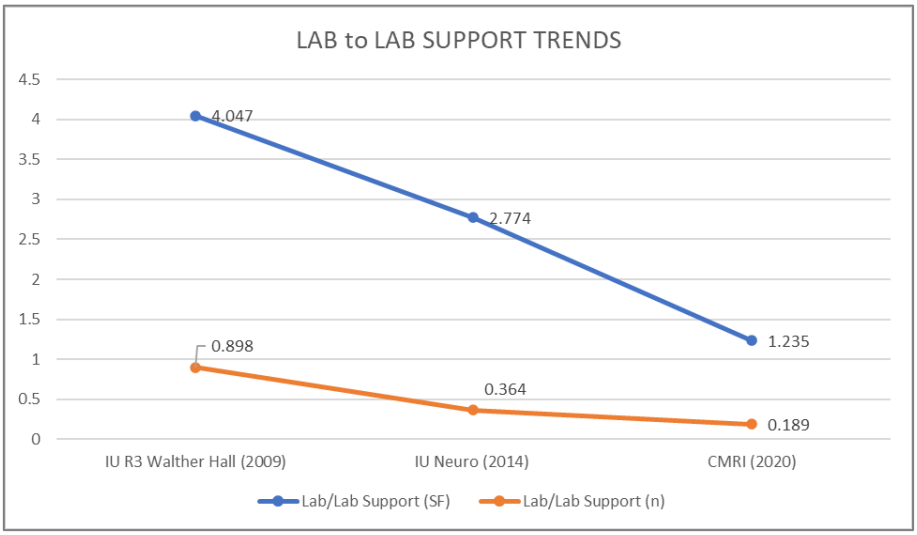
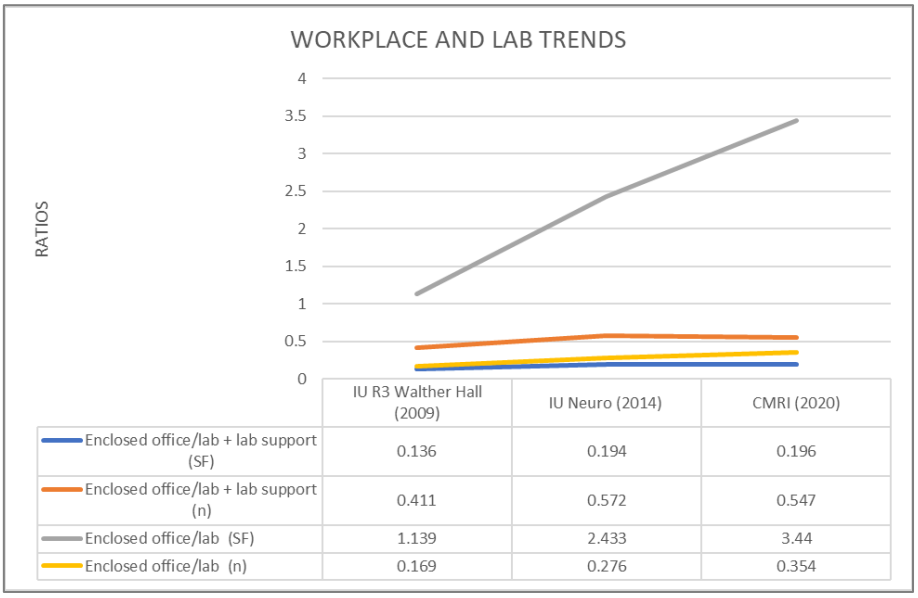


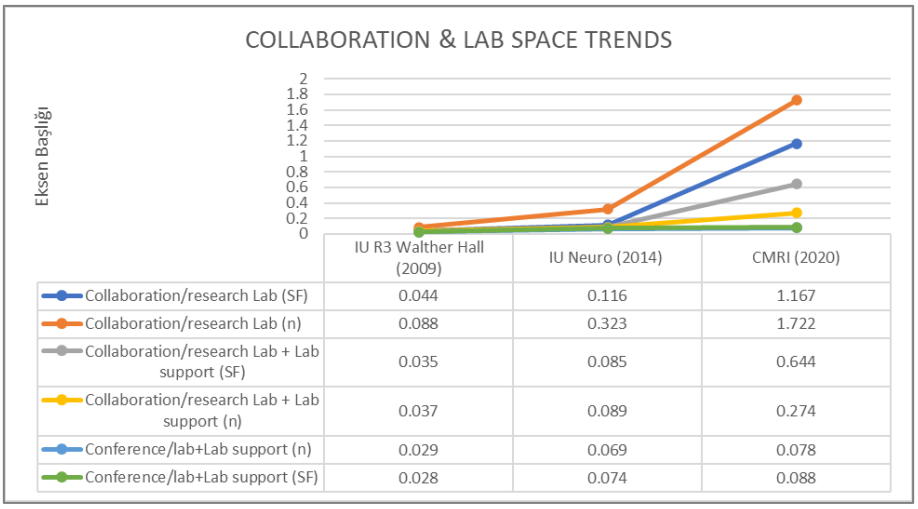
Figure 7 The ratio of lab-to-lab support decreased over time.



	IU R3 Walther Hall (2009)	IU Neuro (2014)	CMRI (2020)
Enclosed office/lab + lab support (SF)	0.136	0.194	0.196
Enclosed office/lab + lab support (n)	0.411	0.572	0.547
Enclosed office/lab (SF)	1.139	2.433	3.44
Enclosed office/lab (n)	0.169	0.276	0.354

Figure 8 Workplace and lab trends and ratios across time.

The study results revealed significant changes in the design of laboratory and workspace areas over time ($p < .001$). As Figure 9 illustrates, these changes included an increase in the ratio of collaborative spaces to lab and lab support areas and an increase in the ratio of enclosed offices to lab space. ($F(2, 11) = 6.597$, $p = 0.013$; $F(2,11) = 6.519$, $p = 0.014$, respectively).



	IU R3 Walther Hall (2009)	IU Neuro (2014)	CMRI (2020)
Collaboration/research Lab (SF)	0.044	0.116	1.167
Collaboration/research Lab (n)	0.088	0.323	1.722
Collaboration/research Lab + Lab support (SF)	0.035	0.085	0.644
Collaboration/research Lab + Lab support (n)	0.037	0.089	0.274
Conference/lab+Lab support (n)	0.029	0.069	0.078
Conference/lab+Lab support (SF)	0.028	0.074	0.088

Figure 9 Relationship between collaboration and research lab quantity and size over time.

3.2. Lab module, casework, and equipment allocations

This study compared lab modules' width and length attributes at a micro-scale level across three projects (Figure 10). Our results indicated that the width of the Walther Hall Module was significantly less than that of IU Neuro and CMRI ($F(2, 423) = 53.531$, $P < 0.001$). Furthermore, the length of the CMRI Module was significantly less than that of the older projects ($F(2, 423) = 99.243$,

P <0.001). We also examined the lab module space allocation (SF) across the three projects (Figure 11) and found that the CMRI Lab module size was significantly smaller than that of both older projects (F(2, 423) = 39.256, P <0.001). On average, Neuro Lab modules were 20 SF larger than Walther and 43 SF larger than CMRI (P <0.001).

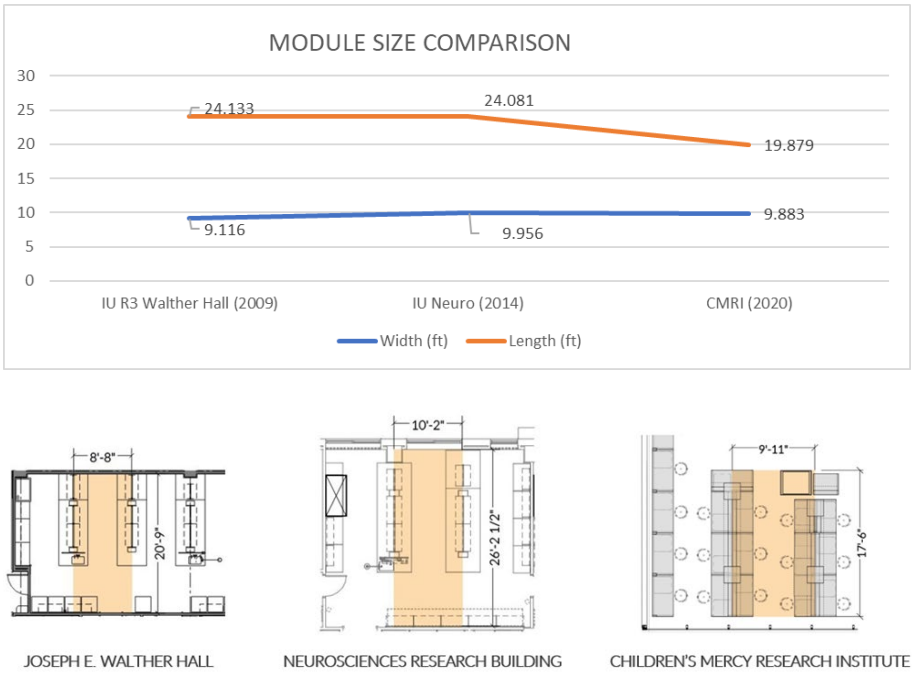


Figure 10 Lab module length and width size comparison across time.

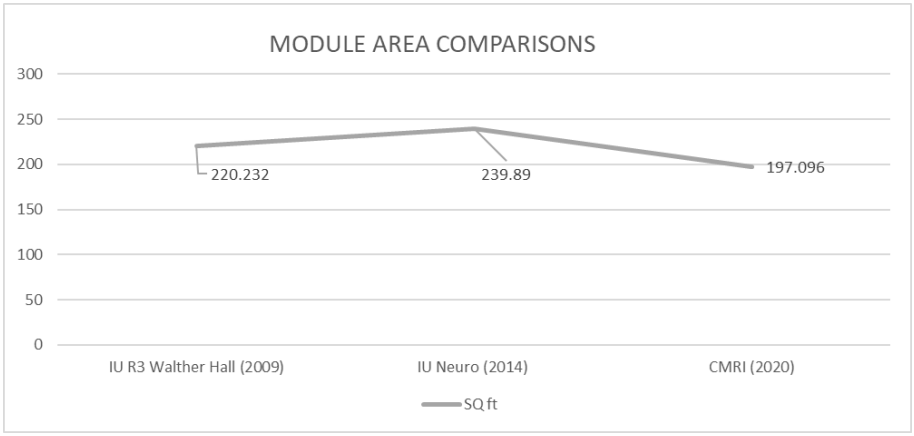


Figure 11 Average space allocation per lab module across the three projects.

The study results indicate that the ratio of lab module SF per lab room size was significantly lower in CMRI, which is attributed to smaller module sizes. This finding is supported by the statistical analysis, which shows a significant difference between the three projects (F(2, 94) = 12.883, P < .001). In addition, the CMRI project had a more significant number of lab workstations outside the lab rooms, resulting in a higher ratio of lab bench/lab workstation count. This finding is also supported by the statistical analysis, which shows a significant difference between the three projects (F(2,88) = 15.64, P < .001). However, the difference in the ratio between Walther and Neuro was insignificant (P > .05). Figure 12 provides a clear visual representation of the changes in lab modules across the three projects. The figure shows an increase in the count of lab modules over time, accompanied by a reduction in size.

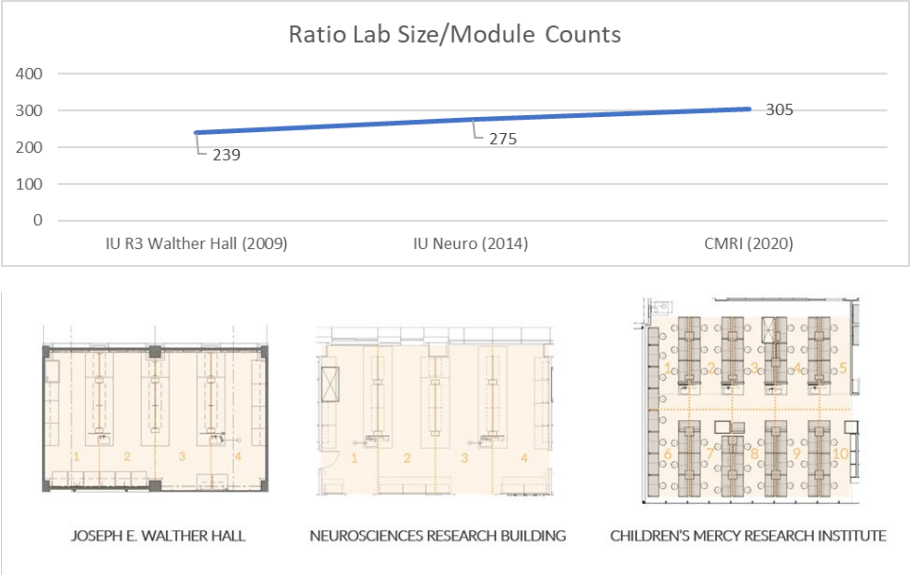
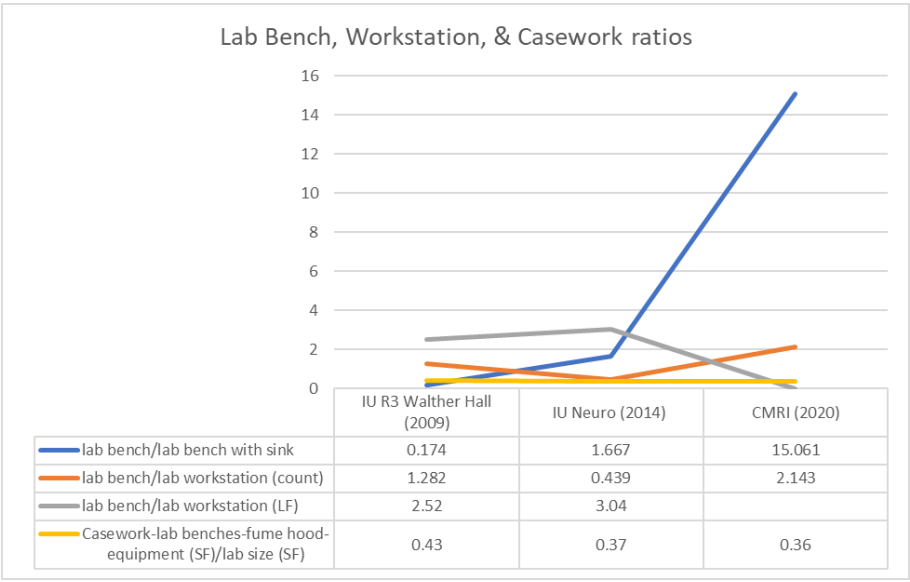


Figure 12 The average ratio of lab size to module counts per project.

The analysis presented in this study sheds light on the evolution of laboratory space and equipment allocation trends over time. Figure 13 shows that there was a significant increase in the number of sinks per lab bench, indicating a trend toward improving laboratory processes and hygiene ($F(2, 105) = 1048$, $P < .001$). Concurrently, there was a significant reduction in the allocation of casework, lab benches, fume hood, or equipment (SF) space per lab room size, resulting in increased free space for movement or work ($F(2, 108) = 12.98$, $P < .001$).

However, while these trends suggest a shift towards maximizing space utilization and reducing costs, there were no significant changes in the ratio of the Lab bench to the Lab workstation (Linear Feet) ($P > .05$). Figure 14 displays the transition of lab workstation benches across the three projects, showing a reduced number of workstation benches inside the laboratory room and their transition towards dedicated open workspace areas outside the lab room.



	IU R3 Walther Hall (2009)	IU Neuro (2014)	CMRI (2020)
lab bench/lab bench with sink	0.174	1.667	15.061
lab bench/lab workstation (count)	1.282	0.439	2.143
lab bench/lab workstation (LF)	2.52	3.04	
Casework-lab benches-fume hood-equipment (SF)/lab size (SF)	0.43	0.37	0.36

Figure 13 Lab bench, workstation, and casework trends across the projects.

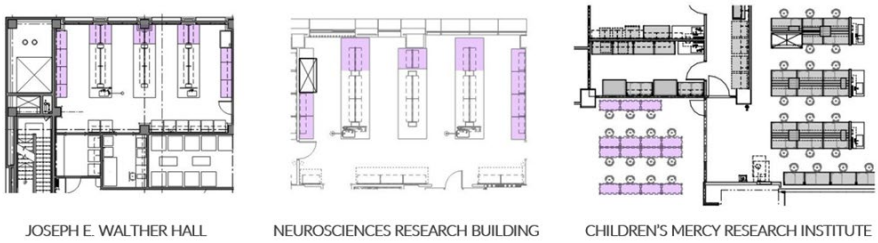


Figure 14 An example of lab workstations transitioning outside the laboratory environment within a typical floor plan.

3.3. Visibility Measures

The methodology of this study involved using the space syntax tool to measure and compare the visibility of floor plans from three different buildings. To ensure accuracy, furniture that was below eye level was excluded from the calculation. The Maximum connectivity index was used as the metric of interest, and the three buildings included in the study were Walther, Neuroscience, and CMRI. The analysis revealed that the CMRI building had the highest connectivity and visibility, with a connectivity index of 27606, compared to Walther and Neuroscience, which had 3606 and 7627, respectively. Figure 15 provides a visual representation of the connectivity values for each building, with red cells indicating highly connected areas and darker blue hues indicating lower connectivity spaces. In Walther Hall, the open lab spaces were strategically positioned at the center of the floor plan, contributing to higher visibility and connectivity within the laboratory.

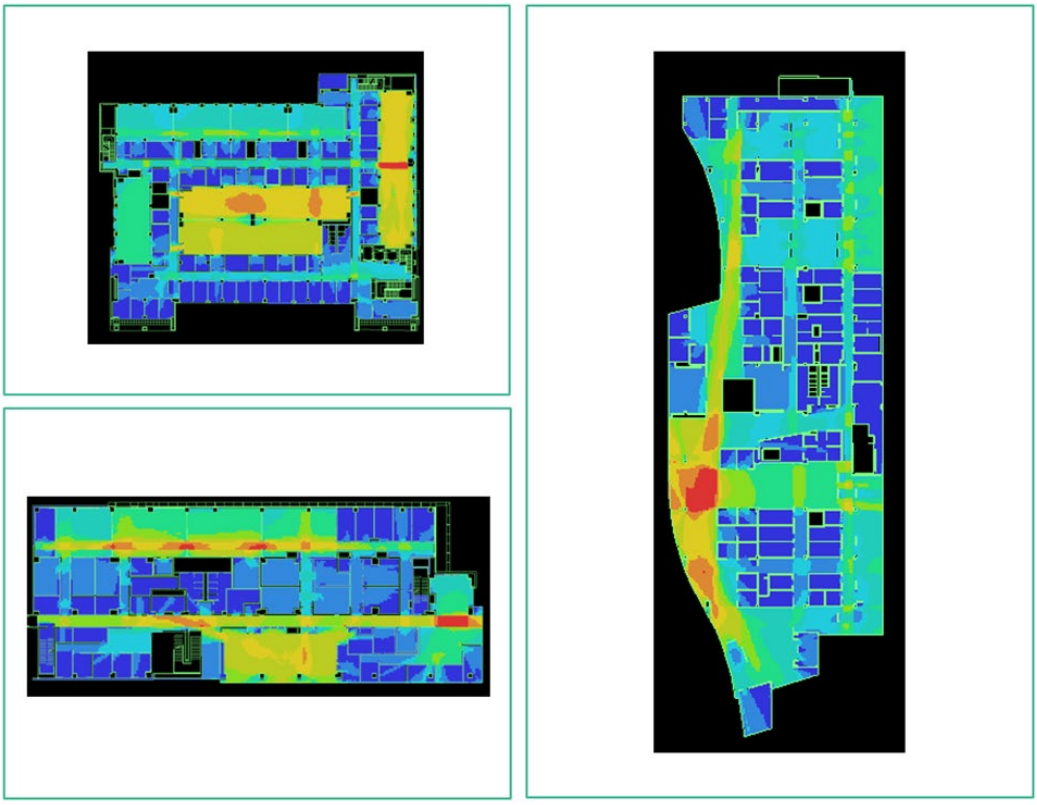


Figure 15 Visibility analysis of typical floor plans (Top left: Walther Hall, Bottom left: Neuroscience, and Right: CMRI).

The layout of the Neuro building differs from the CMRI building in terms of lab space divisions. In the Neuro building, lab spaces are divided, and the interconnecting corridors serve as the highest visibility areas. Conversely, the higher visibility areas in the CMRI building are the open workspace areas intentionally created by designers as the "heart of the building." Moreover, the contemporary laboratory layout of the CMRI building exhibits a higher connectivity index than the Walther or Neuro buildings, with connectivity indices of 3485, 2891, and 2706, respectively (Figure 16). Aside

from internal connectivity, the CMRI lab rooms are positioned along exterior glass walls to enhance natural light penetration and connect users to the external environment.

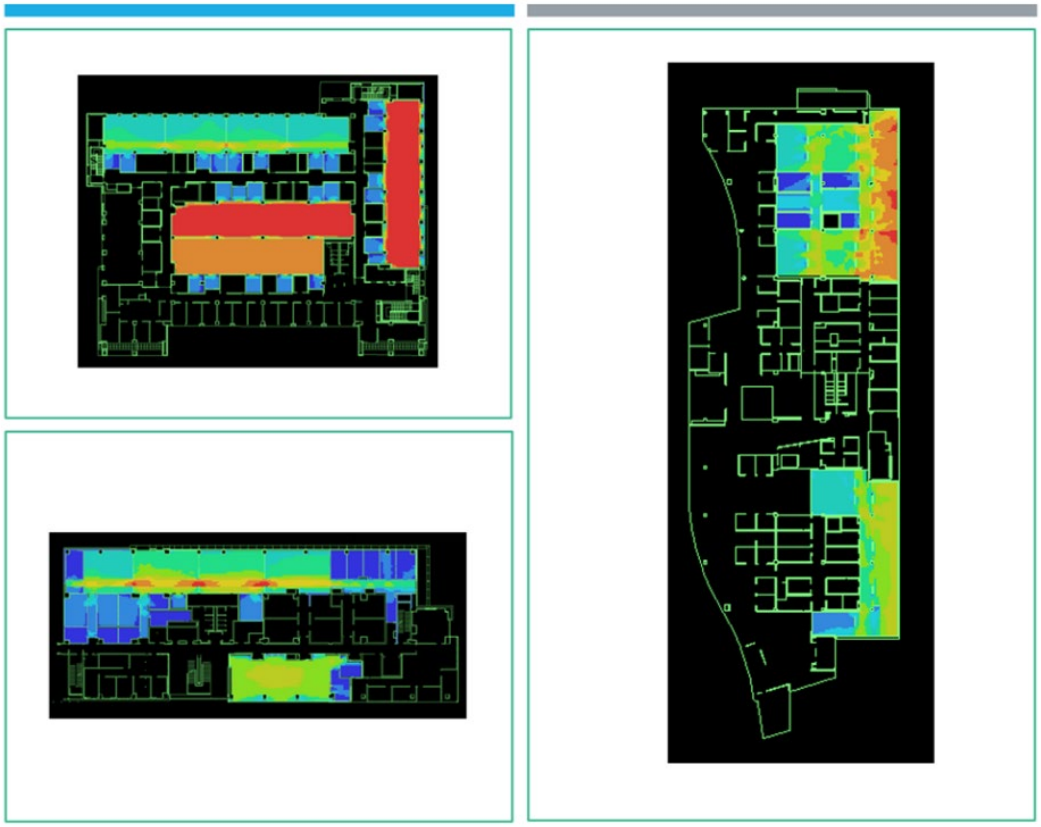


Figure 16 Visibility analysis of a typical laboratory and support room (Top left: Walther Hall, Bottom left: Neuroscience, and Right: CMRI).

4. Discussion

4.1. Design and programming implications

The design of medical research facilities has been an area of research interest for many years. Previous studies have highlighted the importance of efficient layouts, environmental controls, and flexibility in supporting interdisciplinary research team. However, with the evolution of science and technology, new priorities and paradigms have emerged that must be considered when designing interdisciplinary research facilities. The findings of this study will contribute to the existing body of knowledge in interdisciplinary research facility design by identifying the latest trends and evolving priorities in this field. Furthermore, this study can serve as a reference for future interdisciplinary research facility design research. By understanding the key features and design metrics of successful medical research facilities, researchers can develop new design guidelines for future interdisciplinary research facilities.

The study emphasizes the need to consider the evolving needs of researchers when designing research buildings. To enhance productivity, collaboration, and user experience, floor plans in laboratory spaces must be optimized. Despite a constant total area concerning NSF, DGSF, or BGSF metrics, the functionality of key rooms changed over time. As such, the study suggests a closer ratio between lab and laboratory support spaces, increased lab support numbers, and larger lab support rooms. This trend may be attributed to the growing popularity of modular lab layouts with sufficient support spaces to accommodate diverse research needs. A closer ratio of lab-to-lab support is essential as labs are becoming more generic while support areas are increasingly specialized. Thus,

a closer ratio of lab and laboratory support spaces can better accommodate diverse research needs, while increasing the number and size of lab support rooms can enhance functionality.

Over the past decade, universities have increasingly emphasized a more collaborative, innovative-focused mode of operation, influencing physical environment layouts (Etzkowitz & Leydesdroff, 2000). The study found that the emergence of various office layouts, such as enclosed offices, open-plan offices, conference rooms, or co-working spaces, was a direct result of the shift in workstyles caused by the changing nature of technology, workforce, workplace collaboration, and knowledge. Findings showed that collaborative spaces are also becoming increasingly important, indicating the need to balance private work areas and collaborative spaces. These findings are consistent with previous research, indicating a growing trend toward designing collaborative, open teamwork zones and meeting spaces in research settings to promote visibility, collaboration, and innovation, enhancing employee satisfaction, comfort, and efficiency (Davis et al., 2011; Etzkowitz & Leydesdroff, 2000; Wohlers & Hertel, 2016).

The Space syntax analysis indicated that the CMRI building exhibited superior connectivity and visibility compared to the Walther and Neuroscience buildings. Notably, the layout of the CMRI building boasted a higher connectivity index, primarily attributed to the strategic placement of open workspace areas as the focal point of the building's design. The CMRI laboratory rooms were also thoughtfully positioned along exterior glass walls to optimize the natural light penetration and foster connections with the external environment. Taken together, these results suggest that the deliberate arrangement of open lab spaces and interconnecting corridors can significantly influence the connectivity and visibility of a building, particularly in the context of science and technology buildings. The implications of these findings underscore a potential shift towards a preference for highly connected open laboratories in science and technology buildings. Furthermore, the Space Syntax methodology provides a valuable tool for architects and designers to design well-connected and visible spaces in science and technology buildings during pre-construction.

This space syntax finding aligns with the trend towards open office layouts with a higher need for visibility and accessibility, which enhances the likelihood of unplanned consultations among coworkers (Toker & Gray 2008). This is particularly important for scientists who depend on face-to-face communication for collaboration and information exchange (Toker & Gray, 2008). However, research has also shown that open office spaces can result in overcrowding, noise, and distractions, reducing productivity and job satisfaction while increasing employee stress levels (Davis et al., 2011; Elsbach & Bechky, 2007). To address these issues, office designers have turned to multi-space environments, such as activity-based flexible offices or combi offices, which provide a range of workspaces to meet diverse work requirements (Zamani & Gum, 2019).

Our research findings indicate an increasing proportion of enclosed offices compared to laboratory spaces. This trend may signify a need for a more balanced distribution of open and private enclosed spaces, particularly for dry lab and computational tasks, as highlighted in previous studies (Wohlers & Hertel, 2016; Heinzen, et al., 2018). For instance, Watch's (2001) observational study found that laboratory users tend to spend half of their time in private offices. Private offices offer individualized research environments, greater privacy, and lower noise levels, essential for focused tasks (Lee, 2010; Wajcman & Rose, 2011). In addition to providing a quiet and private environment, enclosed offices offer several other advantages, including increased personalization, autonomy, and control over one's workspace (Sundstrom et al., 1986).

Furthermore, research has shown that the availability of private offices is positively associated with employee job satisfaction and well-being (Kim & De Dear 2013; Raziq & Maulabakhsh, 2015; Zamani & Gum 2019). However, the implementation of enclosed office spaces must be balanced with the need for collaboration and interaction among laboratory users. Thus, it is vital to strike a balance between the availability of private and open spaces in laboratory environments to enhance overall productivity and employee satisfaction. Future studies could explore the most effective distribution of open and private enclosed spaces in laboratory environments, considering the

factors influencing employee productivity and well-being. Additionally, the research could examine the impact of different office configurations on employee satisfaction and well-being, using qualitative and quantitative methods to collect data on employee experiences and preferences. Overall, our research highlights the growing importance of private enclosed spaces in laboratory environments and suggests a more balanced distribution of open and private spaces to enhance productivity and employee satisfaction.

The COVID-19 pandemic changed employee expectations for workspaces, with a growing demand for a combination of collaborative and comfortable home-like features (Kniffin et al., 2021). This shift has led to workspaces incorporating living room setups with plush couches, flexible furniture for breakout groups, and hideaway pods for employee privacy and autonomy.

Moreover, the increase in remote work has reduced the future demand for office and computational workspace. At the same time, meeting rooms, huddle areas, and amenity spaces may rise in importance to encourage collaboration during office visits. Another trend is to move write-up desks into workplace areas, adopting hot-desking and hoteling workstation models to promote collaboration and increase spatial efficiency. Nevertheless, implementing these changes in the post-pandemic era requires an objective evaluation of workspace needs to make informed planning decisions (Kniffin et al., 2021). Such assessments should consider the factors contributing to employee productivity and satisfaction, including noise levels, lighting, and ergonomic furniture. Additionally, an analysis of the benefits and drawbacks of remote work should be considered, along with the potential impact on employee communication and team collaboration.

In designing laboratory workspaces that promote productivity and well-being, studies that employ qualitative and quantitative methods to gather data on employee preferences and behaviors and objective measures of productivity and job satisfaction can be particularly useful. For example, studies on laboratory users' productivity and well-being can determine the optimal balance of open and enclosed spaces to foster productivity and collaboration. Furthermore, research on environmental factors such as lighting, temperature, and air quality can offer insights into designing workspaces conducive to employee performance and health. For instance, investigations into the impact of natural lighting and indoor plants on employees' moods and productivity could be informative. In conclusion, incorporating home-like features, providing focused and collaborative workspaces, and promoting spatial efficiency can be advantageous for S&T organizations to adapt to the changing needs of employees. To improve laboratory workspace design, future research should continue to explore the most influential workspace configurations and the impact of environmental factors on laboratory users' productivity and well-being.

4.2. Lab module, casework, and equipment

In laboratory spaces, satisfaction with safety and security is a critical metric (Mahmoud, et al., 2018). The appropriate size of lab modules is essential for managing initial and long-term operational and construction costs. Modules with wider widths can dedicate casework, bench, or casework area to unnecessary circulation areas, while narrow modules can create unsafe research environments. Consistent with our findings, recent reports indicate a trend towards smaller lab modules to enhance productivity and collaboration between the principal investigator (PI) and research team members (Skolozdra, 2012).

The metrics also reveal an increasing trend in using lab benches with sinks. This trend was influenced by lab users requesting reduced steps and improved accessibility to sinks in the laboratory environment. However, there is a need for more empirical studies to determine whether this relationship between improved productivity and efficiency is significant. Future research could focus on collecting data from laboratory users regarding their experiences with varying sizes and configurations of lab modules. Researchers could also collect objective measures of productivity and efficiency to determine whether the use of smaller lab modules and lab benches with sinks positively impacts laboratory performance.

Overall, these findings suggest that laboratory designers and managers should carefully consider the size and configuration of lab modules and the inclusion of lab benches with sinks to optimize productivity and efficiency in laboratory environments. The present study's findings indicate a decrease in the ratio of laboratory workstations to lab benches. This trend can be attributed to the increasing use of computers and digital workstations, which has resulted in laboratory benches being used as writing surfaces, thereby altering the traditional requirement for workstation benches. Researchers have observed a shift in the location of conversations from lab benches to desks and open multi-office areas to reduce disruption and noise for colleagues (Coradi, et al., 2015; Heinzen et al., 2018). Furthermore, relocating workstation benches to areas outside the laboratory can provide a safer workspace for storing food, books, and paper. However, empirical research is needed to determine whether transitioning workplace benches to outside lab rooms improves cost, satisfaction, and productivity.

Limited studies have specifically examined the effects of relocating laboratory workstations on cost, satisfaction, and productivity. Future research in this area may consider conducting surveys and interviews with laboratory personnel to assess their satisfaction with the new workstation arrangement and to identify any potential cost savings resulting from the relocation of workstations. In addition, objective measures such as productivity and efficiency data could be collected to determine whether the new arrangement has a positive or negative impact on laboratory performance.

5. Conclusion

In conclusion, this study comprehensively analyzes the wet laboratories of three medical research facilities constructed within the last twelve years. By examining these facilities' design metrics and benchmarks, the study highlights the new priorities and paradigms in interdisciplinary research facility design. The results of this study will be valuable for researchers, laboratory planners, architects, and engineers involved in the design of interdisciplinary research facilities. The study's findings suggest that optimizing lab space allocation and workstation placement can maximize efficiency and productivity in the laboratory. The study highlights the importance of optimizing floor plans in laboratory spaces to enhance productivity, collaboration, and user experience. The trend towards designing collaborative, open teamwork zones and meeting spaces in research settings align with previous research, indicating a growing need for visibility and accessibility. The increasing proportion of enclosed offices compared to laboratory spaces indicates a need for a more balanced distribution of open and private enclosed spaces to meet diverse work requirements, particularly for dry lab and computational tasks. Enclosed offices offer several advantages, including increased personalization, autonomy, and control over one's workspace. The collective results of the space syntax analysis indicated that a purposeful organization of open laboratory spaces and interconnecting corridors profoundly impacts the connectivity and visibility of a building, particularly in the domain of science and technology buildings. These findings suggest a potential trend toward a preference for highly connected open laboratories in such settings.

The research findings suggest a trend towards smaller lab modules and using lab benches with sinks to improve productivity and collaboration. However, there is a need for more empirical studies to validate this relationship. Furthermore, the study observes a shift in the location of conversations from lab benches to desks and open multi-office areas and recommends the relocation of workstation benches outside the laboratory to provide a safer workspace for storing food, books, and paper. Finally, the study calls for further research to explore the impact of relocating laboratory workstations on cost, satisfaction, and productivity.

Further research is necessary to investigate the impact of design trends on laboratory and office spaces, ensuring that they are optimized for productivity, cost-effectiveness, and employee satisfaction. Longitudinal studies involving stakeholders are necessary to ensure construct validity and generalizability of the results. Correlations between laboratory design, workspace attributes, and implied outcomes should also be explored to determine whether open lab layouts are

associated with higher productivity, collaboration, or communication outcomes. Engaging laboratory users in these studies would be interesting. Lastly, the inconsistent data entry and terminologies across projects resulted in a lengthy process of standardizing architectural metrics. To facilitate database development and continuous updates across time, we recommend creating a standard room naming protocol with associated descriptions for architectural companies.

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Resume

Zahra is the director of research at BSA LifeStructures and leads various projects such as simulation modeling, Post-Occupancy Evaluations (POE), and benchmarking reports. She is passionate about studying the impact of design and planning decisions on human experience, satisfaction, health, and well-being. Zahra's expertise in data management, analysis, integration, environmental psychology, public engagement, team collaboration, problem-solving, creativity, and publication makes her a valuable team member. She is interested in exploring human dimensions and social needs in connection with design. Zahra has published and presented her research in multiple journals and international conferences. Her contributions to the industry include market research, customer needs analysis, and providing innovative solutions to complex problems.

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Alternative window wall ratio of glasses with different solar heat gain coefficient and solar transmittance and their effect on total energy consumption in alternative directions

Hakan Ünalan*
Emrah Gökaltun**

Abstract

Energy simulation model of the building of Eskişehir Technical University Industrial Engineering Department Academic and Administrative Staff rooms were created in this study carried in the scope of energy efficiency and performance of buildings. In the aforementioned energy simulation mode, in line with the International Measurement, Verification and Energy Needs Standards and Protocol (IPMVP) "energy consumption verification"; heating energy, indoor-outdoor environment and climate data were defined, energy consumption verification was carried out and a realistic model was achieved. Using the realistic model achieved, alternative directions were applied to alternative window wall ratios thereby calculating "reference energy consumptions" in "reference building models". Energy consumptions, calculated by applying alternative glass types to reference models, were then compared with reference energy consumptions

Keywords: energy efficiency, building orientation, window wall ratio, energy simulation, energy verification / calibration

1. Introduction

Increasing energy consumption rapidly distorts the natural ecological balance and sustainability. Sustainability affects the restricted energy resources and is important economically in terms of energy consumption of users' buildings. In addition, factors such as climate change and population concentrating in urban areas increase the attention to resistivity (Shamsuddin, 2020). "Energy efficiency" gains importance in the interface of sustainability and developing urban resistance. When considered on basis of sectors, energy consumed in buildings is defined as 37% for residential homes, 35% for commercial buildings and 27% for industrial buildings (URL 1). In this context, active and passive design criteria are noteworthy for designers, engineers and operators in construction sector. Because active design criteria are systems integrated in buildings, they indirectly lower energy cost. On the other hand, passive design criteria must be considered before constructing a building because they directly affect the operating costs. Passive design criteria are mainly as follows:

- Chosen location,
- Orientation,
- Building form,
- Physical characteristics of the building envelope,
- Solar control systems,
- Natural ventilation design,
- Physical characteristics of the window glasses. (Uslusoy Ş. S. & Altin M., 2014, URL 2).

*(Corresponding author) Assist. Prof. Dr.Anadolu University, Türkiye, hunalan@anadolu.edu.tr
**Assoc. Prof. Dr. Eskişehir Technical University, Türkiye, egokaltun@eskisehir.edu.tr
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Looking at the energy consumption in offices, energy consumptions for heating-cooling and lighting account for 53% of total energy consumption (Figure 1) (URL 3). “Building envelope and orientation” constitute the surface that transfers the heat between indoor and outdoor environments, directly and indirectly receiving solar radiation and balances the wind infiltration (Danielski, I., et al., 2012, p. 24). These are among the principal criteria that need to be designed and/or agreed upon at the design state as these directly affect the total energy consumption (Chiras, D., p. 19).

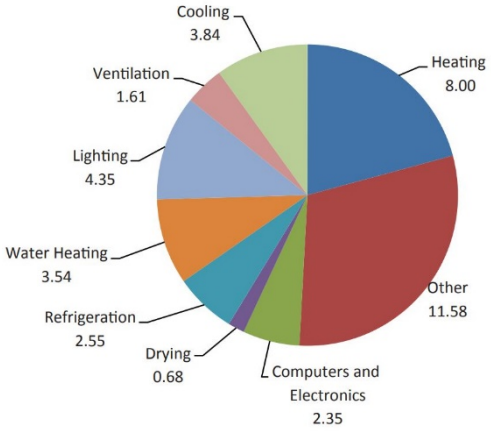


Figure 1 Total primary energy use in buildings (URL 3)

In a study conducted by Boyer et al, one of the leading applications for energy efficiency of buildings, Boyer et al discussed that buildings’ energy simulations could be applied to different targets using “multiple model” approach and following logical steps were necessary in relation to design and research aspects. This way savings of energy consumption would be possible noting the figures calculated using energy simulation programs during the building design phase.

Yaşar Y. and Kalfa S. M. have compared eight different glass types’ heating and cooling energy consumptions using a calculation model in Design Builder programme in absence of a realistic model for Blocks F and C of TOKI Housing Project in Trabzon.

Yang Q. et al have studied in 3 difference cities the effects of 3 different HVAC, 2 different glass types, 4 main directions and 9 window wall ratios on heating/cooling and total energy consumption. Kheiri, F. has studied optimum window wall ratios in four main directions in relation to illumination energy and HVAC in four cities of various countries.

Rizki A. Mangkuto R. A. et al’s study, the space observed is an office room, having internal dimensions of L 5.4 m, W 3.5 m, H 2.7 m. Reflectance values of the ceiling and the floor were respectively 0.85 and 0.20. The window was assumed to consist of a single glazing with typical visible transmittance of 0.88. No shadings, furniture, and other accessories were associated with the space. The WWR was varied from 30% to 80% in an interval of 10%. They concluded that, three optimum solutions are found, all of which belong to four Pareto frontiers. The most optimum solution with the least mean distance to the utopia points is the combination of WWR 30%, Wall reflectance of 0.8, and south orientation.

In this study, the aim is to assess energy consumption changes of alternative glass types in different directions and increasing window wall ratios. This way, for the Eskişehir Technical University, Engineering Faculty, Industrial Engineering Department, Academic and Administrative Staff Building Block’s:

- Energy simulation model was prepared;
- Consumption verification was made;
- Alternative window wall ratios were turned to alternative directions; and
- Heating-cooling energy consumption values were calculated to analyse.

2. Methodology

Attaining more realistic values is necessary due to uncertainty of calculations of energy simulations in buildings. To achieve that, energy consumption verification must be carried out in line with the protocols (such as M&V and IMPVP) foreseen by the Department of Energy (DOE) (Güçyeter B., 2010).

For the purposes of raising consciousness and awareness for effective architectural energy design of office buildings and probing the window wall ratio of building structure of office buildings in terms of heating energy performance following principles must be clearly defined:

- Examination of building energy performances in line with the International Measuring Performance and Verification Protocol and standards (IMPVP, Article 3.4.4. D),
- Measuring the energy consumptions of sample building in terms of in detail (one year; 8760 hours),
- Equalizing the energy calculated by energy simulation program and energy consumed within the limit values defined in line with these standards, and creating a realistic model,
- Turning the realistic model of the building to cardinal and intercardinal directions based on various window wall ratios, thereby recalculating and assessing the energy consumption,

Building energy consumptions were measured as per ASHRAE 2002, CIBSE (Section A) and M&V and the simulation model was created in line with ASHRAE 2005, IMPVP and M&V protocols. It was ensured that the indoor environment temperature values and energy consumption values were within the limit values defined in line with the IMPVP. Limit conditions are assessed in terms of 8760-hour measurement data by:

- The Stability Coefficient (sensitivity percentage / R) and
- Square Root Average Error Margin (RMSE)

When indoor temperatures are brought to limit conditions, the same operation must be repeated for calculated-measured energy consumption as well. The energy model that satisfies all of the above is referred to as the "Realistic Model" (Ke M. et al, 2013).

3. Location and current situation of the Sample Building

Eskişehir Technical University, Engineering Faculty, Industrial Engineering Department Academic and Administrative Staff Building Block is located on the latitude of 39.81 and longitude of 30.53. With an orientation of 38.69º north-south, the building was completed in 2000 (Figure 2). Two-storey reinforced concrete building has 10 rooms on ground floor and 9 rooms on first floor and the first-floor projects by 90 cm compared to the ground floor (department head's room is of the size of 2 rooms) (Figure 3-4). Aerated concrete blocks were used to fill the outside walls and the façade of ground floor was cladded with glazed bricks. The building's heating requirement is met by a heat centre that works on natural gas. Heat conductivity values of the construction elements used on the building envelope are given in Table 1.

Table 1 Building Envelope Element's U values

Building Envelope Element	U (W/m^2K)
Ground Floor Wall	0.875
1^{st} Floor Wall	0.96
Reinforced Concrete Wall	3.05
Ground Floor Pavement	2.34
1^{st} Floor Pavement (contact inside)	3.29
1^{st} Floor Pavement (contact outside)	3.23
Roof floor	3.54
Windows and Joinery	2.80

Figure 2 ESTU Industrial Engineering Department

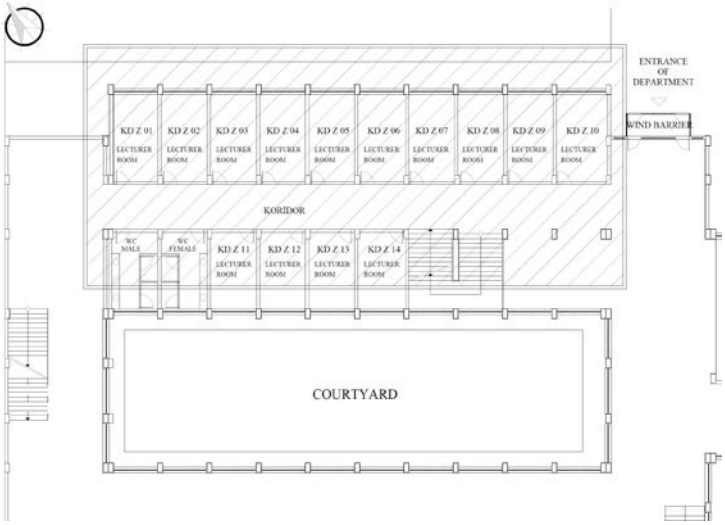


Figure 3 ESTU Industrial Engineering Department Ground Floor Plan

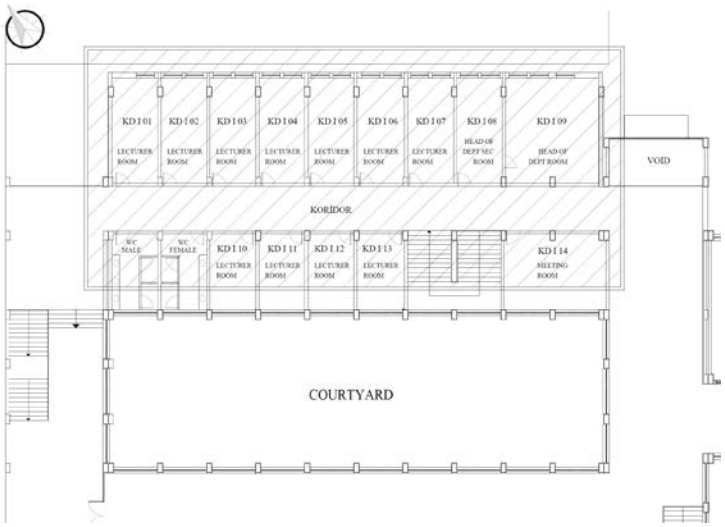


Figure 4 ESTU Industrial Engineering Department First Floor Plan

3.1. Taking the Measurements of the Sample Building to Enter into the Model

"Dynamic Calculation Model" is used to attain more realistic results in energy consumption calculations with energy simulation programmes. Synchronously collected data are used in dynamic calculation model to reveal the performance of the building envelope in particular. Indoor and

outdoor environment data that affect the sample building's energy consumption, and the amount of energy consumed in heating system are measured.

Data including outdoor environment temperature, relative humidity, direction and speed of wind and pressure readings were obtained from TUMAS system of the General Directorate of Meteorology (Metar-type station) and a climate data file was created. As for the indoor environment, indoor temperature, relative humidity and net heating energy were measured using datalogger and calorimeter. Dataloggers were placed at 150 cm height on the inner wall surface, ensuring that they're not exposed to solar radiation, in two rooms at each end and one room in the middle on ground and 1st floors (measurement interval was 15 minutes). On the other hand, calorimeter was connected to the heating pipe at the entrance of the building block. Calorimeter consisted of two probes measuring incoming and outgoing temperatures, a flowmeter and data recording device (measurement interval was 1 minute).

3.2. Creating the Model of Operation Buildings in Energy Simulation Programme

Simulation model of the Eskişehir Technical University, Engineering Faculty, Industrial Engineering Department Academic and Administrative Staff (Lecturer) rooms building were modelled in Design Builder programme in line with the standards set forth above, noting the architectural characteristics of the building (Figure 5).

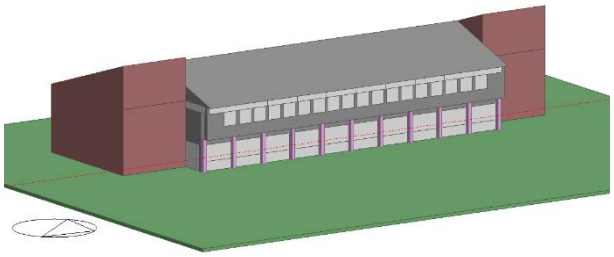


Figure 5 ESTU Industrial Engineering Department Building Simulation Model

3.3. Energy Performance Simulation Accuracy of Measured Buildings

In this comparison, coefficient of determination (Coefficient of Determination/R), coefficient of variation (Coefficient of Variation / RMSE) and average error (MBE) are used. Coefficient of determination (R) [%].

$$R^2 = \left(1 - \frac{\sum_{i=1}^{n} (y_{pred,i} - y_{data,i})^2}{\sum_{i=1}^{n} (y_{data} - y_{data,i})^2} \right) \times 100 \quad (1)$$

Coefficient of variation (CV / RMSE) [%];

$$CV = \frac{\sqrt{\frac{\sum_{i=1}^{n} (y_{pred,i} - y_{data,i})^2}{n-p}}}{y_{data}} \times 100 \quad (2)$$

And average error (MBE) [%];

$$MBE = \frac{\frac{\sum_{i=1}^{n} (y_{pred,i} - y_{data,i})}{n-p}}{\bar{y}_{data}} \times 100 \quad (3)$$

Where;

$y_{pred,i}$...; Value at which the calculated data equals to measured data,
$y_{data,i}$...; Value at which measured data equals to the calculated data,
y_{data}.....; Average value of measured data,
n.....; Number of data included in assessment,
p.....; Number of regressions used within the model.

Acceptable limit values of simulation data results in creating a realistic model are given in Table 2.

Table 2 International Performance Measurement and Verification Protocol's (IPMVP) Verification limit values

	ASHRAE G14 (2014)		IPMVP (2020)		M&V (2008)	
	MBE	RMSE	MBE	RMSE	MBE	RMSE
Hourly	±10%	25%	-	10-20%	±10%	30%
Monthly	±5%	15%	±20%	-	±5%	15%

Coefficient of determination, coefficient of variation and average error values for indoor temperature data of the Industrial Engineering Department Staff rooms are given in Table 3.

Table 3 Measured and calculated indoor temperature limit values (8760-hour) of Industrial Engineering Department Lecturer Rooms

	Coefficient of Determination (R)	Coefficient of Variation (RMSE (CV))	Average Error (MBE)
KD Z 01	0.89	16.78	0.62
KD Z 04	0.91	16.60	0.53
KD Z 10	0.94	15.43	0.21
KD I 01	0.96	16.19	1.09
KD I 05	0.95	15.20	0.37
KD I 09	0.94	15.48	0.33
AVERAGE	0.93	15.95	0.53

3.4. Calculation of reference energy consumptions based on alternative direction and window wall rations in the realistic model

In the realistic model that was created, window wall ratios were assessed in respective order in 8 different window wall ratios in the range of 10%-80% (Figure 6) without intervening the system and only considering the surface area of the windows. Only the heating and cooling energies were considering in calculating the reference energy consumptions, and electric energy consumption was not included in calculations.

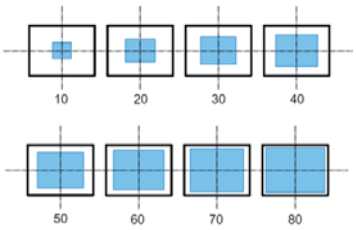


Figure 6 Window wall ratios used in the realistic model

3.5. Calculating total energy consumption values of alternative glass types applied to alternative direction and window wall ratios

Spectral data measured in manufacturer's laboratory setting in accordance with:

- Solar heat gain coefficient (SHGC) and solar transmittance (ST) EN 410 standards; and
- Solar Transmittance to EN 673 and EN 12898 standards;

were defined to 8 different base/basic model to determine the impacts of alternative glass types to heating/cooling energy consumption (Table 4). Total energy consumptions of new alternative models created (defining 5 different glass types to 64 models) were calculated.

Solar heat gain coefficient (%), solar transmittance (%) and Heat Transfer Coefficient (W/m²K) of alternative glass types applied to alternative direction and window wall ratios are shown in Chart 3.1 (URL 4).

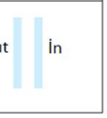
In alternative glass types:

- Type A glass is defined as glass that has low-e coated (ecotherm) double glaze that provides heat control in its inner glass;
- Type B glass is defined as double glaze glass coated with low-e (ecosol) that provides solar control;
- Type C glass is defined as triple glaze glass that has solar control on outer glass (ecosol) and low-e coating (ecotherm) that provides heat control on inner glass;
- Type D glass is defined as triple glaze glass that has low-e coating (ecotherm) that provides heat control on both inner and outer glasses;
- Type E Glass is defined as double glaze that has low-e coating (cool plus) that provides heat control on outer glass only; and

Current double glaze glass that does not have coating.

"Alternative heating-cooling energy consumptions" were calculated after making these definitions for each glass type.

Table 4 Characteristics of glass types used in the model (Low-e coating providing heat control, Low-e coating providing solar radiation control, Low-e coating providing solar radiation and heat control, Glass) (URL 4).

Glass Type	Thickness	Material	Glass Characteristics/properties	Solar Heat Gain Coefficient (%)	Solar Transmittance (%)	Heat Transfer Coefficient (W/m²K)	
A	4mm	Outer Glass	Plain Glass	60	78	1,3	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Low-e Coating (ecotherm) (heat control)				
B	4mm	Outer Glass	Low-e Coating (ecosol) (solar control)	43	71	1,3	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Plain Glass				
C	4mm	Outer Glass	Low-e Coating (ecosol) (solar control)	32	63	0,7	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Plain Glass				
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Low-e Coating (ecotherm) (heat control)				
D	4mm	Outer Glass	Low-e Coating (ecotherm) (heat control)	48	69	0,7	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Plain Glass				
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Low-e (ecotherm) (heat control)				
E	4mm	Outer Glass	Low-e Coating (cool plus) (solar and heat control)	33	49	1,1	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Plain Glass				
M (Current Glass)	4mm	Outer Glass	Plain Glass	68	80	2,9	
	12mm	Air Gap	Argon				
	4mm	Inner Glass	Plain Glass				

3.6. Findings

- Calculating the reference total energy consumption Based on Alternative Directions and Window wall Rations it is evident that:
  - Energy consumption increases linearly with increasing window wall ratio in all directions:
    - 13% increase in north direction (92.076-104.018kW/year),
    - 17.7% increase in north-east direction (91.985-108.270kW/year),
    - 16.5% increase in north-west direction (91.904-107.026kW/year),
    - 20.1% increase in east direction (91.132-109.466kW/year),
    - 16.6% increase in west direction (90.698-105.733 kW/year),
    - 0.8% increase in south direction (87.747-88.972kW/year),
    - 12.1% increase in south-east direction (89.589-100.407 kW/year),
    - 8.6% increase in south-west direction (89.094-96.730kW/year),
  - Energy consumption decreases in the following order: east, north-east, north-west, west, north, south-east, south-west and south.
- Energy Saving Rates Based on Alternative Directions and Window Wall Ratios

Energy saving rates obtained by comparing calculated energy consumptions with the reference energy consumptions are given in the Figure 7-14.

Calculated reference energy consumption is compared to energy consumption of alternative glass type, when the window wall ratio get %10 from %80 energy saving ratios for A, B, C, D and E types of glass respectively,

- North; %1.4-%10.4, %1.2-%10.2, %1.7-%14.2, %1.8-%14.5 and %1.3-%11.3,
- Northeast; %1.4-%10.9, 1.2-%12.3, %1.7-%16.4, %1.8-%15.8 and %1.3-%13.6,
- East; %1.3-%10.8, %1.2-%12.9, %1.6-%17.2, %1.8-%16 and %1.3-%14.6,
- Southeast; %1.1-%10.4, %0.7-%10.6, %1.1-%13.9, %1.4-%14.9 and %1.4-%14.9,
- South; %0.9-%9, %0.1-%5.1, %0.4-%7.9, %0.9-%11.1 and %0.1-%4.8,
- Southwest; %1.1-%10, %0.5-%9.1, %0.8-%12.2, %1.2-%13.9 and %0.5-%9.2,
- West; %1.3-%10.4, %1-%13, %1.4-%15.7, %1.6-%15.1 and %1.1-%13,
- North; %1.4-%10.6, %1.2-%11.6, %1.7-%15.7, %1.8-%15.3 and %1.3-%12.9

are determined.

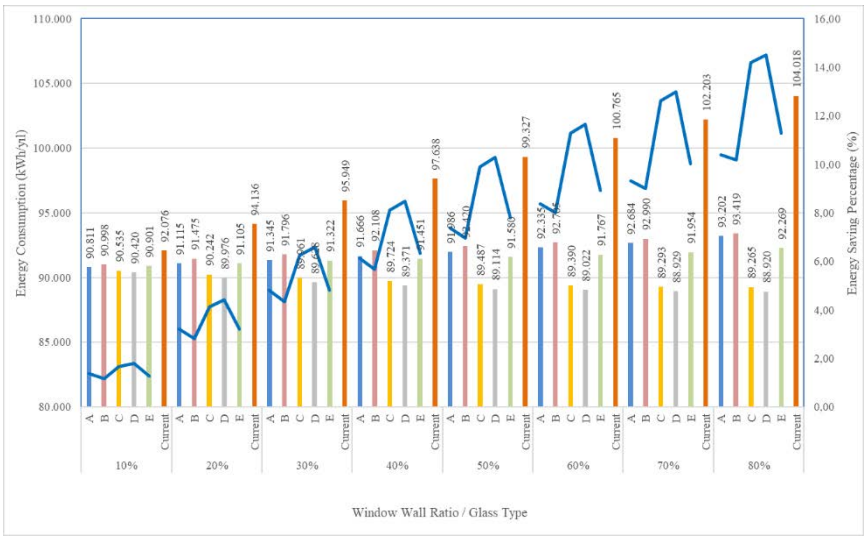


Figure 7 Energy saving rates, calculated energy consumptions and reference energy consumptions for North

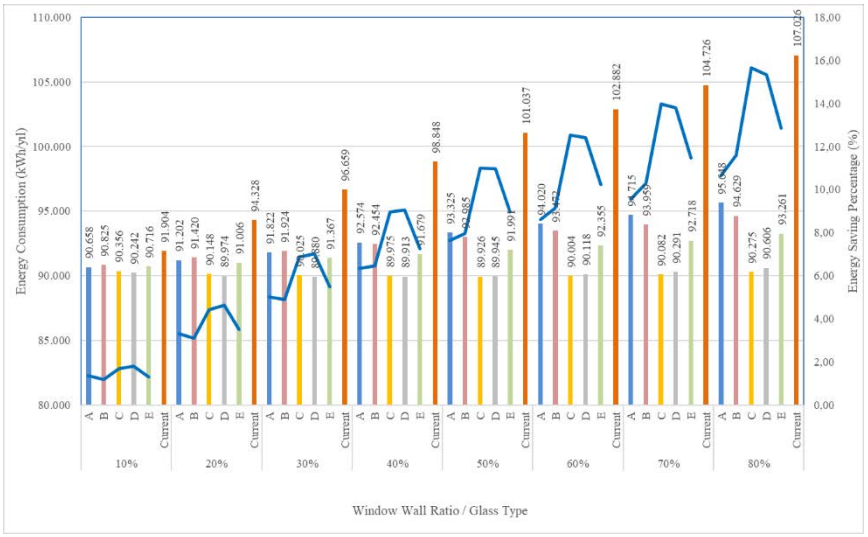


Figure 8 Energy saving rates, calculated energy consumptions and reference energy consumptions for Northwest

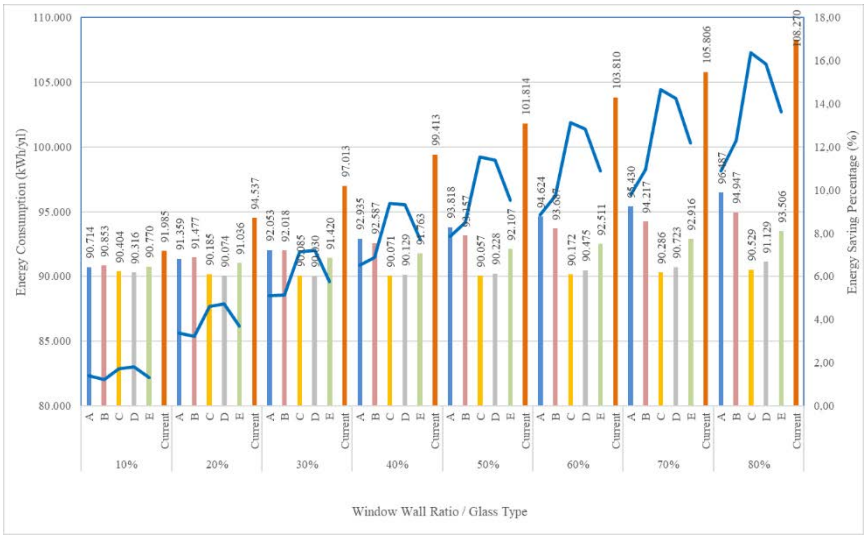


Figure 9 Energy saving rates, calculated energy consumptions and reference energy consumptions for Northeast

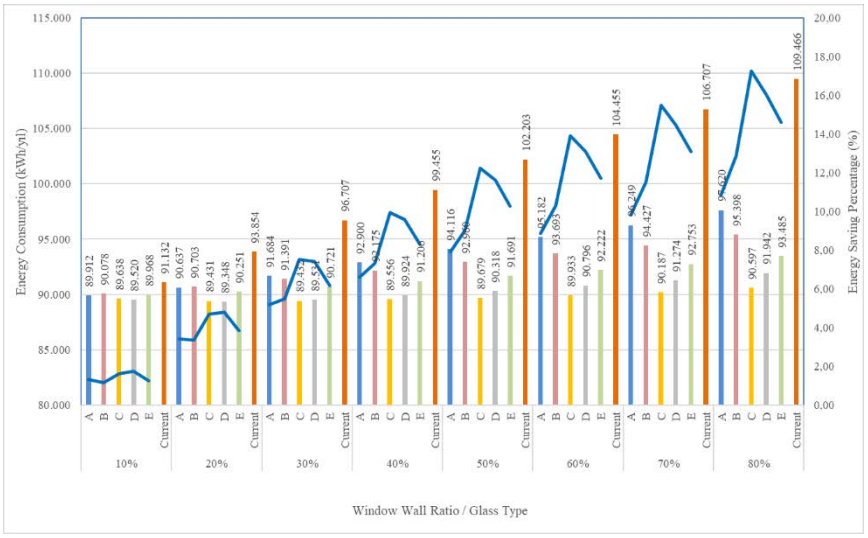


Figure 10 Energy saving rates, calculated energy consumptions and reference energy consumptions for East

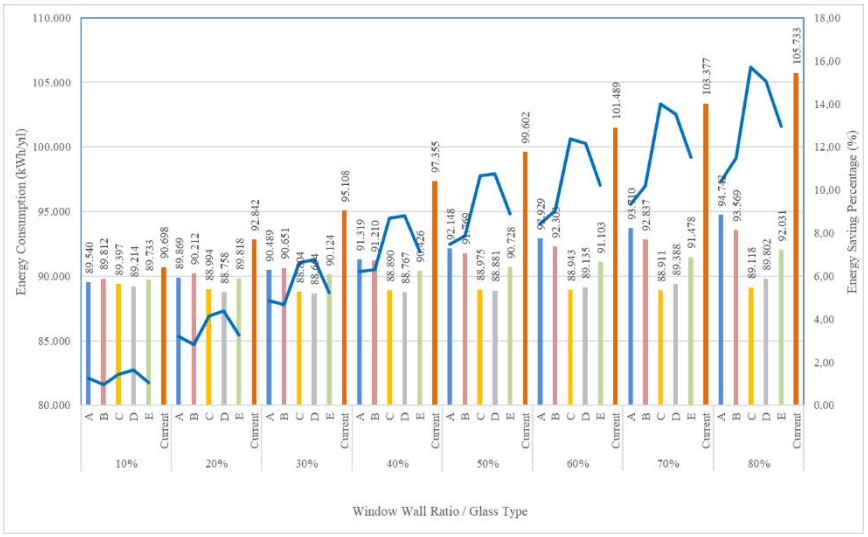


Figure 11 Energy saving rates, calculated energy consumptions and reference energy consumptions for West

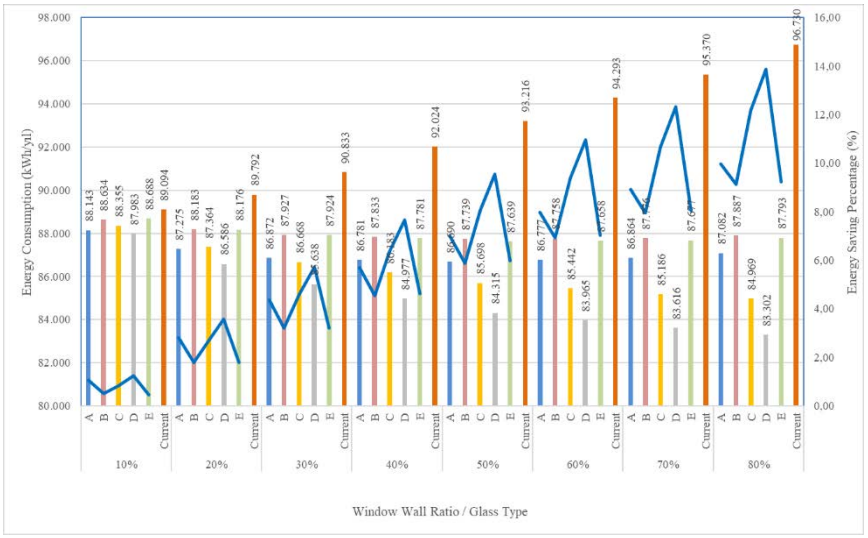


Figure 12 Energy saving rates, calculated energy consumptions and reference energy consumptions for Southwest

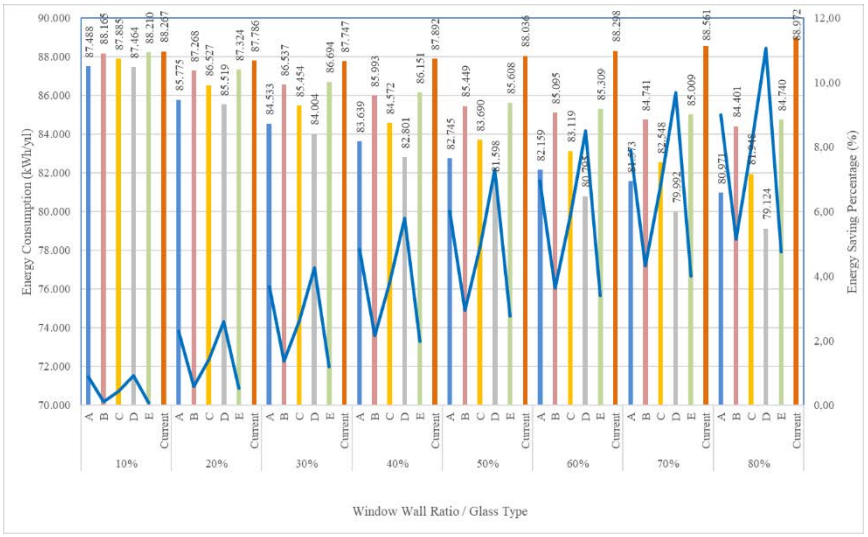


Figure 13 Energy saving rates, calculated energy consumptions and reference energy consumptions for South

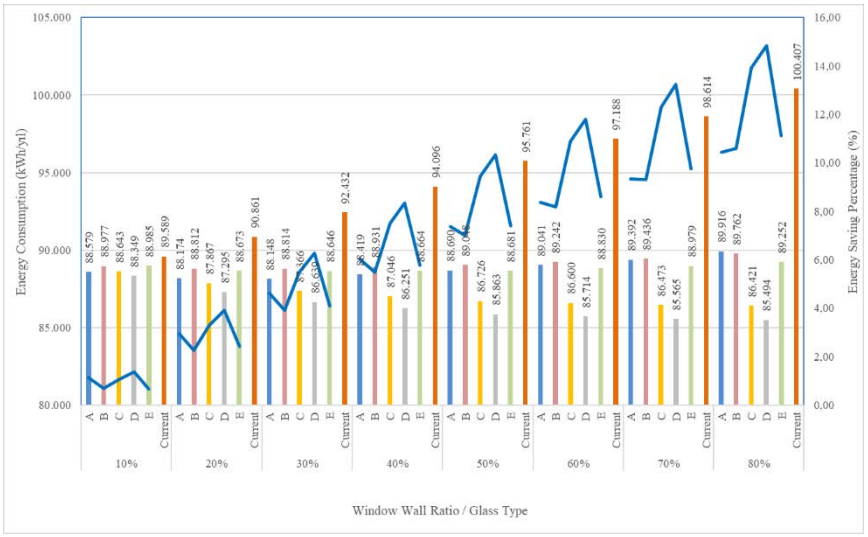


Figure 14 Energy saving rates, calculated energy consumptions and reference energy consumptions for Southeast

4. Conclusion

User comfort is very important in the context of sustainable environment and urban resilience. Therefore in this study, which was carried out for the purpose of drawing attention to energy efficiency in office buildings, which has major contribution to energy performance and efficiency of buildings, indoor and outdoor environment data were measured and heat energy verification was made to yield a "realistic model" to satisfy the norms of ASHRAE, CIBSE, M&V and IMPVP standards in Eskişehir Technical University, Engineering Faculty, Industrial Engineering Department Academic and Administrative Staff Building Block as the model building. Window wall ratios were set in the range of 10% to 80% on this realistic model and by turning the realistic model to cardinal and intercardinal directions, reference energy consumptions were calculated. Alternative glass types were defined in the realistic model created to calculate energy consumptions of alternative models. Consumptions obtained were compared with the reference energy consumptions. Based on the measurement and calculation analysis carried out:

In review of the measurements made it was identified that:

- In Eskişehir (continental) climate area, heating period (7 months) is longer than cooling period (2 months),
- In cooling period, the cooling load decreases because the outdoor temperature drops at nights,
- Fronts facing west and especially east very rapidly cool or heat,
- Window wall rations for total optimum energy consumption must be:
    - 30% in north direction,
    - 10% in all other directions

in new building designs that are similar to architectural characteristics of the sample building in Eskişehir.

When calculated Reference energy consumptions are compared with energy consumptions with the alternative glass types on the other hand; saving rations for window wall ratios in the range of 10% to 80% are given in Table 5 below.

Table 5 Energy saving ratios of alternative glass types based on alternative glass types and window wall ratios

		NORTH	NORTH-EAST	EAST	SOUTH-EAST	SOUTH	SOUTH-WEST	WEST	NORTH-WEST
%10	A	1.266	1.271	1.220	1.010	780	950	1.158	1.246
	B	1.078	1.132	1.054	612	102	460	886	1.078
	C	1.541	1.581	1.494	946	382	739	1.301	1.548
	D	1.656	1.668	1.612	1.240	804	1.111	1.484	1.662
	E	1.175	1.215	1.164	604	57	406	964	1.188
%20	A	3.022	3.178	3.217	2.687	2.011	2.518	2.973	3.127
	B	2.661	3.060	3.151	2.050	518	1.609	2.631	2.908
	C	3.895	4.352	4.423	2.995	1.259	2.428	3.848	4.180
	D	4.161	4.463	4.506	3.566	2.267	3.206	4.084	4.354
	E	3.032	3.501	3.603	2.189	463	1.616	3.024	3.322
%30	A	4.604	4.960	5.023	4.283	3.214	3.961	4.619	4.837
	B	4.153	4.995	5.316	3.618	1.210	2.905	4.457	4.735
	C	5.988	6.928	7.275	5.066	2.294	4.165	6.304	6.634
	D	6.322	6.983	7.176	5.793	3.743	5.194	6.454	6.779
	E	4.628	5.593	5.986	3.785	1.054	2.909	4.984	5.292
%40	A	5.972	6.478	6.555	5.677	4.252	5.243	6.036	6.275
	B	5.530	6.826	7.279	5.165	1.898	4.191	6.145	6.394
	C	7.914	9.342	9.899	7.050	3.320	5.841	8.465	8.873
	D	8.267	9.285	9.530	7.845	5.091	7.048	8.587	8.936
	E	6.187	7.650	8.249	5.432	1.741	4.243	6.929	7.169
%50	A	7.341	7.996	8.087	7.071	5.291	6.526	7.453	7.713
	B	6.907	8.657	9.243	6.712	2.587	5.477	7.832	8.053
	C	9.840	11.756	12.524	9.034	4.346	7.518	10.626	11.112
	D	10.213	11.586	11.885	9.898	6.438	8.901	10.721	11.093
	E	7.747	9.707	10.511	7.079	2.428	5.577	8.874	9.046
%60	A	8.430	9.186	9.273	8.147	6.139	7.516	8.560	8.862
	B	8.060	10.123	10.761	7.945	3.203	6.535	9.186	9.410
	C	11.375	13.638	14.522	10.588	5.179	8.850	12.546	12.878
	D	11.744	13.334	13.659	11.474	7.504	10.328	12.355	12.764
	E	8.998	11.298	12.232	8.358	2.990	6.635	10.386	10.527
%70	A	9.519	10.376	10.458	9.222	6.988	8.505	9.667	10.011
	B	9.213	11.589	12.280	9.178	3.820	7.594	10.539	10.767
	C	12.910	15.519	16.520	12.141	6.013	10.183	14.466	14.644
	D	13.274	15.083	15.432	13.050	8.569	11.754	13.989	14.436
	E	10.249	12.890	13.953	9.636	3.552	7.693	11.899	12.008
%80	A	10.816	11.783	11.846	10.491	8.000	9.648	10.991	11.378
	B	10.599	13.323	14.068	10.645	4.571	8.843	12.164	12.397
	C	14.753	17.741	18.869	13.985	7.024	11.761	16.615	16.751
	D	15.098	17.142	17.524	14.913	9.848	13.428	15.931	16.420
	E	11.748	14.764	15.981	11.155	4.231	8.937	13.702	13.765

Consequently, because the passive design parameters tend to differ for each building, it is fairly difficult to come up with a standard value for the window wall ratio. It is necessary to create individual models and carry out calculations by professional groups specialized in energy simulation program and energy consumption for each building. However, in continental climate it was established, the following would be beneficial:

- Materials to increase thermal resistance must be used throughout the building envelope,
- Thickness of the insulation material on the building facades facing north must be thicker and window and door frames with glass must have argon gas filling,
- On south facades however, glass types with lower Solar Transmittance must be used,
- Shading systems must be used on east and west facing facades to ensure positive results in terms of energy savings and energy conservation.

Moreover, the following must be ensured for optimum total energy savings for the buildings of the typology of the sample building in Eskişehir province according to glass type;

- Low-e coated triple glazing (Type D glass) with high thermal resistance, which provides heat control in both exterior and interior glass in the range of 10%-80% opacity window wall ratios in north, south, southeast and southwest directions,
- Window wall ratio in north-east as follows:
    - In the range of 10%-30%; triple glazing (D type glass) with low-e coating with high thermal resistance that provides heat control in both exterior and interior glass,

    - In the range of 40%-80%; Low-e coated triple glazing (C type glass) with a low Solar Heat Gain Coefficient providing solar control on the outer glass and high thermal resistance providing thermal control on the inner glass,
- Window Wall ratio in north-west as follows:
    - In the range of 10%-40%; triple glazing (D type glass) with low-e coating with high thermal resistance that provides heat control in both exterior and interior glass,
    - In the range of 50%-80%; Low-e coated triple glazing (C type glass) with a low Solar Heat Gain Coefficient providing solar control on the outer glass and high thermal resistance providing thermal control on the inner glass,
- Window wall ratio in east as follows
    - In the range of 10%-20%; triple glazing (D type glass) with low-e coating with high thermal resistance that provides heat control in both exterior and interior glass,
    - In the range of 30%-80%; Low-e coated triple glazing (C type glass) with a low Solar Heat Gain Coefficient providing solar control on the outer glass and high thermal resistance providing thermal control on the inner glass,
- Window wall ratio in west direction as follows:
    - In the range of 10%-50%; triple glazing (D type glass) with low-e coating with high thermal resistance that provides heat control in both exterior and interior glass,
    - In the range of 60%-80%; Low-e coated triple glazing (C type glass) with a low Solar Heat Gain Coefficient providing solar control on the outer glass and high thermal resistance providing thermal control on the inner glass,

are determined.

Acknowledgements

This study is produced form doctorate thesis "Analysis of The Heating and Cooling Energy Performance at Building Envelope in Terms of Orientation, Window Wall Ratio and Glass Type for Office Building in Eskisehir Climate Conditions" that supported by Anadolu University Scientific Research Project number of 1210F158, 2016.

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Resume

Hakan Ünalan graduated Department of Architecture (Anadolu University, 1997), after he worked two different architectural offices and then started in Anadolu University as lecturer (1998). He received his Ph. D. (2016) and Assist. Prof. Dr in 2019 in Architectural Doctorate Program from Anadolu University. He currently works in Department of Architecture and Urban Planning, School for The Handicapped, Anadolu University.

Emrah Gökaltun was born in Eskişehir in 1968. He completed his primary, secondary and high school education in Eskişehir. He completed his undergraduate studies at Anadolu University, Department of Architecture in 1990, his graduate studies at the same university in 1993, and his doctorate studies at Istanbul Technical University, Faculty of Architecture in 1997. From 1990 to 2018, he worked as a faculty member at Anadolu University, Faculty of Architecture and Design, Department of Architecture. Since 2018, he has been working as a faculty member at Eskişehir Technical University, Faculty of Architecture and Design, Department of Architecture.

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Basic design course through art-based research in interior architecture education

Nilay Özsavaş Uluçay*

Abstract

This article presents the basic design course applications based on the design education of first-year interior architecture students. This study aims to emphasize the importance of education in the design-oriented thinking process with practice through the content of the basic design course. Within the scope of the study, art-based research in interior architecture education was carried out, and the intersections of its results are described. In the studio, basic design elements and principles were conveyed with the techniques commonly taught in schools, and architectural movements were given to students as term papers for research. The study directs the student to create 2D and 3D compositions by combining the studies he/she has done during the term and the research assignment. The findings show that students can reflect on their research on architectural movements to new three-dimensional abstract spaces by combining them with basic design education. While grounding this reflection, the design process of the students is based on form and elements without color. The results also show a significant correlation between students' practices and Gestalt Principles. This article emphasizes the importance of applying basic elements and principles of design and being integrated with field-specific studies to achieve better results in design education. This study is an experimental and original studio product. With the basic design education given only in the first semester, the students were given examples to determine and understand forms and approaches without color knowledge, especially through basic principles, using architectural movements instead of abstract expression.

Keywords: art-based research, basic design, design thinking, gestalt, interior architecture

1. Introduction

Education is a social process that provides supervised individual development. It plays a vital role in every step of life. Therefore, it is essential to establish the proper connection of the professional culture with the social culture and update education according to the needs of the developing society. A master-apprentice relationship existed in art and design education history until the 17th century. In ancient times, it was known that craftsmen worked for money and gave lessons to their students in exchange for money (MacDonald, 2004). After the 17th century, academies began to emerge, emphasizing vocational education. In the 19th century, the Industrial Revolution transformed the trends in production and moved the communication between art and design from master apprenticeship to academic platforms (Ranjan, 2005, p. 15).

At the same time, with the emergence and spread of trends that question formal and functional priorities in interior design, education programs were seen in this field. Academies on art and design started to come to the fore in vocational education. The first art academy with a regular curriculum,

*(Corresponding author) Assoc. Prof. Dr., Muğla Sıtkı Koçman University, Türkiye, nozsavas@gmail.com
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École des Beaux-Arts (Fine Arts School), was established in France (Pile, 2000, p. 244). Studio model in education programs has drawing, anatomy, perspective, and history lessons (Pile, 2000; Dilmaç, 2010); painting, sculpture, architecture, and engraving departments are separated after 1863 (Dilmaç, 2010, p. 72). It is one of the schools that form the basis of today's art and design education with its studios and approaches to education, and similar education is given in universities. What distinguishes architectural education is its focus on learning by doing/experience (Schön, 1985, p. 89). The main goal of Deutscher Werkbund German Industry, founded in 1907, was to gather artists and designers under one roof and improve the quality of the country's products (Malnar & Vodvarka, 1992). The philosophy put forward by Werkbund later formed the basis of Bauhaus's ideas and teachings. The Bauhaus School (Das Staatliche Bauhaus) was established in 1919. Its founder Gropius aimed to make the school an open school for ideas, a place for intellectual activity and creativity, and to combine art, craft, and architecture (Malnar & Vodvarka, 1992, p. 173). Bauhaus education, which De Stijl also influences, is greatly influenced by the design-science relationship and the ideas of developing methodology in design (Cross, 2001). It is one of the critical features of the school to make applications in the studios to have information about the industry, materials, and production. The studio-based courses called Vorkurs (Basic Design) taught in the first six months of the curriculum aim to reinterpret the boundaries of abstract approaches in architectural education and develop design practice skills based on conceptual references (Bulat et al., 2014). It has developed an applied education proposal structured with Bauhaus methods and principles, which provides the opportunity to experience basic design education independent of formal analysis and abstract experience concepts on concrete materials (Türkmen, 2020, p. 230).

Basic Art/Design Education (Initial Education, Enseigment Préliminaire, Foundation Course, Vorkurs) formed the basis of the education process in design and architecture schools. It has been included and developed in the Basel School of Design programs, Vkhutemas, Bauhaus, Chicago Bauhaus and the Ulm School (Hochschule für Gestaltung) (Boucharenc, 2006; Meggs & Purvis, 2006). The most important breakthroughs in Basic Design Education took place within Bauhaus. The education process developed in this school has become an essential reference for other schools and today's Basic Design Education process. With the developments in the field of education from past to present, as in every field, learning and teaching methods and education structure in the 21st century have been updated with new approaches, and design thinking has come to the fore, especially for all fields. Design thinking, which constitutes the basis of design education, has guided the students in developing their approaches and ways of seeing design principles. In this study, in which art-based research on design education was conducted, an evaluation was made, especially on the basic design course given in the first year of all design education.

1.1. Basic Design Course

Design is transforming a form of communication and expression into a visual language. Design requires solving any problem with imagination as well as knowledge and being solution-oriented with aesthetic concerns. Design is the process of solving problems, producing new things or transforming useful things (Friedman, 2003). The concept of design and the design-oriented thinking structure includes more than just an approach to produce a final product. At the same time, the design expresses a process. Design thinking is an analytical and creative process that includes experimentation, prototyping and modeling, feedback, and redesign (Razzouk & Shute, 2012, p.330). Meinel and Leifer (2011) express design thinking as human-centered, which examines and solves problems by blending many disciplines. Brown (2009) also states that a human-centered problem-solving method focuses on original and innovative solutions. Design thinking is, therefore, defined simply as the problem-solving process in line with needs. However, when considered in detail, the message, source, and evaluation processes, which are always included in the communication processes, as well as feedback and behavior, are included in this process. This thinking approach is adopted with a good analysis of the whole process. Although it is stated that it is completed with the problem formation and the design completion, feedback is also one of the critical sections since it is made for needs. In design education, feedback should have the same

importance as completing the process at this point. In the context of being problem-focused in the creative process, the individual highlights the solution with all academic knowledge and background experiences. In this context, design education has an individual and applied structure that blends all experiences and teachings.

Design education helps students develop the expression of the concept with their creativity. Design education can be explained as learning a new language, the forms of expression that will enable this language to communicate, and the thought system of this language (Ledewitz, 1985). This visual language is the basis of creation in design. The designer must be equipped with this language's principles, rules, and concepts for developing visual editing skills (Wong, 1993, p. 41). Students develop visual perception and design skills with design elements and principles in design education. Visual perception transforms the sensory information acquired by the living thing from its environment through the visual organ into a meaningful whole at the end of a mental process (Goldstein, 2007; McKim, 1980). Visual perception development in design education is provided by learning all the basic criteria in design applications. Subject teaching is based on traditional education, significantly increasing students' creativity and providing non-verbally expressed knowledge as a source of actions based on abilities (Hodgkin, 1985, p. 146). Education is the process of learning a form of communication and expression for design students. It includes solving problems with imagination, producing based on aesthetic concerns and needs, and transforming them into useful models with experience.

Furthermore, the critiques it receives in the studio environment also cause the feedback process to be completed and focus on creative thinking for redesign or revision. Design thinking in the educational environment also includes students working in cooperative teams, giving mutual criticism with practices, and self-development. At the same time, this process, which can be considered intuitive, proceeds similarly in professional life, so students need to realize the basics of design education under appropriate conditions. The development of the students and the improvement of the learning methods of the instructors proceed with a design-oriented mindset. In addition, it is one of the basic criteria for design education and learning and is included in the design process. Basic design education, the subject of this study, is the most important part of this process, forming the basis of design education. Basic Design Education focuses on using this skill in the design process. The course's main objective is to develop students' perception, interpretation, creative idea generation, and visual expression skills.

Basic design education is a core course for design and art disciplines. The basic design course deals with the abstract and conceptual thinking necessary for the problem-solving action involved in the design. Basic Design Education is a system that regulates the production of ideas (Denel, 1981), basic education in training the creative powers of the individual, controlling and using the experience and knowledge related to visual perception (Balcı & Say, 2002, p. 8), learning the design language and processes in general, and organizing individual creativity. (Boucharenc, 2006). The basic design course plays an essential role in design education in generating ideas and making factual inferences from an abstract concept. It centers on vision, tries to systematize the existence of a visual language, and develops its methods accordingly (Seylan, 2005, p. 17). It aims at an educational environment that not only focuses on visual sensitivity but also examines how to understand problems and produce solutions (Chastain & Elliot, 2000). Its structure is the education of visual perception-knowledge, thought, and aesthetic animation-mental structuring of simulation, invention-inspiration-creativity process, developing-raising hand-eye-brain abilities, activating dream-imagination-intuition powers (Atalayer, 1994, p. 77). Within the scope of this course, it was stated as the basis Itten to release the student's artistic talent and creative powers, facilitate the student's career choice and present the principles of creative composition, form, and color rules (Wick, 2000, p. 101). The Basic Design course can be enhanced by students' curiosity and experience, enabling them to discover a personal bond with various elements and develop creativity (Boucharenc, 2006, p. 2). In this context, this course, which forms the basis of design education, also provides space for the student to perform design-oriented thinking. This system of

learning and thinking is acquired and developed through experience. Carroll et al. (2010) stated in their study that the design-oriented approach affects learning positively and that activities with a design-oriented approach improve students' empathy skills, help them get closer to each other, and overcome difficulties by developing their feelings of trust. In other words, basic design is a fundamental field that targets teaching and interaction. It aims not only analytical learning but also emotional development.

Considering the structure of basic design education, it is seen that there are a group of elements and principles. Basic design is divided into two parts elements of design and principles of design. In general, the structure of the course in interior architecture departments is to learn the elements and principles of design, examine examples, to create and evaluate two and three-dimensional compositions. Two- and three-dimensional studies are essential for students to understand space (Chen & Heyligen, 2006). Within the scope of this course, elements of design include point, line, stain, form, texture, light-shadow, interval, and principles of design include contrast, repetition, hierarchy, sovereignty, balance, unity, harmony, rhythm, and space-fullness. The application of the theoretical subject, which includes elements and principles of design for design fields, by the students, constitutes the basis of the course. Design education in the fields of art and architecture aims to provide skills related to the design process. In particular, design disciplines take place by prioritizing interaction, which is one of the requirements of design-oriented thinking in the studio environment. Studios are an environment/culture where students and lecturers share their experiences. They are environments where differences and original expressions are discussed and developed. Therefore, mutual communication is necessary for design education, and it has a feedback-based structure.

Moreover, since it is a visual and applied field, it can achieve its purpose with the presentation, sample, and experimental studies (Özsavaş Uluçay et al., 2022). This study includes the applications made within the scope of the Basic Design course in the interior architecture department. In addition, it aims to show the structure of education based on one-to-one practice and to share the method of teaching the course and its outcome.

2. Material& Method

As a methodology of the study, a literature review has been made about basic design education as a primary way to learn elements and principles of design. The qualitative research method is used in this study and is an application made with the students in the basic design course as art-based research. Art-based research can be defined as the systematic use of art and the actual making of artistic expressions as the primary way of understanding and examining researchers' experiences (McNiff, 2007, p. 29). Research and teaching are merged with arts-based projects, and the approach used can lead to the development of learning strategies that lead to better practice (Greenwood, 2012). Art-based research has emerged as an application of the epistemological process of artistic knowing and inquiry, an extension of studies investigating the experience of art in higher education and professional practice (McNiff, 1998). This study employed a studio-based research method involving studio activities using materials, techniques, tools, and aesthetic analysis (Greenwood, 2012). Also, in this study, students create a visual composition by developing the information conveyed within the framework of an artistic approach. Students studied architectural movements and created a new experience with the forms of expression with what they learned in the basic design course. This course allows students to express and develop their observations, impressions, feelings, designs, and images through art education by revealing their creative powers.

Within the scope of this study, it was requested to prepare an end-of-term project based on the topics that Interior Architecture first-year students learned in Basic Design education. Therefore, the following topics were given for the project, and the students created two and three-dimensional abstract compositions describing the topics. This course was taught by distance education method in the Department of Interior Architecture and Environmental Design in the fall semester of the 2020-2021 Academic Year. The research assignments given include architectural movements, and

the students research the subject and then create a composition with abstract thought on this idea and visual activity. Design thinking takes place with the experimentation, prototyping and modeling, feedback, and redesign stages that Razzouk and Shute (2012) stated in their study.

Throughout the semester, literature and theoretical knowledge were transferred within the scope of the course. This course includes elements of design (point, line, stain, form, texture, light-shadow, and interval) and principles of design (contrast, repetition, hierarchy, sovereignty, balance, unity, harmony, rhythm, and space-fullness). During the 15-week semester, the information given before the research assignment and the applications are summarized in the table below (Table 1).

Table 1 Basic Design course content

Week	Topic	Information	Application
1	Point	Design education and basic design course information. The concept of point, its place in art and design.	Abstract square lines, abstract curvilinear lines, object creation point work.
2	Line	Basic information about the concept of line. Hue with line.	Free line work. Light-medium-dark tones with straight-curved lines.
3	Line Direction, Movement, Optical illusion	Line as a design element. Creating direction, movement and optical illusion based on the line.	Abstract line work with direction and motion concept. Optical line work. Free line work in different thicknesses.
4	Stain, Form, Shape Ground Relation Form, Surface Measure, Harmony	Stain, shape, form, form and surface concepts. Creating measure and harmony.	Creating harmony with stain work. Form, visual organization, 3d collage harmony work.
5	Light-shadow Hue-value	Basic information of vision and light. Creating light-shadow gradation.	2d light-shadow work. Perspective, 3d light-shadow work.
6	Stain-Shape-Surface Balance, Symmetry	Creating balance, symmetry and asymmetry with stain, shape, surface investigations and obtained data.	Stain work from the object. Symmetrical, asymmetrical balance.
7	Repetition, Rhythm	Generating form with full repetition, spaced repetition, variable repetition. Repetition-rhythm practice.	Repetition with forms. Rhythm composition with repetition.
8	Ratio, Interval, Space-Fullness, Hierarchy, Emphasis, Sovereignty	Information about ratio, interval, hierarchy, emphasis, sovereignty. Space-fullness practice.	Space-fullness practice. 2d emphasis, sovereignty work. 3d emphasis, sovereignty work.
9	Texture, Unity- Integrity, Diversity, Contrast	Texture types, spatial texture, contrast types.	Texture work. Texture-contrast practice.
10-15	Architectural movements	Research topics, information about the presentation.	Student presentations. Line, stain, form collage and 3d model.

In general, the course structure in which the study is conducted is about learning the elements and principles of design, examining the examples, and creating and evaluating two and three-dimensional compositions. In light of these topics, applications were made within the scope of the course, and the results were revealed. The given project assignment has three main objectives.

- Students research the architectural trends given throughout the semester about their fields and reinforce the knowledge they have learned in other courses.
- Students develop the ability to create two- and three-dimensional compositions on any subject in line with basic design principles.
- As a result, students' work is evaluated in the workshop environment within the scope of Gestalt principles, and feedback is provided. All students have information about each subject and have the opportunity to criticize and evaluate other studies mutually.

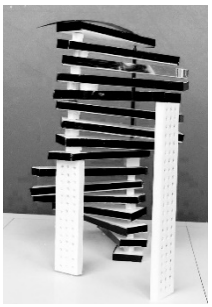
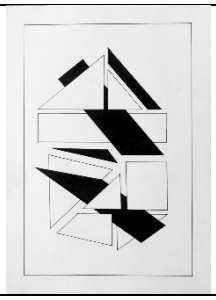
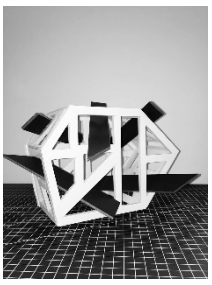
Thus, it was ensured that the students made detailed examinations about their fields, had basic knowledge about architectural movements, and designed compositions that would describe them

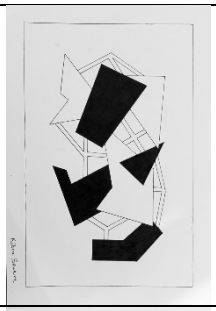
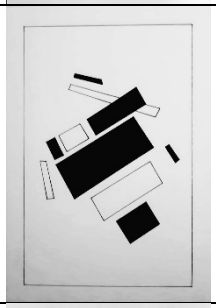
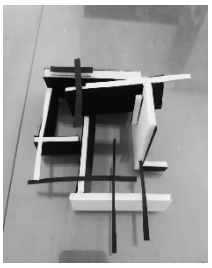
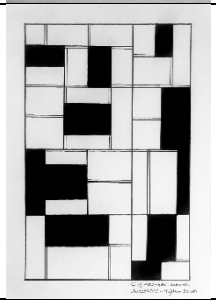
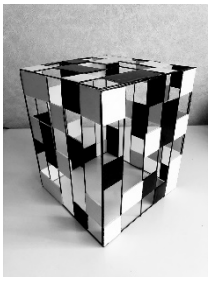
by considering a concept, concept, or movement with the abstract thinking method. In general terms, art education is a multi-faceted interaction. Art education is a process guided by the instructor in line with the student's ability and interest and is a student-educator, student-student, and student-environment interaction. In this context, active learning can be mentioned. In active learning, the learners are responsible for their education, recognize themselves, explore, wonder, share, make decisions, and consciously bring together mental abilities and bear responsibility as a part of the learning process (Polat & Karagöz, 2020, p. 420). Mutual evaluation in the main objectives plays an active role in student-instructor, student-student, and student-environment interaction. As a result of the weekly topics covered, students explore, wonder, share, make decisions, and consciously bring together mental abilities as part of the learning process.

3. Findings and Results

In Basic Design Education, theoretical information and art-based information in the same field with applied studies in the visual field are for a particular purpose and in a specific organization. Abilities and skills; by seeing, kneading, drawing, constructing, and creating a connection with objects and reality, it is guided by behaviors and awareness of this subject (San, 1983). In this study, the main aim is to direct the knowledge they acquired in basic design education to create visual compositions. They were asked to research architectural trends within the studio's scope, especially for their profession. As a result of their research, two and three-dimensional compositions describing the movement was designed. In addition, the knowledge of color was planned as the subject of the second term, and students were expected to explain the trends in their research in black and white, mainly based on their features, such as form, shape, shape, and texture. Regardless of all course content and topics, one of the issues affecting the course is that it is an online course. The course was taught during the pandemic period, only online criticism was given, and it is important to know that students were limited in the material during the lockdown. The flow and compositions of some selected studies are given below (Table 2, Table 3).

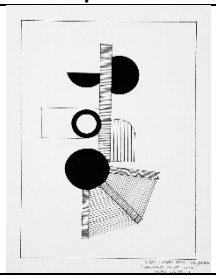
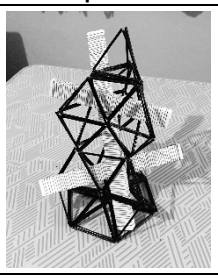
Table 2 Information about movement and 2d, 3d compositions prepared by students

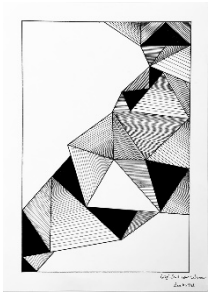
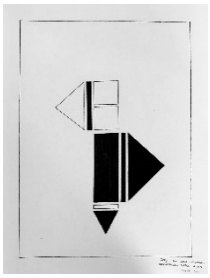
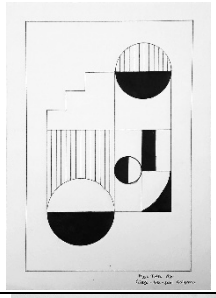
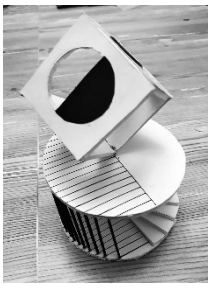
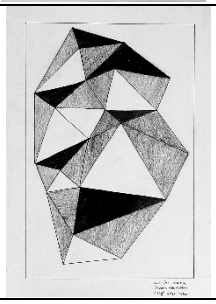
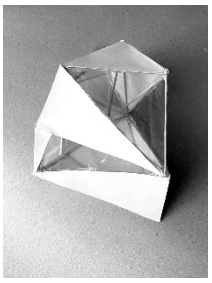
Concept	Basic Information	2D Composition	3D Composition
Art Nouveau 1890-1910	It is a movement in which decorative ornaments, patterns, arches, curving lines, organic shapes, and sculptural, vegetal ornamentation are used. Commonly used motifs include stylized versions of leaves, flowers, vines, insects, animals, and other natural elements. Apart from the organic forms used in this movement, different materials and earth colors are seen, and materials in natural forms are common.		
Expressionism 1905-1920	Expressionism is in the foreground with extreme angles, flattened forms, garish colors, and distorted views. It is the expression of emotions, thoughts, and experiences by transforming them into simple forms by distorting reality. It is a dominant movement in architecture and literature.		

Futurism 1912-1920	Futurism is based on technological advances, dynamic structuring, speed and energy, vitality, and change approach in the modern period. Futuristic designs feature long dynamic lines, a sense of motion, and strong chromaticism and are at the forefront of architecture in walls and corners in the form of angled cutaways.		
Suprematism 1915-1917	Suprematism is structured as a new understanding of freedom and escape from the real world, mainly reflected in art fields. Basic geometric forms such as colored circles, squares, lines, and rectangles are kept in the foreground in the compositions. With this structuring, it emphasizes the superiority of pure emotion and perception.		
De Stijl 1917-1931	The De Stijl movement takes shapes and colors simply and uses geometric forms such as the straight line, the square, and the rectangle. It is also a modern art form that values abstraction and simplicity. The primary colors, the dominant use of black and white, horizontal and vertical clean lines, and right angles are seen in art and architecture.		

The students who studied the currents in the examples in Table 1 created 2 and 3-dimensional compositions after their detailed research. In the *Art Nouveau* work, it was seen that shapes and a sculptural design were created in the 3d composition with curved lines and a vegetal ornamentation approach. In *Expressionism*, a composition was created by distorting reality and transforming it into a form on distorted structuring and forms. The flow feature related to the pieces passing through the central mass was emphasized in the 3d work. In *Futurism*, a composition consisting of long dynamic lines was created, and angled corners were included. The same composition has also been adapted to 3d work. In *Suprematism*, there is a composition created from irregular rectangular forms. The superiority of perception is expressed in 3d work. In the *De Stijl,* a composition was created using geometric forms consisting of the straight line, the square, and the rectangle, and a 3d design was made with black and white balance using the same simplicity.

Table 3 Information about movement and 2d, 3d compositions prepared by students

Concept	Basic Information	2D Composition	3D Composition
Bauhaus 1919-1933	It is a movement in which functional, practical, mass-produced simple designs and basic geometric forms are used. Even though the Bauhaus School is famous for its architecture, simple color schemes, functional forms, holistic designs, furniture, and typography designs are at the forefront with their unique style.		

Modernism 1920s-1950s	Modernism is a design movement completely devoid of ornaments and has simple, clean lines. This trend favors technology, mass production, functionality, and practicality, mainly white and neutral color palettes combined with geometric forms. In this design approach, the combination of pureness and aesthetics is the essential feature of architecture.		
Minimalism 1960s-1970s	It is a design style adorned with minimal design principles like soft colors, predominantly white, gray tones, cream tones, and neutral colors. The texture is at the forefront with various materials. Quite plain, simple, functional, easily determined forms are in the foreground. Simplicity and pureness are the main elements.		
Postmodernism 1970-1990	Postmodernism is known as a structured movement against modernism. Contrary to modernism, its decorative elements, asymmetrical forms, and bright and vibrant colors are used, and its relation to function is not prioritized. It adopts a versatile structure that ignores all the basic foundations associated with art and design. It is known as the return of ornament.		
Deconstructivism 1980s-1990s	Deconstructivism exhibits a harmonious approach, often far from continuity and symmetry, which adds a fragmented feeling to the building. Its basic architectural principles are defined as the redefinition of shapes and forms while visually striking and confusing beyond classical patterns with its deformation.		

The students who studied the currents in the examples in Table 3 also created 2 and 3-dimensional compositions after their detailed research. In the *Bauhaus*, a composition was created with geometric forms, and an approach similar to typographic designs was created. In *Modernism*, the composition has simple, clean lines. Hue has been done with geometric forms and lines, creating an aesthetic structure. It is seen that similar pure forms in 3d design. In *Minimalism*, a composition was created with minimal design principles. Simple, easily determined forms and pureness are in the foreground. In the *Postmodernism* work, the composition has asymmetrical forms. Similar forms with a more ornamental understanding are also included in 3d design. In the *Deconstructivism* work, a composition far from symmetry was created, and a confusing approach in 3d work was made with a design that exhibits transparency and continuity.

With this basic design first semester study, students learned by experimenting even with compulsory distance education, shared their experiences, and commented on each other's work. A course technique that develops creativity and simultaneously provides multi-faceted active learning has been applied. As Schön (1985, p. 63) stated, learning by experimenting makes design education privileged. In another study, Yang and Hsu (2020) investigated the differences in the experience of student groups with high and low creativity tendencies. This study concluded that design thinking increased the self-efficacy of students with low creativity tendencies and improved

the creativity of all students. In addition, the studio prepares a suitable environment for a knowledge-creation process in which learning can occur. The studio is carried out in this way in face-to-face education, but in this study, the students have completed education with limited materials and online. However, they had the chance to receive criticism from both the instructor and each other for 8 hours each week. Therefore, interaction has positive effects on the design thinking process.

In this study, it is seen that the students created compositions by determining some features of the given architectural movements, such as shape, form, and texture. They used the elements and principles of design concepts they had learned throughout the term while creating these compositions. This situation emerges as a point where basic design concepts integrate with visual perception. In other words, a significant correlation emerges regarding Gestalt Theory in compositions created with a perception process when considered from a different perspective. As a bottom-up-based theory like induction, Gestalt reaches higher cognitive processes by influencing perception (Soegaard, 2014). Gestalt theory is based on the idea that the human brain will subconsciously try to organize designs in a system that creates a whole from parts (Chapman, n.d.). Thus, the basic design principles learned in the basic design course reveal Gestalt theories in creating the composition. Compositions made by students associated with Gestalt Theory; include similarity, continuity, closure, proximity, figure/ground, symmetry, and order.

Similarity: It is the perception of similar elements in terms of many features, such as form, color, and type. Elements tend to be perceived if they are close together, similar to one another, form a closed contour, or are in the same direction (Wertheimer, 1923; Rock & Palmer, 1990; Soegaard, 2014). Similar elements are perceived as more related than different ones (Lidwell et al. 2015), and the human brain tends to group them.

Continuity: The perception of items going in the same direction by grouping them. The human eye follows the straightest path when viewing lines, regardless of their appearance (Chapman, n.d.). It is stated that the endpoints of the elements should be arranged so that they form continuous rather than sudden lines (Lidwell et al., 2015). If people perceive objects as moving in a specific direction, they think they continue to move in that way.

Closure: It tends to complete incomplete or interrupted forms and patterns (Lidwell, et al. 2015; Sooegard, 2014). Those complementing certain elements are perceived as belonging to the same group (Wagemans et al., 2012). It is the condition that two independent figures will combine to form a single, utterly different figure (Wertheimer, 1923). The human brain has the structure of completing the missing parts, so parts that seem missing in the design can turn into parts that complement each other.

Proximity: When items are placed close together, people assume they are in the same group because they are close to each other and separate from the others. Things close together are perceived as more related than things far from each other (Lidwell et al., 2015). The grouping format that includes the smallest range is the most natural (Wertheimer, 1923). The closer the parts of a design are to each other, the easier it is to perceive them as a whole.

Figure-Groud (Prägnanz): It perceives the relationship between form and surrounding space. Depending on how people view an image, they view the figure (foreground) or the floor (background) as prominent. Gestalt psychology says that the mind simplifies to understand the visual environment and reduces the shape to the most specific and smoothest geometries in a composition consisting of shapes (Ching, 2014, p. 38). The figure/ground is similar to the closure principle, and the exciting thing is that the figure and ground contain two different images (Chapman, n.d.).

Symmetry and Order: Symmetry is the most basic and permanent aspect of beauty and the visual equivalence among the elements (Lidwell et al., 2015). The trend is to perceive objects as symmetrical shapes that form around their centers (Soegaard, 2014). It shows how the human brain perceives shapes quite simply.

While all the elements and principles taught in the basic design course are used to create a composition, create order and reach a meaningful design, it is seen that the features specified in the Gestalt principles are used. This points to how the human brain works in the productivity part of perception and design. In students' works, the perception of similarity as a form is frequently seen. The principle of continuity, in which the same forms are perceived in groups, is included in almost every composition together with the order within itself. Considering that only the form is worked on, it is based on the principle of closure, in which the stains are planned independently of each other, but are often perceived as a whole. The proximity takes place as an underlying feature of their compositions. In student studies, forms that are close and related to each other are included in groups. Although the figure-ground effect is perceived less, it is partially located between stains and forms. Finally, and the most powerful effect in the works, is definitely symmetry and order. These studies show a significant correlation between the perception of the human brain and design principles. Although the figure-ground effect is perceived less, it is partially located between stains and forms. And the most powerful effect in the works, is definitely symmetry and order. These studies show the significant correlation between the perception of the human brain and design principles.

4. Discussion and conclusions

École des Beaux-Art and Bauhaus strongly influence the contemporary or conventional approach to teaching by following the principles and rules that have been developed (Salama, 2009, p. 81). Studios, which are seen in education in two schools and are actively used in today's design education, include the principle of learning by doing; It is an education model that aims to increase students' awareness, understanding, and ability levels (Shoshi & Oxman, 2000). The basic design course is taught to students in the first year of design departments, educating the students on perception and fundamental principles based on the principle of learning by doing. It guides students in transforming visual perception into a meaningful whole at the end of a mental process (Goldstein, 2007; McKim, 1980). This course guides them to develop a design-oriented thinking approach, forming design education's basis. The structure of the course, consisting of a process that includes experimentation, prototyping, feedback, and redesign, fully coincides with Razzouk and Shute (2012)'s definition of design thinking. However, some students think independently of these teachings in their following lessons and when designing. It is seen that they try to rediscover what they have already learned without realizing it, and they have difficulty using the teachings within the scope of this course in their vocational courses. For this reason, the course content has been built on architectural trends and examples in their profession.

The design process involves recognizing the problems conceptually, researching, collecting information, and producing creative solutions. Even though its priorities are defined differently by considering it from different perspectives, the design points to a broad process that blends many subjects (Friedman, 2003; Brown, 2009; Meinel & Leifer, 2011, Razzouk & Shute, 2012). Vision, understanding, and visual perception are vital in this process. For this reason, Gestalt Theory constitutes the theoretical infrastructure of design. The basic design course is critical in the designer's expressing himself with two- and three-dimensional expression tools in basic education and creating this form of expression. The course's scope in this study is shown with fiction about the students' professions, how the course can be taught, and how it can be associated with their profession. It will be easier for them to associate these concepts when examining any design, structure, or visual design with what they have learned within the scope of this course, enabling them to manage the design language and processes. While this study aims to develop an example of a lesson plan, it also aims to show the connection with Gestalt Theories in using design elements and principles in the basic design course. In addition, this course aims to train students' vision and perception in different ways in creating compositions using only shapes without knowledge of color. In line with the results obtained, this study will create an indicator for Basic Design educators and contribute to a more practical education process. This study aims to guide similar studies in the future and contribute to the literature.

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Resume

Nilay Özsavaş Uluçay is an interior architect and associate professor at Muğla Sıtkı Koçman University in Turkey. She graduated from the Department of Interior Architecture and Environmental Design and completed her master's and Proficiency in Arts degree in the Department of Interior Architecture at Anadolu University. Her academic studies are about interior architecture, color, and design education. She has been working on education during the pandemic period, the web and social media in education, and design education.