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MULTIDISCIPLINARY NATURE OF THE AEC INDUSTRY, AND THE POTENTIAL DISTRIBUTION OF AEC FIRMS

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Abstract: *The Architecture, Engineering, and Construction (AEC) sector is diverse. The industry's market is run by businesses of different sizes, specialties, and subordinations, and each active company indirectly participates in adding value to the sector. This paper focuses on the functional distribution of local AEC firms in Southern Hungary, mainly in the South Transdanubia region. The work systematically gathers data about multidisciplinary AEC firms based in the region, introduces the main activities of the collected companies, and reveals the potential AEC divisions, by analyzing the popularity, net revenue, and number of employee factors for each professional division within the industry at the studied region.*

Keywords: *AEC Industry, AEC Firms' Main Activity, Multidisciplinary Nature, AEC Firms' Revenue and Number of Employees, Hungarian Construction Market.*

1. INTRODUCTION

The AEC sector presents the construction industry with all related architectural design/planning, structural/engineering design, and construction services [1]. A wide range of disciplines are required to be involved in complex construction projects from the planning to the decommissioning stage [2]. The multidisciplinary nature of the sector applies to smaller and larger markets, based on information from the American Council of Engineering Companies (ACEC), engineering firms account for more than 5800, from which there are nearly 2800 firms that are involved in structural design (48%) and 950 (16%) involved in structural building design in particular. Other engineering firms account for 2050 firms (35%) [3]. The construction industry in the U.S. is divided into three main segments: general building, heavy construction, and special trade contractors, the latest typically serve as subcontractors, major members at the top of the construction value chain are the architecture and engineering companies and the property owners [4].

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Healthy inter-organizational relationship plays a key factor in enhancing building projects, and collaboration among interdisciplinary project teams needs further studies to identify the structure of these teams, the framework of the relationship among them, and the optimal workflow frequency [5]. The AEC industry needs tighter collaboration; architects, engineers, interior designers, and constructors need to work together from the early phases of the project, early-stage collaboration assures optimal designs, materials, and system selections [6]. This turns the light on the potential of reinforcing the multidisciplinary nature of the AEC market at the educational level, following the rule: train and retain, which in return will result in well-aware professionals in the market with a better understanding of the system's interoperability and more productivity [7]. Since AEC is one of the most information-intense industries, during the life cycle of the project, various teams are involved in the project and deal with this information, and each team is different because they comprise individuals who are derived from various initiates that are conducting various businesses, and management of the information flow among these teams is critical to the project's success [2].

The level of collaboration between the architecture and engineering disciplines should advance, the best workflows are those which are following the business logic as an inter-connected design discipline [8]. Hence, efficient information access and exchange have to be achieved in building projects at both internal and external levels [2]. It is really hard to write about the multi-disciplinary nature of the AEC industry and the required collaboration within that sector without mentioning Building Information Modeling (BIM) [6], [7], [9], [10]. This is also associated with the born of new expressions and methods like Integrated Building Delivery (IBD) as a recent expression in the AEC sector which stands for interdisciplinary collaboration within the industry [8].

Multidisciplinary cooperation and design optimization are critical in the AEC industry, due to the multidisciplinary nature of the industry, developing explicit technical requisites would enhance process design optimization by integrating modeling and analysis tools into the industry [11]. In most large-scaled and complicated projects in the AEC industry, huge swaps and exchanges of building information between several representatives are essential [12]. So efficient information access and exchange has to be achieved in building projects at both internal and external levels, the multi-party nature together with the uniqueness of the AEC industry requires developing a centric model to ensure smooth transformation of information among different representatives, exceed the organizational boundaries, and reduce isolated initiates in the project environment [2].

The Hungarian AEC sector consists of several multidiscipline subsectors, like: AEC manufacturing, construction, real estate activities, and architectural/engineering activities [13]. Observing the construction sector is the initial step for studying any business opportunity within the market, and this is one of the objectives of this research work to observe and analyze the current state of the Hungarian AEC industry, as part of a larger scheme program which has already initiated by classifying the AEC firms based on the size [14]; to study BIM implementation in the architectural/engineering firms at the regional level. Previous study shows that a room for developing and implementing BIM processes in the Hungarian AEC market does exist, since the majority of AEC companies have not yet

fulfilled the requirements of industry 3.0 adoption [15]. Based on the 2021 published country fact sheet regarding the local Hungarian construction market, there are no set laws or binding obligations on public authorities for using BIM processes. Thus, the contracting authorities do have the option of imposing BIM on tenderers, but this has not been applied yet [13].

2. MATERIALS AND METHODOLOGIES

Besides gathering literature data about the nature of the AEC industry, to achieve a better understanding of the structure and allocation of businesses within the sector, the work focuses on the distribution of local AEC firms and their related statistical data which can be employed to derive valuable information about the productivity, sizes, proportions, and potential distribution.

2.1. *Studied Region:*

The study area is located in Hungary, the country's territory is divided into the so-called large and small regions to enhance the handling of statistical data. The three large regions (Central Hungary, Transdanubia, and Great Plain-North) are divided into 8 smaller regions (Budapest, Pest, Central/Western/South Transdanubia, Northern Hungary, and Northern/Southern Great Plain). A comprehensive study of the behavior of the Hungarian construction market revealed the deterioration of construction productivity (presented by net revenue) values for AEC firms based on the South Transdanubia region compared to the same values for other smaller regions in the country [16]. Thus, this research will further study and analyze the AEC market in this region to provide a larger image of the arrangement of this market.

The AEC firms gathering method covered the region's three main counties: Baranya, Somogy, and Tolna, by using the online public acquainted mapping platform supported by Google (Google Maps), as a public reached source to conduct mass filtering for the AEC enterprises based within the borders of the region. The search method includes using search keywords as illustrated in Figure 1 (e.g., Pécs city and Baranya county: architectural firms in Pécs, engineering firms in Pécs, construction firms in Pécs, architectural firms in Baranya, engineering firms in Baranya, and construction firms in Baranya). With a total of 180 search attempts in English and Hungarian languages alike, the three counties and their 27 administrative cities are covered.

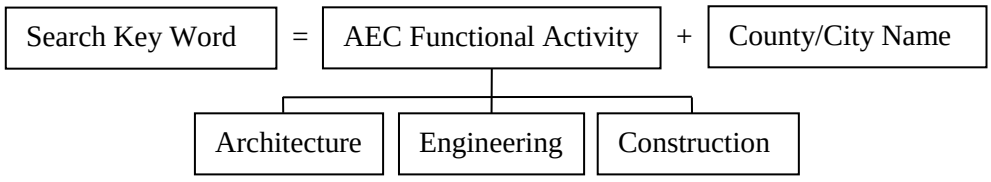

Figure 1 Search keywords.

2.2. *AEC Firms' Sizes and Main Activities:*

By using the previously introduced scanning method, the research collects 169 AEC firms, with 2378 employees, and more than 189 M€ (Million Euros) net revenue, distributed as >79, >13, and >97 M€, with 900, 345, and 1133 workers, for 40, 38, and 91 firms, along Tolna, Somogy, and Baranya counties, respectively. The data of companies revenues and number of employees are collected from the official website of „Céginformáció.hu Kft." which is a limited liability company based in Budapest, Hungary, and provides corporate information and asset management services. Table 1 emphasizes that Somogy county has low revenue/employee values compared to the other two counties in the region, and this difference gap is caused by the absence of large AEC firms in the county, unlike the situation in the other neighboring counties.

County	Tolna	Somogy	Baranya
Total number of AEC firms	40	38	91
Employees count	900	345	1133
Net revenue (M€)	>79	>13	>97

Table 1 The total collected Hungarian AEC firms, and their employees count and revenues, allocated per county.

According to the EU classification of business sectors [17], there are 21 different sections, marked from A to U as shown in Table 2. The research conducts a comprehensive review of the shown business sections, the review includes carefully running through every section and its related divisions, groups, classes, and main activities, to identify the official classification of all possible AEC activities, and use it as a reference for the study. There are 9 possible sections for AEC activities within the official business classification in the EU, from which 7 sections exist in the studied region, indicating the functional diversity of AEC firms among the collected sample.

Section	Title	Divisions	Section	Title	Divisions
A	Agriculture, forestry, and fishing	01 – 03	L	Real estate activities	68
B	Mining and quarrying	05 – 09	M	Professional, scientific, and technical activities	69 – 75
C	Manufacturing	10 – 33	N	Administrative and support service activities	77 – 82
D	Electricity, gas, steam, and air conditioning supply	35	O	Public administration and defense; compulsory social security	84
E	Water supply; sewerage, waste management, and	36 – 39	P	Education	85

	remediation activities				
F	Construction	41 – 43	Q	Human health and social work activities	86 – 88
G	Wholesale and retail trade	45 – 47	R	Arts, entertainment, and recreation	90 – 93
H	Transportation and storage	49 – 53	S	Other service activities	94 – 96
I	Accommodation and food service activities	55 – 56	T	Activities of households as employers; undifferentiated goods and services producing activities of households for own use	97 – 98
J	Information and communication	58 – 63	U	Activities of extraterritorial organizations and bodies	99
K	Financial and insurance activities	64 – 66			

Table 2 EU sections of businesses, highlighted sections exist in the studied region.

2.3. *Categorizing the Data per AEC Main Activity:*

The collected information regarding the scanned AEC firms include the main activity, class, total revenue, number of employees, and location. This data can be further manipulated to classify the market based on the main activity.

Table 3 presents the number of AEC firms based on their function, these numbers can identify how frequent are certain specialized activities compared to other practices within the AEC market. Moreover, an allocation picture can be derived from the number of AEC companies based on the location; the highest proportion of AEC firms in the South Transdanubia region accounts for Baranya county with 54%, meanwhile, 24%, and 22% accounting for Tolna, and Somogy counties, respectively, see Figure 2.

Moreover, table 3 illustrates the classifying method of the collected data, which simply can be explained by adding up values derived from different firms with the same main activity. Consequently, all data related to the collected firms can be shown based on the main activities that are approved by the Hungarian and European structured business classification.

Main Activity	Manufacture of assembled parquet floors	Manufacture of concrete products for construction purposes	Manufacture of metal structures and parts of structures	Manufacture of central heating radiators and boilers	Manufacture of other special-purpose machinery	Steam and air conditioning supply	Development of building projects
Class	16.22	23.61	25.11	25.21	28.99	35.30	41.10
Total Net Revenue (€)	2186591	36114068	1843404	25332514	514477	1354011	3684146
Number of Employees	158	301	29	382	14	22	4
Number of companies	1	1	1	1	1	1	4
Main Activity	Constructions of residential and non-residential buildings	Constructions of bridges and tunnels	Construction of utility projects for fluids	Construction of water projects	Electrical installation	Plumbing, heat, and air-conditioning installation	Painting and glazing
Class	41.20	42.13	42.21	42.91	43.21	43.22	43.34
Total Net Revenue (€)	47617388	1994084	22106814	1218837	1066042	3491360	1379487
Number of Employees	519	25	200	21	12	86	24
Number of companies	33	1	4	1	1	2	1
Main Activity	Other specialized construction activities	General construction of buildings and civil engineering works	Retail sale of hardware, paints, and glass in specialized stores	Buying and selling of own real estate	Renting and operating of own or leased real estate	Real estate agencies	Business and other management consultancy activities

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Class	43.99	45.21	47.52	68.10	68.20	68.31	70.22
Total Net Revenue (€)	165355	165018	3963781	161824	49431	562238	Unknown
Number of Employees	8	11	30	2	4	6	Unknown
Number of companies	1	2	2	4	2	2	1
Main Activity	Architectural activities	Engineering activities and related technical consultancy	Other professional, scientific, and technical activities	Security systems service activities			
Class	71.11	71.12	74.90	80.20			
Total Net Revenue (€)	12327685	11125815	75757	237217			
Number of Employees	142	119	3	11			
Number of companies	66	31	1	1			

Table 3 Collected AEC firms' count, class, number of employees, and revenue, per main activity.

2.4. *Results and Discussion:*

The research systematically collects more than 165 different AEC firms within the studied region and their related information, the data is analyzed, and allocated based on the EU sections of businesses. Accordingly, an accurate percentages regarding the companies' count, net revenue, and number of employees per main activity are drawn.

Figure 2 illustrates the allocation of AEC firms, and their number of employees and net revenues based on the county. The results show that the AEC firms located in Baranya and Tolna counties are dominating in terms of number of employees (48% and 38%) and revenues (51% and 42%); the reason is that at least one of the two largest AEC companies in the region is based in Baranya and Tolna counties. On the other hand, Baranya county is considered the AEC firms capital of the region, since it accounts for 54% of the total AEC firms in the region.

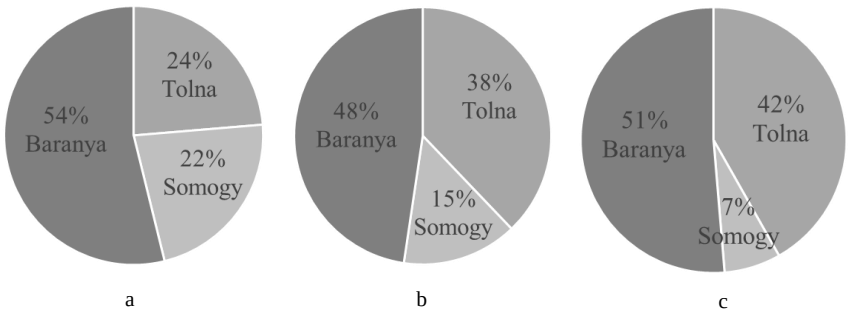

Figure 2 The allocation of AEC firms per county, a: based on the number of AEC firms, b: based on their number of employees, and c: based on their net revenue.

Based on the frequency factor, the most common AEC firm type is architectural firms, with 40%, followed by building contracting firms, and engineering firms, accounting for 20%, and 19%, respectively, see Figure 3.

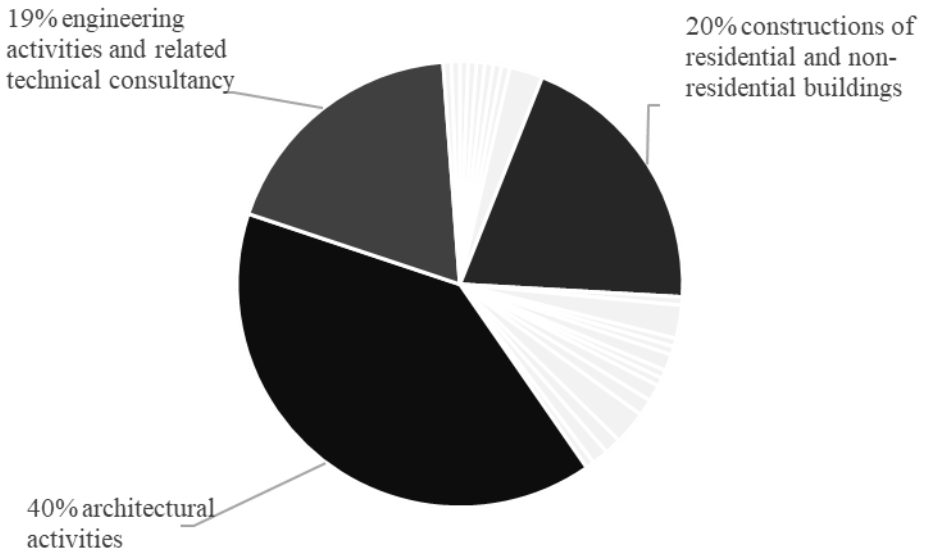

Figure 3 The most frequent AEC firms according to the main activity.

The prevailing values for architectural/engineering firms in terms of popularity, with a total share of 59%, do not match the values of revenues and number of employees, accounting for 13% per each, see Figure 4 and Figure 5.

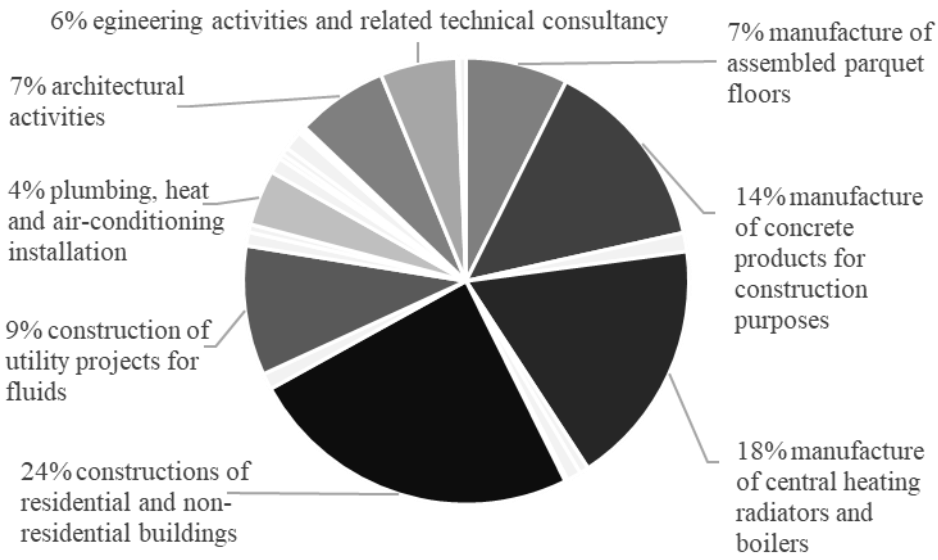

Figure 4 Number of employees allocation according to the main activity of the AEC firm.

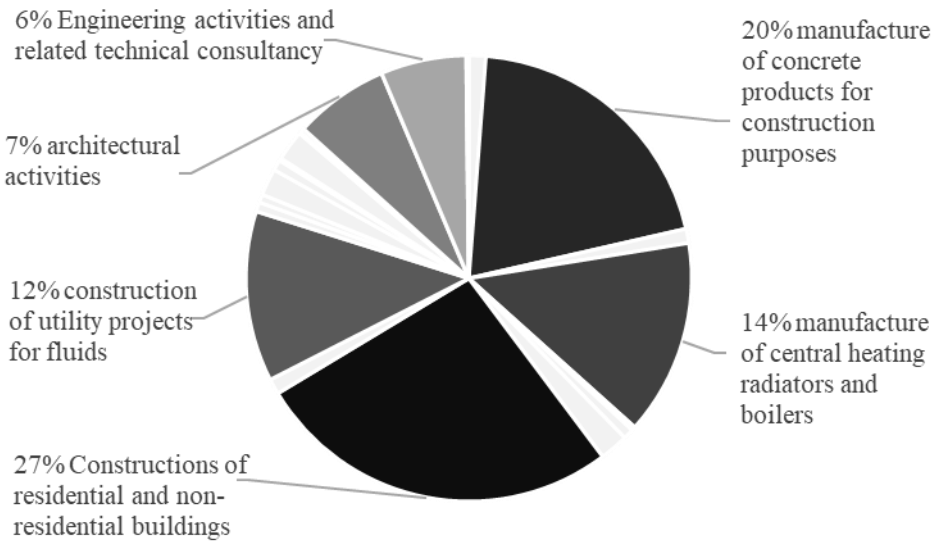

Figure 5 Net revenue allocation according to the main activity of the AEC firm.

4. *Conclusion*

The research reviews the business activities structure, introduces the AEC related sections, and reveals the multidisciplinary nature of the AEC industry in the studied region; by systematically collecting and analyzing data for the AEC firms. The study introduces a county-based allocation for the AEC firms and their related size information. Furthermore, it reveals the potential AEC main activities within the studied region, based on the size (revenue and number of employees) and frequency indicators; the most frequent AEC main activities with 59% and 20% share, are architectural/engineering and building construction activities, respectively. The most potential AEC main activities based on the size indicators are AEC manufacturing, general construction, and architecture/engineering activities, accounting for 39%, 37%, and 13% in connection with number of employees, and 34%, 39%, and 13% regarding the net revenues, respectively.

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