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Regional and subsector labour productivity differences in Europe's construction sector: a two-way ANOVA approach

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Abstract – **This study investigates differences in construction labor productivity across European regions and subsectors using data from 2022. Labor productivity is defined as turnover per employee. Focusing on 28 European countries, we compare the construction subsectors of Building Construction, Civil Engineering, and Specialized Construction Activities, across four broad regions (Western, Northern, Southern, Eastern Europe). A two-way ANOVA reveals statistically significant productivity differences both by subsector and by region. Building and civil engineering firms exhibit higher average productivity than specialized construction firms. Additionally, countries in Western and Northern Europe outperform those in Eastern and Southern Europe in productivity levels. A significant interaction effect is also observed. The subsector productivity gaps vary in magnitude across regions (although the pattern of Specialized being the lowest-productivity subsector is consistent in most regions). These findings highlight structural disparities in Europe's construction sector, with implications for targeted workforce development and investment policies to address the productivity gap.**

Keywords – construction sector; labor productivity; Europe; subsectors; regional differences; ANOVA

1. INTRODUCTION

Building things, making homes, and creating jobs are all important parts of the European economy. Despite its economic relevance, the sector has long faced productivity issues. While productivity is generally assessed at the national level, this technique can mask major within-country and within-sector inequalities that could have actual implications for successful governance. Such aggregate analyses may overlook the complexities of regional economic circumstances or the distinct operational features of various construction subsectors. We want to alleviate this restriction by disaggregating productivity analysis at a more detailed level.

The research presented here examines the existence of statistically significant and practically relevant disparities in construction worker productivity across European regions and subsectors, utilizing Eurostat data from 2022. The analysis is driven by a fundamental inquiry. Are cross-group productivity comparisons even meaningful, or are structural differences the most significant finding? The enormous range of economic growth, institutional frameworks, and market structures across Europe implies that productivity in a particular sector may not follow a consistent trend. It is impossible to devise targeted and effective policies aimed at increasing sectoral efficiency and achieving economic convergence without first comprehending these discrepancies.

Our research contributes to the literature by providing a detailed analysis using a robust two-way ANOVA design, supplemented by extensive robustness checks. The analysis explicitly examines the interplay between regional and subsectoral factors. Hence, allowing for a more nuanced understanding of productivity dynamics. The main point of the study is that the primary takeaway is not only that there are differences, but that these variances are what make the European construction industry divided and fundamentally different. This framework provides a more realistic basis for informing both private investment decisions and public policy.

2. LITERATURE REVIEW

Productivity is a key focus of economic research, with the European construction sector often highlighted for lagging behind more dynamic industries (e.g. manufacturing), a trend reflecting a broader global slowdown [1]. Construction performance, which contributes significantly to GDP and employment, is an important indication of national economic health [2]. According to Eurostat [3] and the OECD [4], large productivity gaps throughout Europe are connected to variations in technology usage, investment levels, business size, and labor skills.

The literature provides an insightful but often fragmented understanding of the factors influencing construction labor productivity. At the micro-level, studies on labor-intensive projects in developing economies consistently identify on-site management practices and workforce skills as foundational issues [2, 5, 6]. A study on labor-intensive construction in Zambia found that management and project-related factors have the highest impact on worker productivity. Researchers in Ghana highlighted *inadequate employable skills* as a key issue [2, 5]. In concurrence, a study on construction projects identified inadequate site management, a lack of skilled labor, and absenteeism as primary pawns affecting productivity [6]. The human element extends beyond skills to morals. A lack of recognition and poor treatment can significantly reduce motivation and output [6]. The physical conditions of the construction site likewise exert considerable influence, with elements such as inadequate site management, design flaws, and adverse weather emerging as significant determinants of performance [6].

Technology and capital investment are consistently found to be powerful drivers of productivity. A statistically significant and positive relationship between the use of technology and labor productivity was discovered due to a study conducted in Kenya [7]. However, this positive correlation is often undermined by barriers. High initial costs, a lack of training, and resistance to change prevent the full utilization of advanced tools like Building Information Modeling (BIM) software [7]. This observation underscores a fundamental systemic concern, wherein human and technological dimensions are intricately interwoven. [5].

Beyond the construction site, macroeconomic and political environments significantly shape productivity [8]. GDP per capita is strongly linked to construction efficiency, with broader economic conditions proving necessary to interpretation [9]. In Canada, weak productivity has been tied to reduced capital intensity, particularly underinvestment in buildings and equipment [10]. Demographic shifts like workforce aging is also involved. Although their impact may ease as economies shift towards capital- and knowledge-intensive models [11]. National policies are equally influential [12]. In Central and Eastern Europe, productivity convergence with the Eurozone has been spurred by Europeanisation and technology diffusion [13], while overregulation and lack of competition remain key barriers elsewhere [10].

Current scientific investigations often examine productivity at either the regional or subsectoral level. Rarely both are considered simultaneously. National-level disparities have been linked to capital investment and convergence [10, 13], while other studies address subsector-specific issues, such as labor-intensive construction in Zambia [2]. However, the interaction between region and subsector remains largely unexplored [14]. Despite evidence that structural differences may influence productivity across both dimensions. Methodological diversity, from surveys to econometric models, has further fragmented the field. Few studies integrating micro- and macro-level factors into a single, testable framework [6, 1, 9, 2]. This study addresses that gap by analyzing how regional context shapes subsector productivity. Namely, whether specialized construction in Western Europe operates under the same drivers as in Eastern Europe.

This approach responds to calls for more granular analysis [9], particularly given the institutional, technical, and economic diversity across Europe's construction sector. If productivity structures indeed differ significantly by region and subsector, then standardized policy prescriptions may prove ineffective [10, 2, 5]. This brings us to our central research question. Are there statistically significant and practically meaningful differences in construction labor productivity across European regions and subsectors and what are the implications for policy design?

The analysis was performed using R and RStudio. R is a programming language used in statistical computation and graphics while RStudio provides an integrated development environment for it. In other words, Rstudio is a user-friendly interface where one can write, edit, run, and visualize ones R code more easily [15]. As Okoye and Hosseini [16] *explain, R enables efficient implementation of ANOVA models with clear interpretation of interaction effects* (p. 188). One statistical test that assesses the impact of two categorical independent variables (factors) and their interaction on a single continuous dependent variable is called a two-way analysis of variance (ANOVA). In this study, a two-way ANOVA was used to test whether labour productivity differs by region and subsector, and whether these effects interact, a method well suited for comparing group means across two categorical factors.

3. METHODOLOGY

The analysis is based on a dataset of 28 European countries for the year 2022. Focusing on a single year allows us to isolate cross-sectional differences without the confounding influence of time trends or cyclical fluctuations. The year 2022 was selected as the most recent year with complete data available. The dataset was compiled from Eurostat to ensure comparability across countries. For each country, we calculate labor productivity in each major construction subsector as the ratio of turnover to the number of

employees (turnover per employee). Thus, each country provides three productivity observations (one per subsector).

We examine three subsectors of construction, defined according to standard industry classifications. Building Construction (BC) encompasses residential and non-residential construction projects. Civil Engineering (CE) represents infrastructure and heavy engineering projects (e.g., roads, bridges). Specialized Construction (SC) has specialty trades, such as installation, finishes, and other specialized construction activities.

Each of the 28 countries' data is classified into one of four broad European regions based on geographical and economic groupings commonly used in EU analyses. Thus, we have Western Europe (Austria, Belgium, France, Germany, Luxembourg, Netherlands), Northern Europe (Denmark, Finland, Ireland, Norway, Sweden), Southern Europe (Cyprus, Greece, Italy, Malta, Portugal, Spain) and Eastern Europe (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia).

These regional groupings capture differences in economic development and industry context that might affect construction productivity. After categorization, the data structure is a long format with 84 observations (28 countries x 3 subsectors), where each observation is a country-subsector combination with an associated productivity value and a region label.

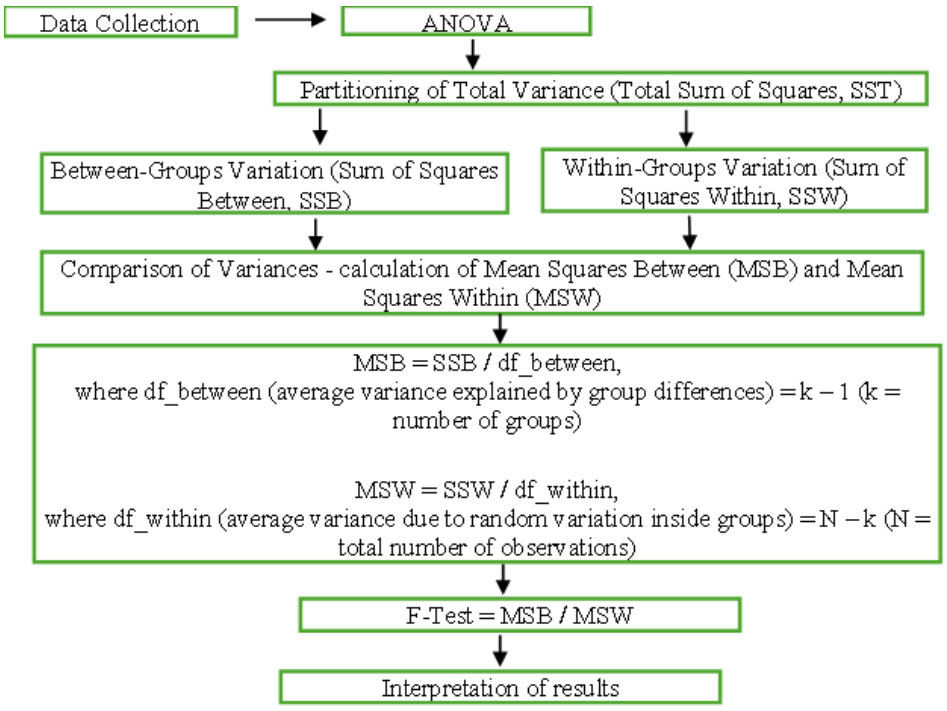


Fig. 1 The logical flow of an ANOVA analysis (Source: Authors' own processing)

ANOVA (Analysis of Variance) (Figure 1) is a statistical method, classified as a linear model, used to compare the means of three or more groups. The basic principle is to compare the variation between groups (the differences between their means) with the variation within groups (the individual differences from the group mean). The ratio of these two components is evaluated by the F-test, which indicates whether the observed differences are statistically significant or can be due to chance.

We employed a two-way factorial analysis of variance (ANOVA) to test for differences in mean labor productivity across Subsector (3 levels: BC, CE, SC) and Region (4 levels: West, North, South, East). Also, to assess the interaction effect between these two factors. The two-way ANOVA allows us to evaluate whether the average productivity differs by subsector, if it differs by region and if the difference between subsectors depends on the region (and vice versa).

Because the data is unbalanced across regions (the four regions contain different numbers of countries), a Type II sum-of-squares ANOVA was used to provide an appropriate test of main effects without assuming equal cell sizes. All tests were performed at a significance level of $\alpha = 0.05$, which means that there is a 5% risk of erroneously concluding that there are differences between groups when, in fact, they do not exist.

We also performed preliminary diagnostics to check the ANOVA hypotheses. The Shapiro-Wilk test assesses whether the residuals follow a normal distribution. The null hypothesis is that the data are normally distributed. A non-significant result ($p > 0.05$) indicates that there are no major deviations from normality. The Q-Q plot (Quantile-Quantile plots) is a visual check of normality. If the points align close to the reference diagonal, the data can be considered approximately normal. The Levene test tests the hypothesis of homogeneity of variances (equality of variances between groups). The null hypothesis is that all groups have equal variances. A non-significant result ($p > 0.05$) supports this assumption.

Recognizing that the classical ANOVA assumptions might not be fully met (as is common with economic data), we planned several complementary analyzes to ensure the robustness of our conclusions. Post-hoc comparisons were used to identify specific group differences. We conducted Tukey's Honestly Significant Difference (HSD) test (controls family-wise error in all pairwise comparisons) for subsector and region means. Additionally, Bonferroni-adjusted independent t-tests (more conservative pairwise test to reduce Type I error) were applied to verify key differences. The Kruskal–Wallis rank-sum test (non-parametric ANOVA alternative based on ranks) was used for the Region factor, to check differences without assuming normality.

For subsectors, we applied a robust one-way ANOVA on trimmed means (less sensitive to outliers, using 20% trimming). For regions, we also used Welch's ANOVA (handles unequal variances between groups). Finally, robust post-hoc contrasts on trimmed means (confirm group differences under robust assumptions) were conducted. For completeness, we computed descriptive statistics (mean, median, standard deviation, skewness, kurtosis) for each subgroup, and generated visualizations including boxplots and an interaction plot of mean productivity by subsector across regions.

All statistical analyzes were conducted in R (RStudio), using packages such as car (for ANOVA with Type II sums of squares), *psych* (for descriptive statistics), and *WRS2* (for robust methods), among others.

4. RESULTS AND DISCUSSION

4.1. Results

In 2022, building construction recorded the highest average productivity (≈0.28 turnover per employee), followed by civil engineering (≈0.23), while specialized construction lagged behind (≈0.15) (Table 1a). This indicates a notable performance gap. Regionally (Table 1b), a clear east-west divide emerges. Northern Europe leads with ≈0.35,

closely followed by Western Europe (≈0.32), whereas Southern and Eastern Europe trail at ≈0.18 and ≈0.13, respectively. On average, a construction worker in Northern Europe generates twice the turnover of one in Eastern Europe.

Table 1 Descriptive statistics of labour productivity: subsector (a); region (b);

(a)

Subsector	N	Mean	SD	Median	Min	Max	Skew	Kurtosis
Building	28	0.28	0.17	0.25	0.08	0.64	0.68	-0.67
Civil	28	0.23	0.10	0.21	0.09	0.44	0.52	-0.95
Specialized	28	0.15	0.08	0.13	0.06	0.35	0.77	-0.07

Source: Authors' own research results via RStudio

(b)

Region	N	Mean	SD	Median	Min	Max	Skew	Kurtosis
Eastern Europe	33	0.13	0.05	0.12	0.06	0.26	0.39	-1.07
Northern Europe	15	0.35	0.11	0.39	0.21	0.54	0.09	-1.44
Southern Europe	18	0.18	0.08	0.18	0.08	0.32	0.20	-1.45
Western Europe	18	0.32	0.15	0.29	0.14	0.64	0.86	-0.23

Source: Authors' own research results via Rstudio

Productivity values tend to be right-skewed (a long tail of high-productivity observations). This is evident especially in the BC subsector and in the Western/Northern regions. A few countries achieve very high productivity relative to others. The overall distribution of labor productivity across all observations has a positive skewness ($s = 1.16$) and a high value of kurtosis ($k = 4.04$). Positive skewness means that most values are below the mean, but there are a few very large observations that skew the distribution to the right. The kurtosis (or *sharpness* of the distribution) shows how much the data is concentrated around the mean and how pronounced the tails of the distribution are. A high value, like the one observed here, indicates a leptokurtic distribution. The data is concentrated around the mean, but there are also long tails, suggesting a few countries with extremely high productivity relative to the rest. In contrast, within-group kurtosis values for individual regions and subsectors are substantially lower, often even negative. Hence, productivity distributions differ structurally across contexts. The variability also differed by group. The West exhibited a larger spread (higher standard deviation) in productivity values than the East. A formal Levene's test confirms that variance is not equal across all groups ($p \approx 0.002$), violating the homogeneity of variance assumption. Moreover, Shapiro-Wilk tests for normality were significant for most sub-groups ($p < 0.05$). The Q-Q plots (Figure 2) inspection suggested deviations from normality (some heavy tails and skewness). These diagnoses imply that the classical ANOVA results should be interpreted with caution and verified with robust techniques. Nevertheless, the clear differences in group means evident from the descriptive analysis already suggest. Both subsector and region are important sources of productivity variation.

The ANOVA analysis (Table 2) reveals strong main effects for both factors. Subsector has a significant impact on productivity ($F(2, 72) = 21.17$, $p < 0.001$). Region also has a highly significant effect ($F(3, 72) = 40.16$, $p < 0.001$). These p-values are well below the 0.05 threshold, indicating that the differences observed in the sample are very unlikely to be due to chance. In addition, the interaction between Subsector and Region is statistically significant ($F(6, 72) = 3.77$, $p = 0.0026$).

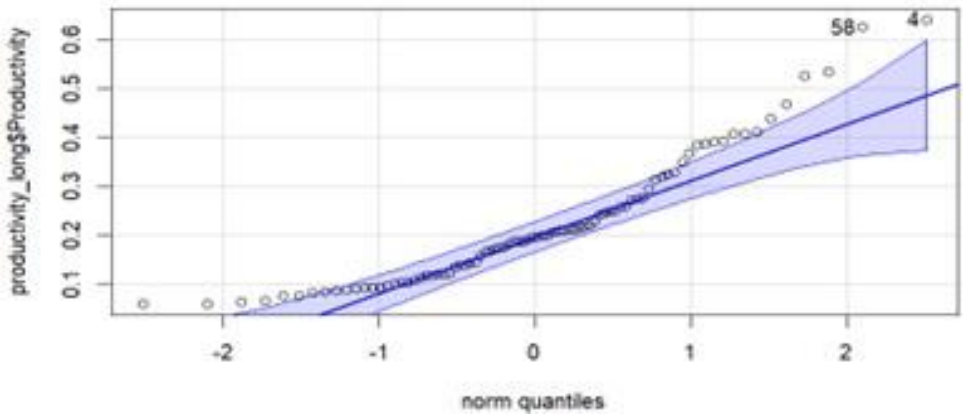


Fig. 2 Q-Q Plot Productivity (Source: Authors' own research results via RStudio)

This supports the idea that the effect of subsector on productivity is not uniform across all regions (and conversely, regional differences are not perfectly consistent across all subsectors). All three effects (two main effects and their interaction) are not only statistically significant but also practically meaningful when considering effect sizes.

Table 2 Two-Way ANOVA (Type II)

Source	Sum Sq	Df	F value	Pr(>F)	Significance
Subsector	0.235	2	21.17	<0.001	***
Region	0.670	3	40.16	<0.001	***
Subsector x Region	0.126	6	3.77	0.0026	**
Residuals	0.400	72			

Source: Authors' own research results via RStudio

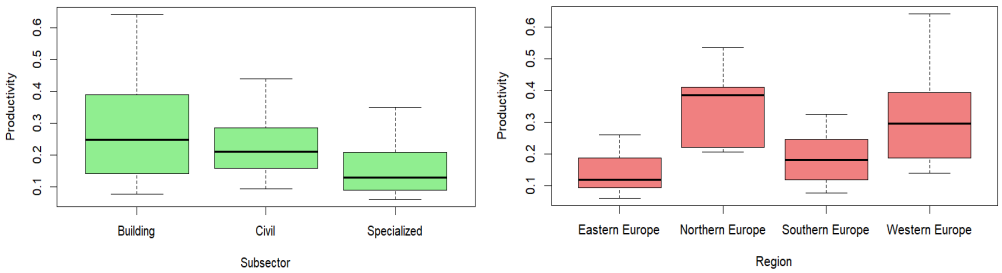
The partial eta-squared (η^2) values (Table 3) indicate that Region differences account for the largest share of variability in productivity ($\eta^2 \approx 0.63$, suggesting over 60% of the explainable variance in productivity is associated with regional grouping). Subsector differences account for a smaller but still substantial portion ($\eta^2 \approx 0.37$), and the Subsector x Region interaction accounts for about 24% of variance. In sum, the region in which a country is located appears to be an even stronger determinant of its construction productivity than the subsector of activity, although both factors matter significantly.

Table 3 Effect Sizes from Two-Way ANOVA on Productivity (Partial Eta Squared)

Effect	η^2 (eta squared)	Partial η^2 ($\eta^2 p$)	Interpretation
Subsector	0.164	0.370	Large
Region	0.468	0.626	Large
Subsector x Region	0.088	0.239	Medium-Large

Source: Authors' own research results via RStudio

To better interpret these results, we examined the group means and conducted post-hoc pairwise comparisons. The means plot (Figure 3 (a) and (b), Figure 3) illustrates the pattern. Productivity is highest in BC and CE sbsectors, particularly in Northern and Western Europe, while the SC subsector trails in all regions.



(a) (b)

Fig. 3 Boxplot of labour productivity by subsector (a) and by region (b)
Source: Authors' own research results via RStudio

The Tukey HSD post-hoc tests confirm which pairwise differences are statistically significant. For subsectors, SC has significantly lower productivity than both BC and CE. Specifically, the mean difference between SC and BC is large and significant ($p < 0.001$). SC is also significantly lower than CE ($p < 0.001$). In contrast, the productivity difference between Building and Civil Engineering subsectors is relatively small and was not statistically significant at the 5% level ($p \approx 0.08$ in the Tukey test). It is indicated that those two subsectors achieve roughly comparable productivity on average. The Bonferroni-corrected comparisons corroborated these key findings, lending further support to the strength and consistency of the observed productivity gaps.

Moreover, the post-hoc comparisons show that the West and North do not differ significantly from each other ($p = 0.65$). Although, each of them is far ahead of the South and East ($p < 0.001$ for each of those comparisons). On average, firms in Western/Northern Europe generate substantially more turnover per worker than those in Southern or Eastern Europe. The difference between East and South is modest and was not statistically significant ($p \approx 0.15$). These two regions are similarly low in productivity relative to the European core. Notably, the largest gaps were between Northern Europe (the top performer) and Eastern Europe (the lowest). The Tukey HSD indicated that Northern Europe's mean productivity was about 0.21 higher than Eastern Europe's (in turnover/employee units), a difference that is highly significant ($p < 0.0001$).

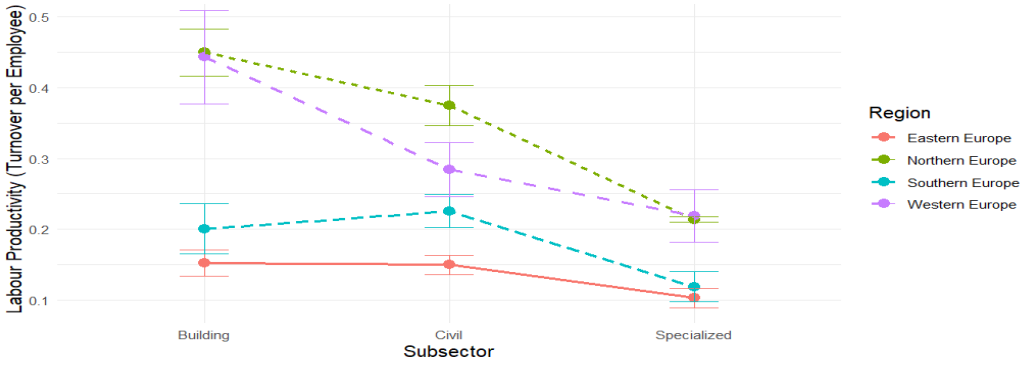


Fig. 4 Interaction plot of mean productivity by subsector across regions (Source: Authors' own research results via RStudio)

The interaction plot (Figure 4) suggests that the overall pattern of subsector performance (BC and CE outperforming SC) holds in each region. The lines representing

different regions are roughly parallel rather than crossing. Specialized Construction is the weakest subsector in every region. The degree to which it lags behind the other subsectors is amplified in high-productivity regions (West/North) and slightly less extreme in low-productivity regions (East/South). Statistically, some specific subsector differences are significant in certain regions but not in others.

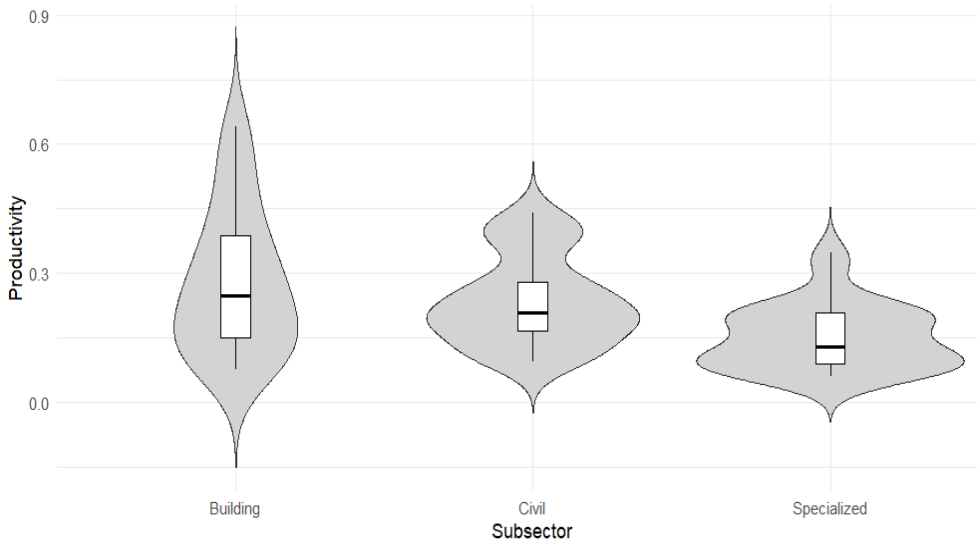


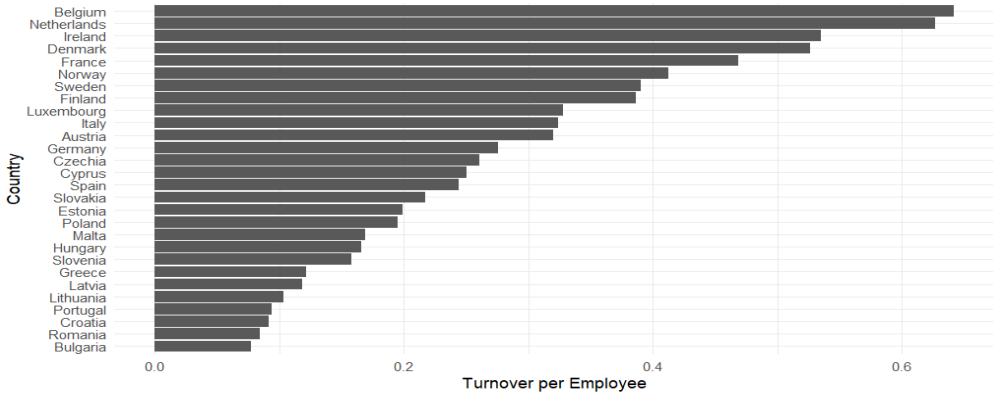
Fig. 5 Distribution of Productivity by Subsector (Source: Authors' own research results via Rstudio)

The violin plot (Figure 5) shows that Building Construction has the widest productivity spread and the highest outliers, with some countries exceeding 0.6. Civil Engineering has a narrower distribution centered around moderate productivity levels, while Specialized Construction clusters at lower values with few high performers. All three subsectors show positive skewness, specially Building, where a few high-performing countries raise the mean. This indicates that while Building often drives Europe's construction output, its productivity is highly uneven across countries. Civil and Specialized are more consistently modest. The differing distribution shapes support treating subsectors as distinct systems with unique challenges.

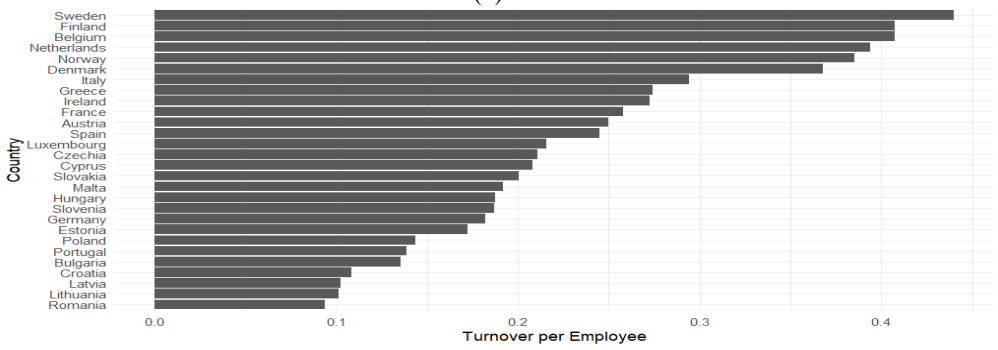
Country rankings (Figure 6a, 6b and 6c) further illustrate the geographic stratification of productivity. Belgium, Netherlands, Ireland, Denmark, and France lead Building Construction, while Sweden, Finland, and Belgium dominate Civil Engineering. In Specialized Construction, Belgium and the Netherlands are clear outliers at the top, while Romania, Latvia, and Bulgaria cluster at the bottom across all subsectors. This repeated North-West versus South-East pattern suggests that national productivity is shaped not only by sectoral structure but also by broader institutional and economic environments. Countries at the lower end likely face systemic barriers, such as skill shortages, underinvestment, and lower digital adoption. Thus, limiting their productivity catch-up potential without targeted interventions.

Given a breach of ANOVA assumptions (non-normality and heteroscedasticity, as previously stated), we undertook various robustness checks to confirm the reliability of our

findings. The results of these supplementary analyzes corroborated the main ANOVA conclusions.



(a)



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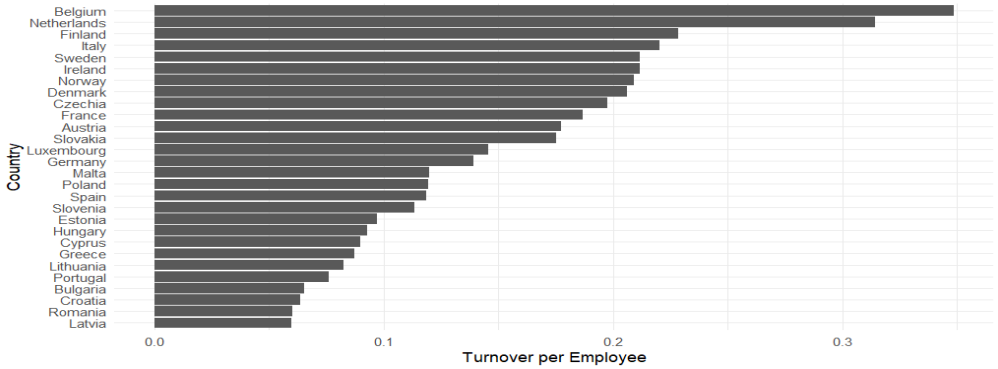

(c)

Fig. 6 Productivity Rankings: (a) Building Construction; (b) Civil Engeneering; (c) Specialized Construction (Source: Authors' own research results via RStudio)

Without assuming equal variances, a Welch ANOVA (a statistical test that compares the means of three or more groups when the assumption of equal variances is not met) still

found highly significant differences across regions (Welch's F-test for Region was $p < 0.001$), confirming that regional disparities are not an artefact of unequal variances.

A non-parametric comparison of median productivity across the four regions was conducted. The Kruskal-Wallis test yielded $\chi^2 \approx 41.5$ ($df = 3$, $p < 0.001$), indicating that at least one region's median productivity is significantly different from the others. This aligns with the parametric result that region matters. Pairwise Wilcoxon tests (with Bonferroni correction) further supported the ranking. Western and Northern medians were each higher than Eastern and Southern ($p < 0.01$), with no significant difference between Western vs Northern or Eastern vs Southern.

Using a 20% trimmed-mean approach for the subsector factor (which reduces the influence of outliers and heavy tails), we still found a significant effect of Subsector ($p \approx 0.006$). The robust effect size for subsector differences (measured by a robust analogue of η^2) was around 0.44, indicating a meaningful difference consistent with the classical ANOVA's findings. A robust post-hoc test (lincon for 20% trimmed means) confirmed that Building vs Specialized and Civil vs Specialized comparisons remain significant under this approach, while Building vs Civil does not. Hence, mirroring the pattern from the standard Tukey test.

Even when alternate measurements (medians or trimmed means) were used, the order of group performance remained consistent (Building and Civil higher, Specialized lowest, Western/Northern higher, Eastern/Southern lower). To illustrate, Western Europe's median productivity was approximately double that of Eastern Europe, and the specialized subsector had the lowest median in each area, supporting our previous assessment.

These robustness assessments indicate that the study's basic conclusions are not susceptible to the specific statistical assumptions of ANOVA. The evidence for considerable production differences by area and subsector is solid and consistent across a range of analytical lenses. Minor departures from normality or equal variance do not undercut the conclusion that productivity in Europe's construction industry is unevenly distributed across different areas.

4.2. Discussion

Our scientific investigation revealed significant disparities in labor productivity. This is evident across both regions and subsectors within the European construction sector. Northern and Western Europe consistently outperform Southern and Eastern regions, reflecting broader economic divides in capital access, technological adoption, and managerial practices. These findings reinforce the image of a two-speed Europe in construction productivity.

Subsector variation adds further nuance. Specialized construction lags behind building and civil engineering, likely due to its fragmented, labor-intensive nature and limited scale efficiencies. By contrast, larger capital-intensive projects benefit from greater integration and mechanization. That building and civil engineering show comparable productivity levels suggests shared reliance on project complexity and capital inputs.

Germany provides a concrete example of the structural dynamics highlighted in the studies analysis. Residential construction dominated the national market in 2022, accounting for 61.6% of total construction investment [19]. This strong concentration reflects the sector's heavy reliance on housing demand, while non-residential and civil engineering play comparatively smaller roles. At the same time, specialized construction activities face distinct productivity challenges. The continued use of 2D planning and insufficient integration of heating, ventilation, and cooling (HVC) systems often leads to

rework, as prefabricated components may not fit due to incorrect slot or breakthrough planning on site. This creates ripple effects which translate into delays for other trades, rising costs, and reduced efficiency across projects.

The financial dimension of these inefficiencies is significant. A BauInfoConsult study [18] found that error costs in the German construction industry averaged 8.1% of annual turnover in 2022, equivalent to about €13 billion. Although this represents an improvement compared with 2021 (11.4%) and 2020 (12.8%), the study also revealed that firms' own estimates of error costs in their projects were much higher, averaging 15.9%. This gap between aggregated data and firm-level experience underscores the persistence of structural inefficiencies, particularly in specialized trades. Stakeholders identified better planning, digitalisation, and improved coordination between trades as potential remedies, although many professionals remain skeptical about rapid change.

These German insights mirror the papers empirical findings. Building activities remain central to the sector, but specialized construction suffers from systemic inefficiencies that depress productivity. Error costs on the order of billions of euros highlight how rework and poor coordination translate directly into lower productivity, supporting the broader conclusion that specialized construction is consistently the weakest subsector across Europe.

It is important to mention that, the observed non-normality and heteroscedasticity in our data are not mere technicalities but signs of real-world structural differences. Western Europe's higher variance may indicate a diversity of practices in mature markets, while Eastern Europe's low and consistent productivity points to systemic constraints. Germany offers an insightful example of how external forces, such as financing conditions, shape productivity outcomes. The residential building subsector benefited from a long period of historically low construction loan interest rates (*Bauzinsen*) that began after 2009 (3,30%) and reached a minimum around 2020 (0,80%) [20]. This environment fueled housing demand and sustained construction activity but could also lead to overstretched resources, skill shortages, and inefficiencies. With interest rates rising again in 2021 (1,20 %) and spiking further in 2022 (2,90%) and 2023 (4,50 %) [20], financing costs tightened, dampening demand and exerting downward pressure on productivity. This illustrates how fluctuations in macroeconomic conditions, such as *Bauzinsen*, amplify structural differences across regions and subsectors.

Descriptive visualizations reinforce these results. The violin plot shows that productivity in Building Construction is highly dispersed, while Civil and Specialized are more compact. Similarly, the country rankings reveal a consistent North–West versus South–East divide, with countries like Belgium, the Netherlands, and Sweden outperforming Romania, Latvia, and Bulgaria across subsectors. These descriptive patterns visually confirm the statistical findings and underscore the structural nature of the productivity gap.

Thus, it is shown that productivity-enhancing initiatives should be targeted. Eastern and Southern areas might benefit from focused investments in technology, workforce development, and managerial capability. Specialized construction, which is generally made up of SMEs (Small and Medium-sized Enterprises), might benefit from collaborative networks and shared digital tools [17]. In contrast, existing productive areas and subsectors may concentrate on innovation and sustainable practices. Workforce development is also important. Training programs and cross-border collaborations might assist propagate efficient methods from high-productivity countries to those that are still catching up. Benchmarking for internationally engaged enterprises should take into account both regional and subsector rivals, rather than just national averages.

At the policy level, EU cohesion funding remains necessary but should be paired with mechanisms that promote knowledge transfer and long-term capacity-building. This could be done by linking funding to collaborative tenders or technology-sharing. Finally, the consistency between ANOVA and our robustness checks strengthens confidence in the results. In studies of cross-national productivity, distributional irregularities are common. Relying solely on classical models may miss important signals. Our findings suggest that robust techniques not only validate statistical significance, but also reveal underlying structural realities.

Our current research enhances the literature by disaggregating productivity studies across regions and subsectors, resulting in a more detailed picture of where performance gaps exist and what actions may help narrow them.

5. CONCLUSIONS

The research question was answered with strong statistical evidence confirming significant and meaningful productivity differences across European regions and subsectors, with practical implications emphasizing the importance of differentiated, context-specific policy approaches over one-size-fits-all solutions. This study has demonstrated clear, statistically significant differences in construction labor productivity across European regions and subsectors. Using 2022 data from 28 countries, we found that Northern and Western Europe outperform Southern and Eastern Europe, and that specialized construction activities consistently lag behind building and civil engineering. An interaction effect suggests these gaps are even wider in high-performing regions, confirming that Europe's construction sector is far from uniform.

The structural nature of these disparities was reinforced by the data's departure from classical ANOVA assumptions. Thus, indicating that different regions and subsectors follow distinct productivity patterns. Rather than weakening the analysis, these distributional irregularities highlight the need to treat the sector's components separately.

The implications are straight forward. Uniform policies are unlikely to work. Productivity-boosting measures must be customized, with specific investments in skills, technology, and managerial capability tailored to each area and subsector. Overall, the findings support the idea of Europe's construction sector as a diverse system in which development depends on diversified, context-aware techniques rather than one-size-fits-all solutions.

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