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IDENTIFICATION OF FACTORS BY PRIORITY INFLUENCE ON THE QUALITY OF THE BOOK LAYOUT PROCESS STAGES

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The article analyzes the factors that determine the quality of the stages of the book layout process within the structure of prepress preparation. Layout is considered as a multilevel technological system within which the functional, compositional, and aesthetic integrity of a publication is formed, taking into account the multifactorial nature and structural interdependence of parameters.

The study covers two key stages: the design of the initial publication parameters and the typographic–compositional organization of the layout page. To determine the relative weight of factors, the Analytic Hierarchy Process (AHP) was applied with a consistency check of expert judgments ($CR < 0.1$). To objectify the distribution of influence, the standardized Z-score method was used, enabling a transition to a metrically interpreted dominance scale and the classification of factors by priority levels.

The results demonstrate an asymmetric structure of influence distribution: at the design stage, a limited set of strategically significant factors was identified, whereas at the typographic–compositional organization stage, a group of dominants forming the artistic and technical quality of the layout was determined. It was established that the concentration of significance within a limited number of parameters creates preconditions for optimizing quality management by focusing resources on critically important variables.

The quantitative interpretation of the results enables the integration of the obtained weight coefficients into multilevel hierarchical evaluation models and the further formation of an integral indicator of layout quality. This opens prospects for the use of adaptive decision-making tools, particularly fuzzy logic models, to predict the impact of structural changes on the overall quality level of a book publication. The practical significance of the study lies in the possibility of applying the proposed methodology in real editorial and publishing processes to enhance the validity of design decisions.

The proposed approach increases the objectivity of multicriteria analysis, ensures formalized ranking of structurally interrelated factors, and can be used to construct integral quality indicators and further model the layout process using fuzzy logic tools.

Keywords: *book layout; publication quality; prepress preparation; design of initial parameters; typographic–compositional organization; layout page; structural interaction of factors; Analytic Hierarchy Process (AHP); Z-score; standardization; multicriteria analysis; integral indicator; hierarchical model; fuzzy logic.*

Problem Statement. Within the system of contemporary prepress preparation, the process of book layout constitutes one of the most critical stages, as it is at this level that the compositional structure of the page is formed, the coherence of textual and illustrative elements is ensured, and the integrity of the artistic and technical design is achieved. The quality of layout decisions directly affects the functional, aesthetic, and ergonomic characteristics of a publication. At the same time, this process is characterized by multifactorial complexity, structural interdependence of parameters, and varying intensity of their influence on the final outcome, which complicates the objective identification of dominant factors.

In practice, the ranking of factors is predominantly carried out on the basis of expert judgments or simplified approaches that do not provide sufficient statistical validity or metric interpretability of the obtained results. Under conditions of a dense distribution of weights, this leads to uncertainty in identifying strategically significant parameters and complicates the construction of integral quality indicators and predictive models for managing the layout process. Accordingly, there is a need to develop a formalized methodological approach to identifying factors with priority influence on the quality of layout stages through the application of multicriteria analysis tools and statistical standardization.

Analysis of Recent Research and Publications. In contemporary studies on multicriteria analysis, considerable attention is given to the formalized determination of criteria weights, particularly through the Analytic Hierarchy Process (AHP) proposed by T. Saaty. The method is widely used in engineering, quality management, and risk management. In applied research, Chang employed AHP to align criteria for innovative development; Sayed and co-authors integrated it with optimization methods to select technical solutions; and Vitrano applied it to risk management tasks and supplier selection. This confirms the versatility of AHP as a tool for structuring complex problems and establishing factor priorities.

At the same time, applied statistics widely uses the Z-score method to standardize heterogeneous indicators and to construct composite indices. Andrade described the methodology for calculating and interpreting standardized scores, while Zhang applied Z-scores to integrate a set of indicators into comprehensive assessments. Modern research increasingly combines AHP with subsequent weight standardization, enabling a transition to a metrically interpretable dominance scale and providing a foundation for analyzing factor priority in complex systems, including the book layout process.

Purpose of the Article. The purpose of this article is to develop and substantiate a methodological approach to identifying factors with priority influence on the quality of the stages of the book layout process, based on the integration of the Analytic Hierarchy Process and statistical standardization using the Z-score method. The approach the identification of relevant factors for the stages of designing the initial publication parameters and the typographic–compositional organization of the layout page, the determination of their weight coefficients with a consistency check of expert judgments, and their subsequent classification according to priority levels.

Presentation of the Main Research Material. Within the structure of contemporary publication preparation technologies, particularly at the prepress stage, the page layout process occupies one of the key positions in terms of complexity and responsibility. The quality of the final book product largely depends on the correctness and consistency of layout decisions. Layout is among the most technologically intensive stages of publication preparation, since compliance with established typographic and technical requirements ensures stylistic unity, compositional coherence, and the integrity of the artistic concept—both at the level of an individual page or spread and across the publication as a whole [1].

In the context of this study, it is advisable to focus on two functionally interrelated components of the layout process: the stage of designing the initial publication parameters and the stage of typographic–compositional organization of the layout page.

The quality assurance system of the book layout process is characterized by multifactorial complexity, structural interdependence of parameters, and heterogeneity in the degree of their influence on the final outcome. At the stages of designing the initial publication parameters and organizing the typographic–compositional structure of the layout page, the foundations of the functional, aesthetic, and ergonomic quality of the layout are established. In this regard, the key objective of the research is to identify factors with priority influence and to formalize their weight characteristics.

An analysis of contemporary research in the field of printing and visual communications indicates that factor ranking is traditionally performed using the Pareto principle or expert-based ordering without subsequent mathematical verification [2–4]. However, when a significant number of factors have close weight values and form a dense distribution interval, the application of the 80/20 rule does not allow for the accurate identification of dominant variables. This necessitates a transition to a statistically grounded standardization procedure.

To objectify the distribution of weights, the Z-score (standardized score) method was applied, which is widely used in multicriteria analysis to determine the degree of deviation of an individual parameter from the sample mean [5, 6].

The Z-score method is a fundamental tool of mathematical statistics employed to transform heterogeneous numerical data into a unified dimensionless scale within multicriteria analysis frameworks [7]. Its primary purpose is to quantify the deviation of a specific value from the average level of the sample, taking into account data variability.

The essence of the method lies in transforming each empirical value into an indicator that reflects the number of standard deviations by which it differs from the

arithmetic mean. Thus, the Z -score not only indicates whether a value is above or below the mean, but also enables a quantitative assessment of the magnitude of this deviation in standardized units [8].

Formally, the standardized score is defined as:

$$Z_i = \frac{X_i - \mu}{\sigma},$$

де X_i – the empirical value of the i -th indicator; μ – the arithmetic mean of the sample; σ – the standard deviation of the sample.

Such an approach enables the transition from relative ranking to a metrically measurable dominance scale, which constitutes a necessary stage in the construction of integral indicators [9].

The initial numerical values of the factors were obtained through a procedure for determining their relative priority using the Analytic Hierarchy Process (AHP) [10]. At the first stage, a set of factors characterizing the design stage of the initial publication parameters was formed (content and technological organization, reader interest, type of publication, reader age group, publication volume, and layout design option). Subsequently, expert pairwise comparisons were conducted to establish the intensity of preference of each factor over the others, after which a reciprocal comparison matrix was constructed.

Table 1

**Matrix representation of the comparative significance of factors
in designing the initial publication parameters**

	T_1	T_2	T_3	T_4	T_5	T_6
T_1	1	3	4	5	6	7
T_2	1/3	1	2	3	4	5
T_3	1/4	1/2	1	2	3	4
T_4	1/5	1/3	1/2	1	2	3
T_5	1/6	1/4	1/3	1/2	1	2
T_6	1/7	1/5	1/4	1/3	1/2	1

Based on the calculation of the principal eigenvector of the matrix and its normalization, a vector of weight coefficients was obtained, reflecting the relative significance of each factor. To ensure the convenience of further statistical processing, the normalized weights were proportionally scaled without altering their relative structure. The consistency check of expert judgments demonstrated an acceptable level of reliability ($CR < 0.1$), which complies with the requirements of the AHP methodology [11].

The principal eigenvector of the matrix is represented as follows:

$$t = (3,689; 2,221; 1,201; 0,765; 0,490; 0,325).$$

Normalization of the components is performed according to the formula:

$$t_{ni} = \frac{t_i}{\sum_{k=1}^6 t_k}$$

As a result, a local weight vector was obtained,:

$$t_n = (0,424; 0,255; 0,138; 0,088; 0,056; 0,037)$$

for which the following condition holds:

$$\sum_{i=1}^6 t_{ni} = 1.$$

For further integration into the hierarchical model, the values were proportionally scaled by a coefficient k :

$$t_n^{(k)} = (424; 255; 138; 88; 56; 37).$$

The maximum eigenvalue of the matrix is:

$$\lambda_{\max} = 6,18.$$

The Uniformity Index (UI) is calculated using the following formula:

$$IU = \frac{\lambda_{\max} - n}{n - 1}$$

for $n = 6$

$$IU = 0,036.$$

The obtained value satisfies the normative admissibility condition, indicating an acceptable level of internal consistency of expert judgments. The consistency ratio equals 0.029, which does not exceed the threshold value of 0.1.

Taking these results into account, a discretized priority vector was formed:

$$T_0^{(p)} = (40, 10, 30, 20, 20, 10).$$

The aggregation of the normalized and discretized values is presented in generalized form.

Table 2

**Variants of weight values of factors for designing
the initial publication parameters**

i	1	2	3	4	5	6
t_n	0,424	0,255	0,138	0,088	0,056	0,037
$t_n^{(k)}$	424	255	138	88	56	37

As a result, an empirical set of quantitative indicators was formed, reflecting the integral significance of the factors at the studied stage and used for the subsequent standardization procedure.

For the stage of designing the initial publication parameters, the empirical sample is represented as follows:

$$X = \{424, 255, 138, 88, 56, 37\}.$$

Let us calculate the arithmetic mean value for the given sample:

$$\mu = \frac{1}{n} \sum_{i=1}^n Xi,$$

де μ – the arithmetic mean of the distribution; X_i – the empirical value of the i -th factor; n – the number of factors in the sample;

For our sample of factors, the arithmetic mean is calculated as: $\mu = 998/6=166,33$.

The standard deviation σ is determined by the formula:

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (X_i - \mu)^2}.$$

For our sample of factors $\sigma = 135,5$.

Table 3 presents the calculated values and priority levels of the factors at the stage of designing the initial publication parameters.

Table 3

Calculated Z-score Values and Priority Levels of Factors

Factor	$X - \mu$	Z-score	Priority Level
1	+257,67	+1,90	High
2	+88,67	+0,65	Medium
3	-28,33	-0,21	Low
4	-78,33	-0,58	Low
5	-110,33	-0,81	Low
6	-129,33	-0,95	Low

The obtained Z-score values demonstrate a markedly asymmetric distribution structure: one factor has a value of $Z = 1,90$ (pronounced dominance), the second — $Z = 0,65$ (moderate influence), while the remaining factors have negative values, indicating their secondary role.

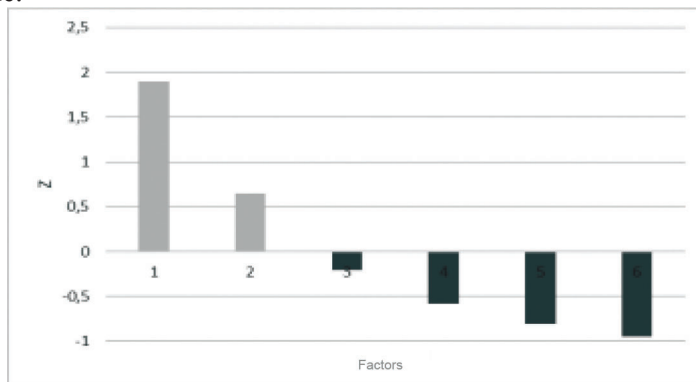


Fig. 1. Z-score values of factors at the stage of designing initial publication parameters

The interpretation is carried out according to the following scale:

- $Z > 1$ — high priority;
- $0 < Z \leq 1$ — medium priority;
- $Z < 0$ — low priority.

Thus, within the first subsystem, only two factors can be classified as strategically significant for further modeling.

An analogous procedure was carried out for the stage of typographic–compositional organization of the layout page. Based on the сформований list of factors—page format of the publication, layout page format, number of columns, implementation of typographic design, processing of illustrative design, proportion of book page components, text complexity group, illustration complexity group, text composition rules, text placement rules, illustration placement rules, and layout modeling—a corresponding pairwise comparison structure was developed for subsequent weight determination and standardization.

Table 4

**Matrix representation of the comparative significance of factors
in the typographic–compositional organization of the layout page**

	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈	L ₉	L ₁₀	L ₁₁	L ₁₂
L ₁	1	3	5	3	4	2	4	4	5	6	6	2
L ₂	1/3	1	3	2	3	1	3	3	4	5	5	2
L ₃	1/5	1/3	1	1	1	1/2	2	2	3	3	3	1
L ₄	1/3	1/2	1	1	2	1	2	2	2	3	3	1
L ₅	1/4	1/3	1	1/2	1	1	2	2	2	2	3	1
L ₆	1/2	1	2	1	1	1	2	2	2	3	3	1
L ₇	1/4	1/3	1/2	1/2	1/2	1/2	1	2	2	2	2	1
L ₈	1/4	1/3	1/2	1/2	1/2	1/2	1/2	1	2	2	2	1
L ₉	1/5	1/4	1/3	1/2	1/2	1/2	1/2	1/2	1	2	2	1
L ₁₀	1/6	1/5	1/3	1/3	1/2	1/3	1/2	1/2	1/2	1	2	1
L ₁₁	1/6	1/5	1/3	1/3	1/3	1/3	1/2	1/2	1/2	1/2	1	1
L ₁₂	1/2	1/2	1	1	1	1	1	1	1	1	1	1

As a result of determining the principal eigenvector of the matrix, the following vector was obtained:

$$l = (3,360; 2,168; 1,113; 1,303; 1,059; 1,428; 0,813; 0,724; 0,598; 0,481; 0,414; 0,891).$$

Normalization of the components is performed according to the formula:

$$l_{ni} = \frac{l_i}{\sum_{k=1}^{12} l_k}$$

which made it possible to form a vector of local weights:

$$l_n = (0,232; 0,149; 0,077; 0,090; 0,073; 0,099; 0,056; 0,050; 0,041; 0,034; 0,029; 0,062)$$

for which the following condition holds

$$\sum_{i=1}^{12} l_{ni} = 1.$$

For the purpose of further use in comparative analysis, the weight values were proportionally scaled by a coefficient k :

$$L_n^{(tc)} = (234; 151; 78; 91; 74; 99; 57; 50; 42; 34; 29; 62).$$

The maximum eigenvalue of the matrix is:

$$\lambda_{\max} = 12,565.$$

The consistency index is determined using the standard formula:

$$IU = \frac{\lambda_{\max} - n}{n - 1}$$

for $n = 12$

$$IU = 0,051.$$

The obtained indicator does not exceed the permissible normative threshold, which indicates satisfactory internal consistency of expert judgments. The consistency ratio equals 0.033, confirming the acceptability of the results.

Based on the normalized values, a discrete weight vector was formed:

$$L_0^{(tc)} = (100; 70; 30; 40; 30; 40; 20; 20; 20; 20; 10; 30).$$

The comparison of the normalized and discretized representations is presented in the summary table.

Table 5

**Comparative characteristics of weight coefficients for factors
in the typographic–compositional organization of the layout page**

i	1	2	3	4	5	6
l_n	0,232	0,149	0,077	0,090	0,073	0,099
$L_n^{(tc)}$	234	151	78	91	74	99

Continuation of table 5

**Comparative characteristics of weight coefficients for factors
in the typographic–compositional organization of the layout page**

i	7	8	9	10	11	12
l_n	0,056	0,050	0,041	0,034	0,029	0,062
$L_n^{(tc)}$	57	50	42	34	29	62

For this stage:

$$\mu = 999/12=83,25$$

$$\sigma = 53,17$$

If the stage of typographic–compositional organization of the layout page is analyzed, the corresponding priority values shown in Table 1.6 are obtained.

Table 6

Calculated Z-score values and priority of factor influence at the stage of typographic–compositional organization of the layout page

Factor	$X - \mu$	Z-score	Priority Level
1	148,75	+2,79	High
2	65,75	+1,24	High
3	15,75	+0,3	Medium
4	6,75	+0,13	Medium
5	-6,25	-0,12	Low
6	-10,25	-0,19	Low
7	-21,25	-0,4	Low
8	-27,25	-0,51	Low
9	-33,25	-0,62	Low
10	-42,25	-0,8	Low
11	-42,25	-0,8	Low
12	-54,25	-1,02	Low

Thus, for the stage of typographic–compositional organization of the layout page, the factors with values 232, 149, 99, and 90 are identified as key according to the Z-score method and represent the most significant variables within the artistic and technical design stage.

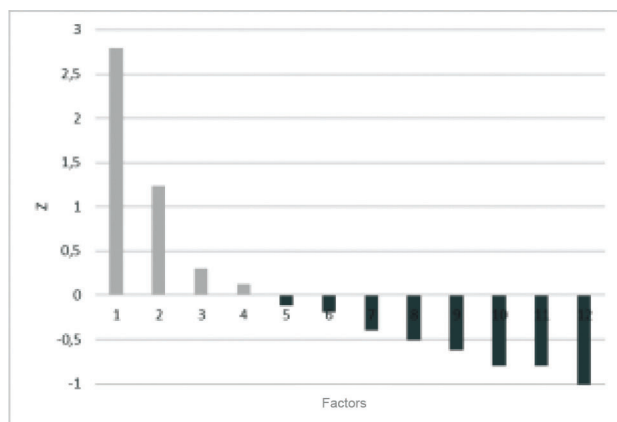


Fig. 2. Z-score values of factors at the stage of typographic–compositional organization of the layout page

The priority factors identified at the two stages of the book layout process will serve as the basis for constructing predictive models using fuzzy logic tools within a multicriteria decision-making framework [12].

Conclusions. As a result of the conducted research, a methodological approach to identifying factors with priority influence on the quality of the stages of the book layout process was developed and tested. The approach is based on the integration of the Analytic Hierarchy Process and statistical standardization using the Z-score method. The application of AHP made it possible to formalize the procedure for determining factor weight coefficients and to ensure the consistency verification of expert judgments, while the use of Z-score enabled the transition from relative ranking to a metrically interpretable dominance scale and their classification according to priority levels.

It was established that the structure of factor influence at the studied stages has a pronounced asymmetric character: at the stage of designing the initial publication parameters, a limited set of strategically significant factors dominates, whereas at the stage of typographic–compositional organization of the layout page, a group of key parameters forming the artistic and technical quality of the layout was identified. The obtained results create a foundation for constructing integral indicators of layout quality and for further developing predictive models using fuzzy logic tools, thereby enhancing the validity of managerial and design decisions in the publishing process.

REFERENCES

1. Vasylyshyn, D. V. (2011). *Tekhnolohiia naboru ta verstky: navch. posib.* Lviv: Ukrainian Academy of Printing, 272 p.
2. Repeta, V., Kukura, T., Havrylyshyn, V., & Kukura, Y. (2023). Analysis of factors and construction of prognostic quality models of flexographic printing process of packaging with solvent based inks. *Journal of Graphic Engineering and Design*, 14(3), 37–44. <https://doi.org/10.24867/JGED-2023-3-037>.
3. Durniak, B. V., Pikh, I. V., & Senkivskiy, V. M. (2022). *Teoretychni osnovy informatsiinoi kontseptsii formuvannia ta otsiniuvannia yakosti vydavnycho-polihrafichnykh protsesiv* [Monograph]. Lviv, Ukraine: Ukrainian Academy of Printing, 356 p. Retrieved from <https://biblio.uad.lviv.ua>.
4. Pikh, I. V., Senkivskiy, V. M., & Andriiv, R. R. (2015). Design and calculation of alternative variants for technological process implementation. *Tekhnolohiia i tekhnika drukarstva*, 2(48), 55–62. [https://doi.org/10.20535/2077-7264.2\(48\).2015.48030](https://doi.org/10.20535/2077-7264.2(48).2015.48030).
5. Z-Score in Statistics: Definition, Formula, Calculation and Uses. Retrieved from <https://www.geeksforgeeks.org/data-science/z-score-in-statistics/>.
6. McLeod, S. (2023). Z-Score (Standard Score). Retrieved from <https://www.simplypsychology.org/z-score.html>.
7. Joint Research Centre. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. OECD Publishing.
8. Andrade, C. (2021). Z Scores, Standard Scores, and Composite Test Scores Explained. *Indian Journal of Psychological Medicine*, 43(6), 555–557. <https://doi.org/10.1177/025371762111046525>.
9. Nardo, M., Saisana, M., Saltelli, A., & Tarantola, S. (2005). *Handbook on Constructing Composite Indicators*. Luxembourg: European Commission, Joint Research Centre, 134 p.
10. Saaty, T. L. (2002). Decision making with the analytic hierarchy process.

11. Ishizaka, A., & Labib, A. (2011). Review of the main developments in the analytic hierarchy process. *Expert Systems with Applications*, 38(11), 14336–14345.
12. Zavadskas, E. K., & Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: An overview. *Technological and Economic Development of Economy*, 17(2), 397–427.

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ВИОКРЕМЛЕННЯ ФАКТОРІВ ЗА ПРІОРИТЕТНИМ ВПЛИВОМ НА ЯКІСТЬ ЕТАПІВ ПРОЦЕСУ ВЕРСТАННЯ КНИЖКОВИХ ВИДАНЬ

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У статті здійснено аналіз факторів, що визначають якість етапів процесу верстання книжкових видань у структурі додрукарської підготовки. Верстання розглянуто як багаторівневу технологічну систему, у межах якої формується функціональна, композиційна та естетична цілісність видання, з урахуванням багатofакторності та структурної взаємозалежності параметрів.

Дослідження охоплює два ключові етапи: проектування вихідних параметрів видання та типографічно-композиційну організацію полоси складання. Для визначення відносної вагомості факторів застосовано метод аналітичної ієрархії (АНП) з перевіркою узгодженості експертних оцінок ($CR < 0,1$), а для об'єктивізації розподілу впливів — метод стандартизованих оцінок Z-score, що дозволило перейти до метрично інтерпретованої шкали домінування та класифікувати фактори за рівнями пріоритетності.

Результати засвідчили асиметричну структуру розподілу впливів: на етапі проектування виокремлено обмежене коло стратегічно значущих факторів, тоді як на етапі типографічно-композиційної організації визначено групу домінант, що формують художньо-технічну якість макета. Встановлено, що концентрація вагомості у межах обмеженої кількості параметрів створює передумови для оптимізації управління якістю шляхом фокусування ресурсів на критично значущих змінних.

Кількісна інтерпретація результатів забезпечує можливість інтеграції отриманих вагових коефіцієнтів у багаторівневу ієрархічну моделі оцінювання та подальшого формування інтегрального показника якості верстання. Це відкриває перспективи використання адаптивних інструментів прийняття рішень, зокрема

моделей нечіткої логіки, для прогнозування впливу структурних змін на загальний рівень якості книжкового видання. Практична значущість дослідження полягає у можливості застосування запропонованої методики в реальних умовах редакційно-видавничого процесу для підвищення обґрунтованості проєктних рішень.

Запропонований підхід підвищує об'єктивність багатокритеріального аналізу, забезпечує формалізоване ранжування структурно взаємопов'язаних факторів і може бути використаний для побудови інтегральних показників якості та подальшого моделювання процесу верстання засобами нечіткої логіки.

Ключові слова: верстання книжкових видань; якість видання; додрукарська підготовка; проєктування вихідних параметрів; типографічно-композиційна організація; полоса складання; структурна взаємодія факторів; метод аналітичної ієрархії (АНП); Z-score; стандартизація; багатокритеріальний аналіз; інтегральний показник; ієрархічна модель; нечітка логіка.

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